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Disruptive Technologies - Integration in Existing Supply Chain Processes

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Purpose: Based on technological progress, companies innovate and design a variety of new processes to be implemented in order to gain a competitive advantage. Nevertheless, many companies face issues during the initial integration of these emerging technologies with their existing business processes. This paper will collect and analyze existing procedures to leverage process innovations by means of emerging information- and production technologies with disruptive potential.

Methodology: An exploratory research of relevant procedures for the implementation of new processes is chosen to give a systematic overview of existing models. Furthermore, requirements for the technology integration of emerging information technologies and production technologies are collected within a systematic content analysis and based on these requirements, the existing models are compared and evaluated.

Findings: None of the existing models meet the requirements of a technology-based integration of process innovations. In order to integrate particularly emerging technology based innovations into business processes, existing models must be further developed, particularly with regard to the flexibility requirements of industry 4.0 process changes.

Originality: This paper collects and compares all important models for the implementation of process innovations, based on requirements specific to the integration of emerging information- and production technologies. Blockchain technology and additive manufacturing are used as exemplary current technologies with disruptive potential.

Keywords: Process Innovations, Blockchain, Additive Manufacturing, Supply Chain

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1 Introduction

The development of emerging technologies, especially of those that have a disruptive potential, are increasingly changing existing business processes and affecting the entire supply chain of organizations. In recent years, more and more administrative processes have become obsolete and new processes based on given disruptive technologies have diffused into the processes of organizations. Many of these so called process innovations have been integrated into existing business processes without a strategic approach.

One important field to represent process innovations is the field of IT technologies, where we have process innovations like the blockchain technology that has the potential to radically change business processes. Organizations from various industries already started pilot projects to transfer the technology to their specific case of application. The blockchain, representing a ledger of data that gets distributed over several network nodes, builds a base not only for digital money transactions, but also for chaincode, the so called smart contracts, which represent the missing link for the realization of the vision of Industry 4.0 and the Internet of Things. (Xu, Weber and Staples, 2019, p. 3 ff.) Apart from IT technologies, we also have manufacturing technologies with disruptive potential. