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► To cite this version:

Katri Valkokari, Pasi Valkokari, Helena Kortelainen, Jutta Nyblom. Building Business Impacts of an Industry 4.0 Ecosystem Through Collaborative Network Settings Between IT and Forest Companies. 21th Working Conference on Virtual Enterprises (PRO-VE), Nov 2020, Valencia, Spain. pp.463-474, 10.1007/978-3-030-62412-5_38 . hal-03745794

HAL Id: hal-03745794

<https://inria.hal.science/hal-03745794>

Submitted on 4 Aug 2022

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Building Business Impacts of an Industry 4.0 Ecosystem through Collaborative Network Settings between IT and Forest Companies

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Abstract: The paper provides an empirical example of co-innovation process within an Industry4.0 ecosystem between Finnish IT sector, service designers, researchers and the forest industry companies. Based on empirical evidence the paper summarizes some of key challenges in building business impact from digitalization.

Keywords: Business impact, Ecosystem, Collaborative networks, Industry 4.0, co-innovation, design science, service design

1 Introduction

In this century, data may become the most important form of capital [1]. Currently, a significant part of the data collected by industrial IT systems is not being used, and therefore, the full potential of the business impacts of Industry4.0 is not being realised. Old industrial plants have a plethora of data sources documenting their design and behaviour, ranging from diagrams and software to spreadsheets and text documents. Digital strategies in forerunner organisations go beyond technologies. They target improvements in innovation and decision-making [2], i.e. their aim is to build business impacts for an Industry4.0.

Therefore, digitalisation and data represent significant drivers of change and new business potential in today's business environment. Understanding the systemic change required for Industry 4.0 is at the same time a fascinating academic research question and a practical challenge for all actors within manufacturing industries. This transformation requires novel competencies, solutions and collaboration between companies. Companies aspire to different roles in an ecosystem, and they may also update and upgrade their role over time [3]. In this study, the growth opportunities enabled by digitalisation are examined from the perspective of the business impacts within an ecosystem consisting of IT and forest companies. Thus, this ecosystem can be considered a breeding environment [4] for several collaborative networks constituted around the so-called use cases. Since the area of collaborative networks (CN) is by nature multi-disciplinary as well as interdisciplinary, it can enhance a more

holistic understanding of the technology diffusion at stake, as pointed out by Camarinha-Matos et al. 2017 [5].

There is widespread consensus among both academics and practitioners that innovation is the main driver of productivity, economic growth and job creation. Thus, there is huge potential in combining the digital competences of the IT sector with the manufacturing industry to drive future success as well as create new novel business opportunities for the IT sector itself. A prerequisite for enhancing digitalisation is an active, open ecosystemic innovation platform that fosters dynamic collaborative networking. In other words, this innovation platform could be called a breeding environment [4], which enables the preparedness of its members to quickly become engaged in collaboration and co-innovation processes. The full potential of digitalisation in the platform economy cannot be achieved in closed business networks. This premise is the driving force for our study on building business impacts in an Industry4.0 ecosystem consisting of solution providers (mainly IT companies) and end customers in the manufacturing sector (forest industry companies).

The studied Industry4.0 ecosystem aims to generate new types of networks of collaborative innovation activities (i.e. interactive networks of multiple CNs in line with the concept of Collaborative Networks 3.0). The networks are built around so-called ‘use cases’ originating from the operational needs of forest industry companies and among which IT companies have identified their own business opportunities. The members of the SEED ecosystem¹ developed together digital solutions that will improve the international competitiveness of all participants. In addition to three forest companies, two equipment manufacturers and 13 IT supplier (i.e. solution providers and integrators) companies, the case includes three service design companies and three research organisations (as described in more detail in Table 2). Thus, identifying business benefits of such collaboration from the perspective of all actors is one of the key success factors of the ecosystem, one that requires transparent management of intellectual property between the ecosystem actors [6].

2 Building Constructs for a Joint Research Process

2.1 Data Business and Platform Economy

Companies offering IoT platforms as marketplaces are highly valued in B2C products [7], and there are multiple examples of large-scale platform enterprises engaged in consumer business. It is more than likely that the same phenomena will occur in the B2B sector as well. B2B platforms are still rare, and the development trend seems to be more based on a decentralised model with interconnected platforms than on platform monopolies [8]. The forest industry has not shown a great interest in platform economy development for various reasons, one of them being vendor lock-ins. Large design and engineering solution providers offer integrated solutions that tie end-user companies into a solution from one vendor. This so-called vendor-locking

¹ www.seedecosystem.fi

situation may be a risk for the end-user company. It increases the dependency of the solution provider, as the data content is tied to a specific solution [9]. In some cases, even the ownership of data collected by a forest company during its operations is limited to an equipment or a software provider. However, significant value capture as a result of implementing Industry 4.0 solutions to improve competitiveness calls for knowledge sharing and collaboration in the networks and ecosystems. Collecting and integrating the data from various sources, and refining the data into knowledge, can support different user needs and boost the creation of new business [10, 3].

The emerging Industry 4.0 ecosystems requires focal companies to invite other stakeholders to add value to the common platform so that the ecosystem can co-evolve [11]. Thus, in addition to the forest industry companies, a focal company in a collaborative network may be either an equipment or software company, i.e. there is a need to bring together all key players in order to ingrate different data and knowledge sources. However, within the same the ecosystem players must assure each other that the information content is not tied to specific tools and can be processed and utilised with any standard compliant tool so as not to create novel vendor lock-ins [9]. Competences, skills and models for ecosystem orchestration and good practical examples are needed to solve systemic challenges [12]. The value potential of the platform economy and ways to enhance it need to be presented. Successful ecosystems are founded on common platforms consisting of services, tools or technologies, which the members of the ecosystem are able to use to enhance their own performance [13].

2.2 Ecosystems and Collaborative Networking

Global competition has shifted from taking place between individual companies to competition between business networks or, as the increasing interest in sustainability and industrial ecology suggests, between industrial ecosystems [14]. In the current networked business environment, cooperative actions and decisions are not being made in a centralised manner [15]. Therefore, the full potential of a data-based business and platform economy can be captured in collaboration with a variety of external actors, i.e. ecosystems or collaborative networks (CN) and their breeding environments, as access to and integration of third-party data sources is required to explore changes in the current business environment [16].

An ecosystemic way of co-creation requires going beyond the hub-spoke model of network roles [17]. Hence, we aimed to consider the strategic intentions, business undertakings and processes by which an actor engages in building the systemic solutions for an ecosystem [18], and in this way, define actor roles in ecosystems when analysing of the actors' willingness to contribute to the shared agenda of an ecosystem. Accordingly, we have identified four categories for ecosystem actors with specific interests in the results of co-creation. First, the customers of the co-created systemic solutions, i.e. the companies, with the aim being for the ecosystem to look for new solutions to the challenges faced by customers. Second, the actors include solution developers and providers, meaning firms developing new solution to be integrated into the systemic solution of an ecosystem or firms offering an almost ready and generic solution as part of the systemic solution for an ecosystem. Third,

the actors should include solution integrators, which are firms aiming to bring the systemic solution for an ecosystem to the marketplace. Finally, the fourth category is innovation intermediaries, research institutes and designers offering special expertise needed to boost the innovation and development work within an ecosystem.

2.3. Looking for Business Potential and Impact

The importance of the forest industry and its supplier network is significant for the Finnish economy. Both the forest industry and the machinery manufacturing industry produce products representing 20% of Finnish exports, with the pulp and paper industry's share alone being 15% (National Board of Customs, 2017, based on CN classification). The overall trend towards servitisation has also changed the nature of Finnish exports, and during the last two decades the share of services in Finnish exports has doubled. In 2017, the value of service exports exceeded that of pulp and paper products.² IT-related services alone accounted for 11.4% of the domestic added value in Finland. However, the significance of service innovations is much higher than the figures indicate, as services are also consumed by the export industry and are also included in the value of goods exports (Haaparanta et al., 2017). According to European Commission DESI 2018 research, Finland has one of the most advanced digital economies and strongest digital assets in the EU.³

The competitiveness of Finnish forest industry companies was one of the driving forces in the SEED ecosystem. The use case companies in the forest industry expect that SEED will have a positive impact on business profitability, machine runnability, end-product quality and investments. This in turn is expected to have an impact on several hundred million euros worth of revenues in each use case company. Furthermore, in the longer run the companies also expect the ecosystem be able to boost a new kind of a culture to share and utilise data, and thus, build the first steps towards a platform economy and new kinds of digital services in the industry. On the other hand, the solution provider companies, highlighting new type of business development, improve their understanding of specific forest sector needs when collaborating in the SEED ecosystem, which will help them develop novel or extended service offerings for the growing global bio-based product market. It has been estimated that this growth opportunity will account for 10 to 25% of current revenues in the next 3 to 10 years in large and midcap IT companies, but significantly larger growth expectations were mentioned for smaller companies.

3 Research Approach — Enabling Co-learning between Ecosystem Actors

In-depth empirical research on building business impacts through multiple collaborative networks is still scarce [10], although the vast opportunities and

²Kansantalouden tilinpidon laskelmat 2000–2018, Tilastokeskus (in Finnish) <https://www.stat.fi/tietotrendit/artikkelit/2019/tavaroista-palveluihin-viemme-nyt-enemman-suomalaista-tyota-kuin-ennen/>

³See <https://ec.europa.eu/digital-single-market/en/des>

competition between ecosystems instead between companies have been emphasised for Industry 4.0 ecosystems. Design science was, therefore, a natural choice for the research approach of our study. Using a design science approach [19], we explored the business impacts expected from the shared innovation processes within a hybrid collaborative network setting. The main research questions were as follows: *What could be the benefits of the platform economy as a source of productivity, renewal and growth in the forest industry? How do the roles of various ecosystem actors influence their willingness to contribute to the shared agenda of ecosystems?*

In accordance with design studies, the relevance of the research results and the quality of the research were evaluated against the practices of 24 companies participating in building our Industry 4.0 ecosystem, called SEED, and the coexisting research and innovation processes. Especially the different collaboration and contracting practices were studied in order to assess the ecosystem's co-development path on a deeper level.

Figure 1 presents the SEED ecosystem companies and their roles in shared problem solving within the ecosystem.

