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Boosting Innovation for the Development of Smart-Service Factories of the Future: The Cases of the Federal State of Vorarlberg and its Neighbouring Regions

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Boosting Innovation for the Development of Smart-Service Factories of the Future: The Cases of the Federal State of Vorarlberg and its Neighbouring Regions

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Abstract Factory of the Future is an initiative of the European Commission. It is highly narrative and describes the transformation of "ordinary" manufacturing operations and structures to fully-integrated cyber-physical manufacturing systems. Basing on case study research performed in the greater area of Vorarlberg, this article aims to explore how Small and Medium Enterprises (SMEs) in the field of manufacturing can evolve to smart-service Factories of the Future. It takes a mixed-methods approach with quantitative research (questionnaire) and qualitative case study interviews and provides findings about three main topics in service system engineering: "transformation of an operational need into a description of system performance parameters", "integration of related technical parameters and assurance of compatibility of all physical, functional and program interfaces" and "integration of reliability, maintainability, safety, survivability, human and other such factors". As it turns out, increased servitization measures, service management, service performance and service quality by development of service-oriented architectures (SOA) are key to evolve to a smart-service Factory of the Future.

Keywords: • Service Science • smart-service systems • Factory of the Future • Industry 4.0 • digital transformation •

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1 Introduction

"Factory of the Future" (FoF) is an initiative of the European Commission. It was launched in 2008 with the aim to develop a sustainable and competitive EU manufacturing industry. In its first iteration, the initiative included the development of high added value manufacturing technologies that are also clean, highly performing, environmentally friendly and social sustainable (e.g. European Commission, European Commission (2013)). Since then, FoF has remained as narrative but, due to ongoing digital transformation of the manufacturing industry, it nowadays describes the manufacturing facilities as digital, fully integrated plants evolving to smart-service cyber-physical systems (e.g. Küpper et al. (2016), Project team in the IEC Market Strategy Board (MSB) (2015), v. Heynitz et al. (2016)). Especially in the German speaking countries (but also in neighbouring countries and beyond), FoF is highly associated with Industry 4.0 (I4.0) approach. Both concepts connect technology, information and human resources on equal ground to establish more performant and efficient but also more intelligent and self-managing smart-service systems. Smart-service systems are the subject of service (systems) innovation (Maglio, 2014).

(Smart) service systems are the basic abstraction of the academic discipline of Service Science (e.g. Maglio et al. (2009), Vargo & Akaka (2009), etc.). It is a relatively new academic discipline Böhmann et al. (2014) with roots in marketing research (Vargo & Lusch (2004), Vargo & Lusch (2008)), but also systems engineering with International Business Machines (IBM) as an important protagonist. Anecdotal reference refers to a phone conversation between Jim C. Spohrer and Henry Chesbrough whereas last-named recommended – similar to the 1940s and 50s, where IBM was pioneer in development of computer science – to start Service Science (Intelligent Business Machines (IBM), 2012). Paul Horn, senior VP for research at IBM, approved this idea (Horn, 2005). Service Science was also selected as one of the top 20 ideas in 2005 by the Harvard Business Review (Chesbrough, 2005). Since its emergence, the Service Science community has quickly grown and made significant progress in research – including the study of smart-service systems which are systems in which autonomous technical operation contributes to continuous re-engineering and improvement (e.g., productivity, quality, compliance, sustainability, etc.) and co-evolution in all value creation processes (Demirkan, Spohrer, & Badinelli, 2016).

The aim of this paper is to explore how "ordinary" manufacturing operations and structures can evolve to smart-service Factories of the Future. It intends to identify critical success factors for the development of smart-service Factories of the Future as well as to provide access points for organizational transformation and integration of identified critical success factors. The overall motivation and identified research gap is derived from the BIFOCAlps project scope (BIFOCAlps consoritium & Interreg Alpine Space, 2018): due to globalization, many enterprises – especially small and medium enterprises (SMEs) in manufacturing sector are not as competitive as wished in global markets, resulting in increased levels of unemployment, abandoned facilities and remaining plants that need new products and new processes (BIFOCAlps consoritium & Interreg Alpine Space, 2018). BIFOCAlps is the supporting research project of this article at hand and aims to foster adoption of good practices in the manufacturing value chain, enhance knowledge transfer among its key stakeholders and raise awareness for impacts of the FoF paradigm in the manufacturing sector.

This paper presents the results of 13 case studies on best practices in the manufacturing service sector out of the greater region of Vorarlberg. Applied methodology is case study research (Yin, 2014) that is guided by the research question "**How can Small and Medium Enterprises in the field of manufacturing evolve to a smart-service Factory of the Future?**". To answer this question, the paper looks in particular the ability of companies to perceive digital transformation challenges for industry companies and find a suitable path towards digital transformation, their investment in digital technologies and the knowledge transfer and partnerships with other companies.

This paper at hand is organized in five sections. The following section (section two) gives a quick overview about the body of knowledge (Service Science). Furthermore, the section introduces the selected analytical framework. This framework is applied to present the case study finding (c.f. section 5). Section three explains the research methodology as well as the scope of research. It also describes the chosen data sources. Section four presents the case studies (from a cross-case perspective). Section five summarizes the case study findings and provides a conclusion and an outlook for successful implementation of a smart-service Factory of the Future.

2 Body of Knowledge: Service Science & smart-service Factory of the Future

This scholarly article at hand contributes to the academic discipline of Service Science (e.g. Spohrer & Maglio (2008), Stoshikj et al. (2016)) on the theoretical side as well as to digital transformation, Factory of the Future and Internet of Thing on the practical/operational side.

The goal of Service Science is, according to Wieland et al. (2012) (in reference to Spohrer & Maglio (2008)), "to apply scientific understanding to advance our ability to design, improve, and scale service systems for business and societal purposes". Service Science combines human understanding, according to [5], "with business and technological understanding to categorize and explain service systems, including how they interact and evolve to cocreate value". This discipline "deals with the interaction within and between service systems" (Stoshikj et al., 2016). Spohrer (2008) defines a service system as "the basic unit of analysis, as a dynamic value co-creation configuration of resources, including people, organizations, shared information (language, laws, measures, methods), and technology, all connected internally and externally to other service systems by value propositions". These are "not only data and physical components, but also layers of knowledge, communication channels and networked actors" (Böhmann et al., 2014).

However, service systems are socio-technical artefacts (Alter, 2013, 2015) and the basic abstraction of Service Science (Maglio et al., 2009). Service systems are considered to be "everywhere" (Wieland et al., 2012) and are part of larger service ecosystems. Smart-service systems, according to Polese, base on intensive application and use of Information and Communication Technologies (ICT) for a wise and interacting management of service systems' assets, goals as well as being capable for self-reconfiguration (Barile & Polese, 2010). Polese exemplifies intelligent utility network and metering, intelligent transportation, consumer driven supply chains and manufacturing productivity as smart-service systems. However, smarter service systems serve its clients better and develop enhanced opportunities for win-win situations that again result in increased value co-creation for both service providers and clients (Spohrer & Maglio, 2009). Smart-services in the field of manufacturing, as (Boukhris, Fritzsche, & Möslein, 2017) highlight, are advanced services and – as they cite from (Baines & Lightfoot, 2013) – allow to "provide remote insight into the condition and use of a product, and advanced warning of impending failures".

To boost innovation in manufacturing operations and structures with the general aim to become a smart-service Factory of the Future, efforts and activities into service system engineering are indispensable. (Tien & Berg, 2003) as well as (Buede & Miller, 2016) provide list of common definitions of service system engineering (SSE). Focusing on the framework of the U.S. Department of Defense (1969), SSE is about the (1) transformation of an operational need into a description of system performance parameters and system configuration, the (2) integration of related technical parameters and assurance of compatibility of all physical, functional and program interfaces and the (3) integration of reliability, maintainability, safety, survivability, human and other such factors into the total engineering effort. In this article at hand, this approach serves as analytical framework to analyse the case studies and to synthegrate and summarize the findings.

Digital transformation is about the integration of digital technology into all areas of business and operations but also about replacement of outdated processes and legacy technologies (The Enterprisers Project - a community of CIOs discussing the future of business and IT, 2018). Factory of the Future and Industry 4.0, as discussed in Maurer & Schumacher (2018), "is an emerging paradigm for businesses and industries (e.g. Project team in the IEC Market Strategy Board (MSB) (2015), Küpper et al. (2016), v. Heynitz et al. (2016)). It proposes improvements on three dimensions namely the plant structure, plant digitalization and plant processes Küpper et al. (2016) and aims is to merge the physical with the virtual world of manufacturing. Objective of these no longer reversible paradigms is to digitalize manufacturing processes as well as its services including, for example, product planning, product development, factory and production planning, production and logistics".

3 Research Methodology and description of Data Sources

Applied research methodology in this article at hand is case study research. Case study research is very common in the social research sciences (Yin, 2014). It is a qualitative research method that gives researches liberty to combine heterogeneous data and data collection methods such as interviews, questionnaires, organizational documents, service level agreements, etc. Based on Yin (2014), figure 1 highlights applied research process. It consists of a questionnaire (quantitative research, left hand side of figure 1), disseminated to a diverse group of business professionals, and case study interviews (qualitative research, right hand side of figure 1), performed with 13 representatives[27] in the field of manufacturing. The quantitative research opened the door for the empirical field of digital transformation in organizations, FoF and I4.0 as well as – basing on the evaluation of the quantitative research results – was the origin to develop meaningful and more detailed questions for the empiric research. This article at hand focusses on the combined findings emerging from the last step in this process: the cross-case report.

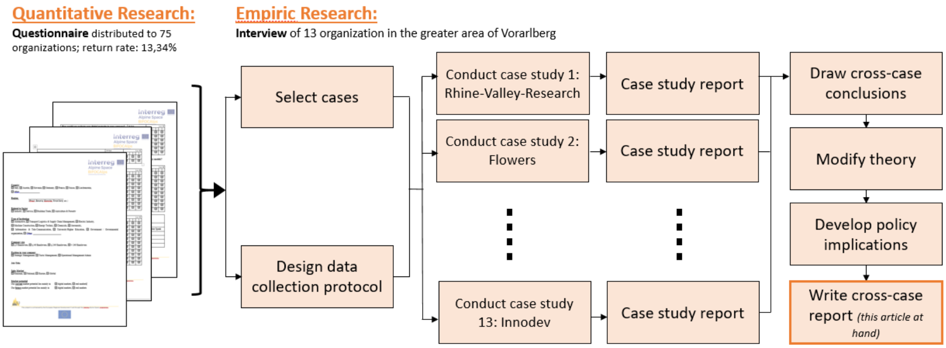

Figure 1: Applied research methodology (adopted from Yin (Yin, 2014))

The questionnaires were disseminated in Spring 2017 to 75 organizations in the manufacturing sector and related sectors (e.g. transport logistics and supply chain management) in the Alpine Space (Alpine Space, 2018). The questionnaire consists of closed questions related to the ongoing digital transformation towards smart-service Factories of the Future. The response options in this questionnaire were predefined on a Likert scale ranging from 6 (high importance) to 1 (low importance).

In continuation, all respondents of the questionnaire out of the region of Vorarlberg (7) plus six freely chosen organizations in the greater region of Vorarlberg were integrated into semi-structured case study interviews. In total, 11 organizations were selected from the Federal State of Vorarlberg (Austria), 1 organization form the canton of St. Gallen (Switzerland) and 1 organization from the region of Stuttgart (Baden-Württemberg, Germany). The return rate of the questionnaire is low (13,34 %; 10 (absolute)) and is not representative. Nevertheless, the questionnaire provides a good overview about managers' perspectives and expectations toward the ongoing digital transformation in the manufacturing industry.

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[27] 7 representatives are from small and medium enterprises (SME's), 2 from large companies, 2 from technical competence/research centers (related to Industry 4.0), 1 from an innovation agency and 1 Professor/Lecturer in the field of Manufacturing/Engineering

The greater region of Vorarlberg is selected for several reasons: Vorarlberg is the second strongest economic region in Austria (behind the capitol of Vienna) and – accompanied to this economic strength – Vorarlberg and its neighbouring regions are one of the most powerful economic regions worldwide. The economic strengths of this region are widely based on innovation and innovative organizations as well as the region's economic power is mainly provided by SMEs that are not only providers of information for this case study research but also co-beneficiaries of this research. Further co-beneficiaries are managers and employees of related institutions to SMEs (e.g. chambers of commerce, business support organizations) as well as scholars and scientist in the field of I4.0 and FoF.

The interviews were conducted in summer and autumn 2017. They lasted in average 1,5h and were conducted either via face to face or via telephone. In the course of the interview, the interviewees first experienced a succinct introduction in the field of research, the motivation and research question and further background about the research project (BIFOCAlps). The interviewees were then asked to comment on three thematic blocks: "ability in perceiving digital transformation challenges for industry companies/ability in perceiving and facing the path towards digital transformation", "investment in digital technologies" and "knowledge transfer and partnerships with industry companies". All interviews were summarized in single case study reports that provide the basis for this article at hand.

3.1 Description of Data Sources

In the analysis of the descriptive data from the questionnaire, it turned out that the majority of the respondents evaluate Industry 4.0 (89 %) and the Factory of the Future (56 %) as an important concept for their organizations[28]. For example, on a Likert scale ranging from 6 (high importance) to 1 (low importance), 33 % (I4.0) and 22 % (FoF) of the respondents evaluated that I4.0 and FoF have highest importance (scale 6) for their organization. Figure 2 highlights the result of the opening question of the questionnaire.

[28] One abstention out of 10 questionnaires

	<-- High Important			Low importance -->				
	6	5	4	3	2	1	N/A	Total
"Industry 4.0", how important is it for your organization?	33%	56%	11%	0%	0%	0%	1	100%
"Factory of the Future" (FoF), how important is it for your organization?	22%	33%	22%	11%	11%	0%	1	100%

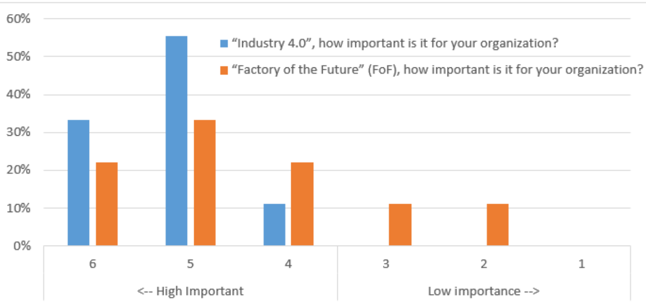

Figure 2: Importance of Industry 4.0 and Factory of the Future paradigm

Related to the question, what a megatrend for I4.0 and FoF is, questionnaire participants answered that "Shorter Product-Life-Cycles", "Dynamic Technology and Innovation" and "Mass Customization" are of extraordinary importance. Further megatrends are, for example, "Globalization and future markets", "Global Knowledge Society", "Scarcity of Resources", "Challenge of Climate Change", "Sharing Global Responsibility" and "Changing demographics". Figure 3 shows the megatrends and their importance for the respondents of the questionnaire.

	<-- High Important			Low importance -->				
	6	5	4	3	2	1	N/A	Total
Shorter Product-Life-Cycles	67%		11%	11%	11%		1	100%
Dynamic Technology and Innovation	50%	50%					0	100%
Mass Customization	50%	20%		30%			0	100%
Globalization and future markets	30%	50%	20%				0	100%
Global Knowledge Society	20%	50%	30%				0	100%
Scarcity of Resources	10%	30%	30%	20%	10%		0	100%
Challenge of Climate Change	10%	10%	30%	50%			0	100%
Sharing Global Responsibility		20%	30%	40%	10%		0	100%
Changing demographics		11%	22%	33%	33%		1	100%

Figure 3: I4.0 and FoF megatrends

As figure 4 indicates, three respondents of the questionnaire expect to change their business models because of emerging I4.0 and FoF paradigm. Two respondents started to perform projects to change business models and three already transformed their business models because of the ongoing digital transformation. Only one respondent answered that business models do not need to get changed.

Replies	Yes	No	Current project	Already done	N/A	Total
10	3	1	2	3	1	10
	30%	10%	20%	30%	10%	100%

Figure 4: Business model change and adaption

Figure 5 highlights the respondents' statements toward I4.0 and FoF paradigm. For example, four of the respondents of the questionnaire rate that I4.0 and FoF require to change business models with the highest rank (6). Additional four respondents rate this statement with the second highest rank (5) und 2 with the third highest rank (4). Computed with its eigenvalue (4 (respondents) * 6 (eigenvalue) + 4 * 5 + 2 * 4 = 52), it turns out that I4.0 and FoF require change in business models is the most correct statement. Following statements with high truth value are: I4.0 and FoF require change in organizational strategy and I4.0 and FoF require increased collaboration with customers and business partners.

	<-- High					Low -->		
Which statement is correct? Industry 4.0 …	6	5	4	3	2	1	N/A	Total
… requires changes in business models	(4) **24**	(4) **20**	(2) **8**					52
… requires changes in organizational strategy	(3) **18**	(5) **25**	(2) **8**					51
… requires increased collaboration with customers	(2) **12**	(5) **25**	(3) **12**					49
… requires increased collaboration with business partners	(1) **6**	(6) **30**	(2) **8**	(1) **3**				47
… create chances	(3) **18**	(3) **15**	(2) **8**		(2) **4**			45
… create challenges	(2) **12**	(3) **15**	(4) **16**		(1) **2**			45
… make markets more disruptive	(2) **12**	(1) **5**	(6) **24**	(1) **3**				44
… produce global competition		(6) **30**	(4) **8**	(1) **3**	(1) **2**			43
… make markets more dynamic	(1) **6**	(2) **10**	(3) **12**	(3) **9**	(1) **2**			39
… requires increased collaboration with politics & government	(1) **6**	(2) **10**	(4) **16**		(1) **2**	(1) **1**	1	35

brackets highlight the amount of responses

Figure 5: Trigger for I4.0 and FoF

4 The cases of the Federal State of Vorarlberg and its neighbouring regions

This section presents the results of the conducted single case study research from a cross-case perspective. It involves 13 single case studies from the manufacturing industry and related fields. 7 managers/representatives are from small and medium enterprises (SMEs) related to various fields of FoF and I4.0 (e.g. IoT managers, CIO of a packaging material company, data scientists), 2 from large companies (CIO and his deputy, data scientist), 2 from technical competence/research centres (related to Industry 4.0; managers on tactical business level), 1 from an innovation agency (responsible for funds related to innovation projects) and 1 Professor/Lecturer in the field of Manufacturing/Engineering.

The organization of this section is related to the thematic blocks addressed during the interviews. Sub-section one presents the "ability in perceiving digital transformation challenges for industry companies/ability in perceiving and facing the path towards digital transformation". Sub-section two presents the "investment in digital technologies" and sub-section three presents "knowledge transfer and partnerships with industry companies".

The opening question is answered positively by all case study partners. They associate the Industry 4.0 (I4.0) paradigm and the Factory of the Future (FoF) approach predominantly with new market opportunities. From a technological perspective, they associate I4.0 and FoF with increased digitalization, big data/analytics, machine to machine, communications/artificial intelligence, augmented reality, supplier-producer-customer network/adaptive automation and Internet of Things (IoT).

4.1 Ability in perceiving digital transformation challenges for industry companies / ability in perceiving and facing the path towards digital transformation

As the interviewee of Rhine-Valley-Research[29] (RVR) highlights, SMEs are basically innovative and have always invested into efficiency increasing technologies. But today, as the interviewees highlight, SMEs are confronted with several challenges. A major issue to become a smart-service FoF is the readiness of ICT infrastructure of particular organization as well as its hardware and software. But this again is challenging, as the case of Flowers[29] and Innodev[29] highlight, because technology changes very fast. Furthermore, cyber-attacks threaten not only parts but also the fully connected resources of a smart-service FoF as a whole. A virus, for example, can cause major disruptions in the smart-service FoF leading to its complete breakdown.

As the single cases turned out, SMEs are far behind current developments and solutions. For example, while large companies already started to simulate the smart-service FoF and test promising technologies as customer service platforms, robots, augmented/virtual reality, digital twins, batch size "one", 3D printing, autonomous driving, artificial intelligence, etc., SMEs are stuck in the further development of its organizational enterprise resource planning (ERP) systems. They are highly challenged by the development of interfaces and the integration of its Manufacturing Execution Planning Systems as well as its suppliers and customers into the manufacturing processes (observed by the interviewee of InnoAgent[29] and case of PaperPack[29] (current project: EDI and GS1 integration)).

Building a smart-service FoF, as examined in the single case studies, highly depends on the organizational capability to achieve an integration of organizational Manufacturing Execution Planning Systems. These systems are connected with organizational resources (e.g. human, technology (as sensors, data processing, data storage, data visualization, etc.) and processes, which again provide ubiquitous data and information for advanced

[29] due to the provision of company secrets in this case study at hand, the case study partner names are editorially modified and anonymized

technologies. Focusing on these data and information, the interviewee of Flowers[29] but also InnoDev[29] expect that (in close future) all systems (human, technology) communicate with each other. This enables increased interaction with service system stakeholders and advanced technologies such as predictive maintenance, tracking/transparent production/manufacturing, remote control, extended software frameworks, machine learning, artificial intelligence, etc. The organizations are able to optimize the manufacturing facilities, its resource equipment and manufacturing processes.

4.2 Investment in digital technologies

According to the interviewee from PaperPack29, financial expenses are the biggest hurdle for SMEs to digital transformation. As the interviewee said: "From a technical perspective, it is definitely possible to automatize PaperPack's[29] production and manufacturing facilities, but due to financial limitation it is impossible".

As the cases show, investments into the digital transformation towards a smart-service FoF are predominantly about human and technical resources. Digital transformation is performed in internal projects and include organizational employees and external consults. But also, as the interviewee of Craddle[29] reports, SMEs start to cooperate with others and develop spin-off organizations. Flowers[29] and SpeedSped[29], both large companies maintain own department for research, development and innovation.

Investments into technological-organizational evolution towards a smart-service FoF are, for example, ERP interfaces, high speed internet solutions to increase speed and reaction times, placement systems, robotics, sensors and wireless communication interfaces – but also 3D printing (of metal products).

Considered from a human resource perspective, all case study partners invest into training and education of its employees. Efforts and activities comprise the organization of workshops, seminars, education and training events. These events are also in cooperation with higher education and training organizations. SpeedSped[29] and InnoDev[29] maintain an own college for employee training and education.

4.3 Knowledge transfer and partnerships with accelerated organizations

Although the case study partners rate their organizational digital maturity as high, emerging topics of I4.0 and FoF are continuously on their agendas. For example, PaperPack[29] – but also remaining case study partners – perform continuous meetings about the chances and challenges of these emerging trends. The discussions involve strategic and operational businesses and incorporate managing directors, managers and employees equally. PaperPack[29] additionally performs experiments that provide data and information to build up of scenarios.

As the cases show, (formal and informal) cooperation are the essence to cope the challenges and take advantage of chances and opportunities of the digital transformation towards smart-service Factories of the Future. Case study interviewees reported organizational cooperation in vertical (same or similar organizations in particular field of business, e.g. competitors) and horizontal (accelerated organizations in particular field of business, e.g. suppliers, governmental organizations, chambers, etc. but also customers) partnerships and networks. These partnerships also cover excursions into friendly organization to evaluate, for example, software implementations, features and updates of ERP systems (e.g. SAP Hana). As the case study interview of CraddleInno[29] reported, SMEs also start to organize themselves in spin-offs.

SpeedSped[29] again, is part of the umbrella organization Logistics Alliance Germany. This is a vertical network and includes transport logistic and supply chain management providers with the aim to drive and support innovation engineering in particular organization. Flowers put premium on the maintenance of its network to industry leaders and trend setters as, for example, Microsoft, IBM and SAP. CraddleInno[29] again maintain a proper customer relationship management (CRM) that allows to immediately react to customer needs and requirements.