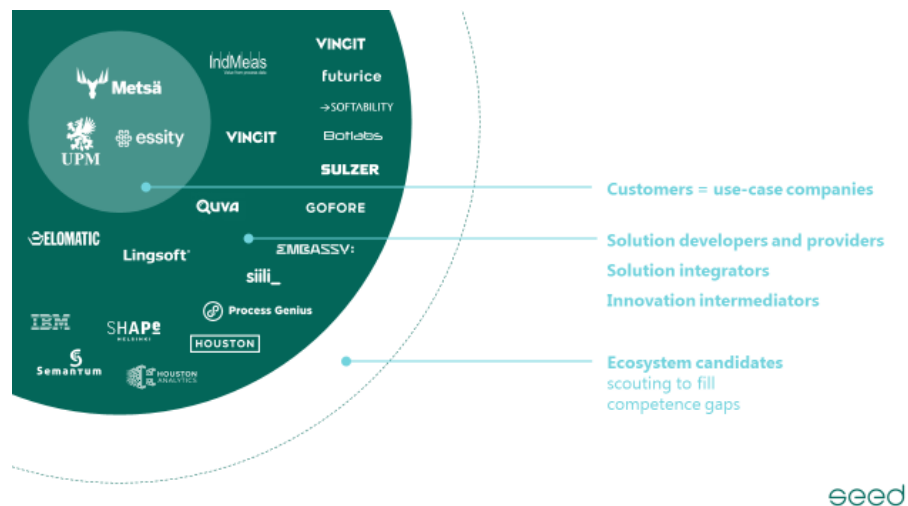


Fig. 1. Three layers of SEED ecosystem

In our study, the forest industry covers mills in the pulp, paper, tissue and board production sectors, i.e. the sawmill industry was not included in this phase. Many forest industry companies, including the companies involved in the studied ecosystem, have initiated their own business ecosystem programmes to boost collaboration with technology providers, and therefore SEED provided a new type of setting for problem solving at the level of an Industry 4.0 ecosystem, one connecting the needs of three forest industry companies. In addition, the SEED ecosystem connects the competences of technology (especially IT) companies and design thinking. Table 1 summarises the roles of the involved ecosystem actors (the roles are defined in section 2.2).

Table 1. Ecosystem actors involved in the study.

Role in ecosystem	Industry	Size	Number of actors
Use case owners	Forest industry companies	3 large	3
Solution providers	Equipment Manufacturing	1 large, 1 small	2
and developers	ICT	6 large, 6 small	12
Solution integrators	ICT	1 large	1
Innovation	Designers	1 large, 2 small	3
Intermediaries	Researchers	2 univ., 1 RTO	3

4 Findings

4.1 The Co-innovation Process

Forest companies offered their production facilities as innovation platforms around which the participating IT, technology and design companies and the research institutes gathered to resolve the challenges presented by the forest companies. As a starting point, actors devised together a two-phase process for joint problem solving. The first phase focused on building deeper *insight*, i.e. framing the problem, defining the research questions and identifying business requirements (viability) as well as technical requirements (feasibility). Therefore, end users, researchers and designers built the core team during the first phase. Then, during the second phase multidisciplinary teams of ecosystem actors worked together to *conceptualise and demonstrate* the possible solutions.

Regarding the joint problem-solving effort, the specific challenge in this study was the prerequisite to combine a diversity of theoretical concepts — as well as practical know-how — from business management and information technology. Here, the design thinking and especially service design approaches offered a prominent solution to involve actors in the joint research process. Thus, the confidentiality requirements regarding the sharing of use-case-specific information between the ecosystem actors presented a bottleneck to the collaborative innovation process for the ecosystem, as the discussions about different collaboration strategies and expectations for ecosystem-level creation required clarification. Therefore, use-case-specific non-disclosure agreements (NDAs) were utilised to enhance knowledge and data sharing between the problem owners (forest companies) and solvers. Table 2 summarises the inputs of actors in different roles and their expectations for collaboration in the network(s).

Table 2. Key activities of ecosystem actors involved in the study.

Role in ecosystem	Industry	Input into the process	Expectation for collaboration
Use case owners	Forest industry companies	Use case requirements, co-innovation platform (factories)	Co-learning for novel solutions, closed own development (other use

Solution providers and developers	Equipment Manufacturing	Existing solutions and knowledge for building novel solutions	case owners not included) Closed own (R&D) development, co-learning for novel solutions
	ICT	Existing solutions and knowledge for building novel PoCs	Closed own (R&D) development Learning by doing and building reference cases
Solution integrators	ICT	Customer requirements, need for solution bundles	Networking and solution integration, models for licencing
Innovation Intermediaries	Designers	User requirements, Design thinking	Networking and building reference cases, competences and tools for co-innovation
	Researchers	Research knowledge and results, design science approach	Enabling co-learning, disseminating research results. ensuring generalisability (comparison between use cases)

4.2 Roles and Collaboration Models

During the development process, the ecosystem actors identified different collaboration models for building business impacts through solutions to be identified and conceptualised together. The models were based on: i) traditional bilateral supplier–customer relationships, ii) system integration and iii) multi-actor solutions based on open boundaries of the digital platform. Figure 2 presents the possible models. Each of the models contain both weaknesses and strengths. The traditional bilateral supplier–customer relationships ensure effective co-operation between the parties because the roles, rights and responsibilities can be formally agreed upon. Thus, the customer has the major responsibility for integrating different solutions, meaning that suppliers have a limited view on customer needs at the system level. The second model, joint offerings, enhances the possibility to integrate the different technological solutions with fluently operating digital tools. Finally, the multi-actor platform model could boost novel business models, such as data-based service offerings. It could also improve the modularity and scalability of solutions, which may require open boundaries and practices for data sharing. Furthermore, the multi-actor model has the potential for solving the challenge regarding vendor lock-ins (see section 2.1).

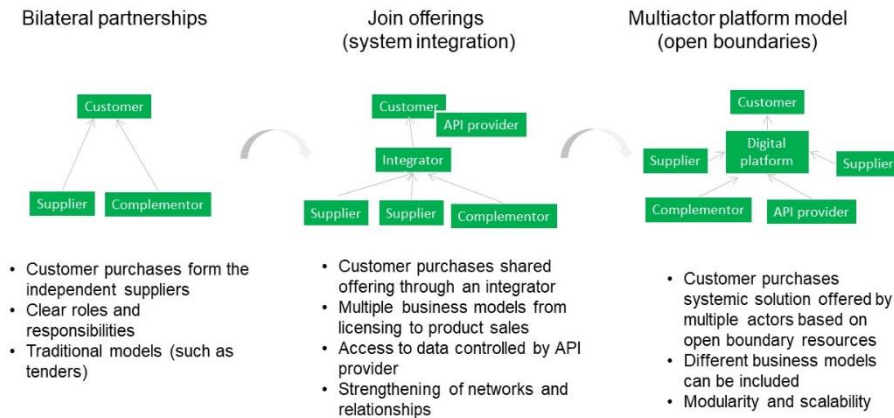


Fig. 2. Three identified collaboration models.

Although the jointly agreed upon ecosystem agenda emphasised systemic solutions, most of the solution provider companies in this study noted that they prefer traditional bilateral partnerships with their potential customers. Therefore, it was realised that the benefits and costs, as well as rights and responsibilities, of these models need to be further analysed. For instance, the governance and need for boundary resources and system integration were recognised by all as important factors that need to be defined.

4.3 Data and Knowledge Sharing

The insight phase led to the acknowledgement that industrial sites have stored huge amounts of data in the various ICT and automation systems during their operations. The challenge here is that the data is not being used to its full potential and no business models exist for utilising the data optimally. Partially, this is due to vendor lock-ins, i.e. to the fact that some of the machinery providers in the forest industry sector are able to control access to the production data of plants. The use case companies estimated that productivity can be increased by several percentage points with new smart solutions and business concepts. In addition, the lack of industrial data format standards hampers the use of data in this domain. Furthermore, the companies lack formal models for sharing and integrating data. Thus, the main obstacle to data sharing often is that companies have not considered their data strategy, i.e. what data could be shared, with whom and what are rules for utilising data. Additionally, making use of the full potential of data requires that the data be further processed as information and knowledge; such a process requires multiple competences from different ecosystem actors. The different dimensions of translating raw data into knowledge require different mechanisms for sharing and protection. The required mechanism will have an impact on possible collaboration models (section 4.2) as well as contracting practices (section 4.4).

Table 3 summarises the key aspects and strategic thinking of the different ecosystem actors with respect to knowledge and data sharing. The forest industry companies are the use case owners; they offered their factories as innovation platforms. For them, it was important to be able to control the ecosystem actors'

participation in their use cases. On the other hand, they also wanted to have the possibility to consider knowledge sharing between the use cases. The solution providers (both equipment manufacturers and IT companies) highlighted the need to utilise the improved understanding of customer needs in their own R&D work. In addition, especially the smaller companies emphasised the possibility to demonstrate their competences and build references in a real-world environment. The designer companies and research institutes, which operated as intermediators, especially in first phase, i.e. the insight-building phase of the collaborative process, pointed out the opportunity to gain an understanding of the ecosystem actors' practical problems, conduct research on the co-innovation practices enabling digital transformation and develop novel tools for such processes.