As observed, the majority of the case study partners cooperate with universities, universities of applied sciences and research centres. Together, they perform student projects but also industry projects. Additional, SpeedSped[29], Rhine-Valley-Research[29] and InnoAgent[29] cooperate in regional, national and/or international projects funded by governments (e.g. Interreg, EU-H2020, etc.). While InnoDev[29] maintains a university for training and education of external people (they organize lectures related to the field I4.0, digital transformation, FoF, etc.), SpeedSped[29] maintains a collage for the training and education of internal employees. Among others, in this collage, employees get prepared for the emerging challenges and trends of smart-service FoF. In cooperation with the University of Liechtenstein, Rhine-Valley-Research[29] provides a certificate program for Industry 4.0 Management.

Only SpeedSped[29] and Flowers[29] maintain departments for research, development and innovation. SpeedSped[29] uses this department for internal development and innovation and to collaboratively perform external research projects with universities and research centres. However, Flowers[29] is more conservative and uses their R&D department only internally: achievements are corporate secrets and are restricted to internal use only.

5 Findings

The majority of interviewees of this case study at hand shows a positive attitude towards the digital transformation of their business activities and associates the ongoing digital transformation towards a smart-service Factory of the Future as chance to create new market opportunities and provide organizational growth and prosperity. Based on the used analytical framework (c.f. section 2), the following sub-sections present the findings and conclusion of conducted case study research.

5.1 Transformation of an operational need into a description of system performance parameters

The interviewees put major emphasis on technological fitness and readiness. They actively transform their ICT infrastructures and build up service-oriented architectures (SOA). SOA architectures aim to improve service management and to increase service orientation.

The cases highlight an essential advantage of large companies: they already transformed their physical and digital infrastructures. As the interviewee of Innodev highlight, a client developed new business models and evolved from a pure manufacturer of cable cars to an operator of cable car services. They now operate city cable cars and – basing on the operational needs – provide additional services (e.g. appropriate music during the passenger transport). They also take advantage by analyse the service client data and information. They now are able to transform operational service client needs into system performance parameters and are able to a broad range of new, service enhancing methods and technologies.

As it turned out, SMEs focus on service-related transformation and started to open their ERP systems for increased customer interaction and value co-creation mechanisms. SMEs actively expand their structures to include the customer into the manufacturing processes with the aim to increase manufacturing transparency and to get and put additional data and information into its service ecosystems. SMEs have realized that efficient and effective service provision systems are of major importance. A physical deviation accompanied with missing information can interrupt production and manufacturing processes – increased communication in these supply chain processes but also in production and manufacturing processes is key.

However, as the single case of PaperPack highlights, many current production and manufacturing processes will continue to be manual in future too. For example, the interviewee does not agree that a robot can replace the change, for example of a 10 tons paper roll at a packaging machine. For that, the robots are not sensitive enough. In addition, the investments would be too high and not affordable for SMEs. Additional, the return on investment is to less: what brings a fully automated packaging machine when the remaining ones are not converted to I4.0 principles?, as the interviewee asked during the interview.

Evolving to a smart-service Factory of the Future is project-, human- and finance based. As the cases show, in the evolution is driven by projects, with clear start and end dates, and requires appropriate human resources, investments and finance. The projects focus on a specific goal and technology that should successfully implemented within the project duration.

5.2 Integration of related technical parameters and assurance of compatibility of all physical, functional and program interfaces

Smart-servcie FoFs are about the interconnectivity of socio-technical systems – including technology, information and human resources – to enable innovative forms of manufacturing, productions and value constellations as well as to achieve holistic communication. Interconnectivity of socio-technical systems enables real-time data analysis and – in further consequence – big data analysis that again are the basis for decision making, artificial intelligence, driverless vehicles, etc. As the cases show, especially the SMEs lack behind the state-of-the-art in development of smart-service FoF. Reasons are, for example, limited resources to adapt and implement digital trends and challenges. As already highlighted, they are stuck in the design, development and implementation of ERP interfaces to increase communication and interactions.

Also, as the cases highlight, smart-service FoF are about advanced use of "Internet of Things" technologies that are, for example, sensors, data storage, data processing to realize track and tracing, predictive maintenance, etc. The case of InnoAgent – the innovation agency of the Federal State of Vorarlberg – underlines this finding. The interviewee reported, that frequently asked questions relate to Manufacturing Execution Planning Systems, automation of production and manufacturing processes, integration of suppliers and customers into these processes, innovative and efficient intra-logistics, digital twins and flexible production towards batch size "one".

5.3 Integration of reliability, maintainability, safety, survivability, human and other such factors

Smart-service FoF are about the digital integration of service clients and stakeholders into manufacturing processes. These stakeholders support providers to improve value constellations, increase service performance and service quality. In this sense, stakeholders are not only beneficiaries of services they are also its co-creators (Donofrio, Sanchez, & Spohrer, 2008). Service stakeholders are seen as essential sources for renewal, change and innovation of products and services, incl. organizational processes and activities.

The cases indicate that it is highly beneficial for SMEs to maintain pro-active networks and partnerships to discuss, share and gain information about emerging challenges and solutions. These networks have a formal, but also an informal part and range from loose contacts to strong linkages to partner organizations. Some SMEs, as the case from CraddleInno highlights, already started to establish spin-off organizations: they cooperate in vertical and horizontal value co-creation networks to work on emerging trends and hot topics in digital transformation. They outsource the risk of failure and decrease the loss of venture capital.

Active and participative employees, especially service and data scientists, become a unique/key resource of an organization. They act as interface between real and digital processes. But also "normal" employees are of importance: well-educated and trained are the back-bone of organizations. However, during the interviews, all case study partners emphasize the lack of appropriate human resources and call for "T-shaped people" (Spohrer, Piciocchi, & Bassano, 2012): people that are able to shape their knowledge and apply functional/disciplinary skills to implement the shift towards increased organizational servitization.

However, to increase sustainability factors, SMEs need to adopt and extend its organizational strategy. This includes the realignment of the vision and mission statements and goals towards the ongoing digital transformation. This also capture the realignment and adaption of organizational business models towards increased co-creation mechanisms in production and manufacturing processes.

6 Discussion, recommendations and conclusion

This article at hand presents a case study using quantitative (questionnaire) and an qualitative methods (interview, single case studies conducted with 13 heterogeneous organizations in and related to the field of manufacturing). It presents a cross-case analysis of three main themes that are "ability in perceiving digital transformation challenges", "investment into digital technologies" and "knowledge transfer and partnerships with accelerated organizations" to respond to the overall research question how "ordinary" organizations in the field of manufacturing can evolve to a smart-service Factory of the Future. As it turned out, Industry 4.0 and Factory of the Future paradigms are highly important to organizations and appears on their daily agendas. Related to I4.0 and FoF are the needs to change and adapt organizational business models, adjustment of organizational strategy and increased collaboration with customers (but also related service stakeholders).

In this research, the need to transform social and technological infrastructures towards service-oriented architectures is recognized. SOAs allow increased service orientation and management in organization. For example, shifting from proprietary to open ERP systems allows interconnections with its service clients. That again fosters increased interaction and information exchange and thus increased servitization. But also, open ERP system are a basis for the integration of data and the implementation of Internet of Things technologies, which are valuable to drive process and service innovation (e.g. predictive maintenance, supplier-customer interaction, robots, autonomous driving). However, as the case studies also show, a fully automated factory is not realistic – at least in the close future. There are processes (e.g. packaging machine) that cannot be digitalized yet and/or supported appropriately by technology.

Evolving towards a smart-service Factory of the Future relates to investments into human resources and technology. As it turned out, large companies have better initial positions: they have resource-based advantages and thus more leeway to overcome the challenges of digital transformation. SMEs have to pro-actively initiate and orchestrate organizational transformation and to integrate processes and activities. They are requested to systematically design, development and pilot of service systems (Böhmann et al., 2014) and capitalize organizational capabilities. However, all case study partners highlight the importance of well-educated and trained employees. It is a call for "T-shaped people" (Spohrer et al., 2012): people that are able to shape their knowledge and apply functional/disciplinary skills to implement the shift towards increased service, service orientation and management, service-orientated architectures and thus increased servitization.

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