Table 3. Knowledge sharing strategies of ecosystem actors involved in the study.

Role in ecosystem	Industry	Key aspects	Strategies
Use case owners	Forest industry companies	Need to control use case participation, knowledge protection between use case owners (due to competition law)	Acquired knowledge and IP by contractual transaction (sub-contracting solutions developed)
Solution providers and developers	Equipment Manufacturing	Need to utilise the knowledge in own R&D work	Acquired knowledge and IP by contractual transaction
	ICT	Ownership and utilisation of co-developed IP (PoCs) also with other customers	Agreement on ownership of co-developed results
Solution integrators	ICT	Ownership and utilisation of co-developed IP (PoCs) also with other customers	Acquired knowledge and IP by contractual transaction (such as licencing)
Innovation Intermediaries	Designers	Customer references, ownership of novel tools and methods	Participation tools and methods utilised openly (often publicly shared), but their use typically controlled
	Researchers	Possibility to utilise data for research (anonymised)	Public research

During the co-innovation process, it was realised that service design approaches, such as more detailed studies of different user profiles regarding digital solutions, bring benefits to lifetime performance improvement endeavours within the use cases. At the forest industry companies, the user profiles cover the whole range of activities from the shop-floor work to planning and long-term decision making. For instance, if more relevant status and alarm information systems and equipment-level condition monitoring would be available, then additional support for fault identification could be offered.

4.4 Contracting Practices

During the first phases of contract negotiations between the ecosystem actors, a need arose to clearly define the contracting structure and links between the contracts, i.e. the ecosystem had a consortium agreement and there was a need for an additional use-case-specific non-disclosure agreement (NDA). Furthermore, the ecosystem work received public funding, which introduced some special requirements to contracting. At any rate, the challenge of aligning the dynamic, evolving ecosystem and 'stable' contracts was obvious. It was especially realised that an ecosystem's contact persons should be better involved in contract negotiations, as there still was the tendency to outsource the subject to lawyers.

The level of impacts in a business ecosystem mainly depends on the business needs that the companies were solving, ranging from the effects of conventional process improvement to the effects in emerging ecosystems. Additionally, the potential is not similar for all players in the same collaborative network, which reveals changes in the roles of solution providers. Here, the right to utilise the results was identified as one of the key success factors, i.e. how the actors were able to agree on the rights to utilise the results, such as the technological PoCs tested in collaborative efforts, was crucial (see Table 3). If the customer companies demand an exclusive right to solutions, then the solution providers and integrators have only a limited potential to broaden their business. On the other hand, the availability of technology as well as company resources to grow or gain access to international markets were identified as other important factors.

5 Conclusions

The Finnish forest industry is known for its extremely high level of technology and competence. It has a long history and established development practices; therefore, collaboration with more agile companies could offer them significant potential. For the traditional industry to take the next big step in terms of competitiveness and productivity, the opportunities offered through the digital solutions of Industry 4.0 need to be carefully considered. In addition to technology, novel practices, products and services, business models and networks need to also be developed. Identifying and exploiting the opportunities of Industry 4.0 requires close cooperation with IT companies and challenging existing ways of working. Thus, it was recognised that one of the first tasks is to find a common language between actors coming from different industrial sectors and backgrounds in order to enable them to work together as an ecosystem.

The network actors in our case study worked together to discover the types of tasks and processes to which Industry 4.0 tools could be applied in forest industry processes, as well as how they could be applied. Such applications included, for example, service and maintenance tasks as well as the exchange of information between shifts and plants. The aim of the two-step process was to proceed as quickly as possible to make the concepts and demos generated from ideas available to end users for testing and also to get the resulting solutions to the marketplace.

The managerial implications of this study consist of the practices involved in a co-innovation process within a hybrid collaborative network and a deeper understanding of the business potential from the perspectives of different ecosystem actors. The theoretical contributions indicate that the design science approach is a suitable method for addressing the ill-structured managerial problems of implementing Industry 4.0 tools and requiring constant learning by the actors.

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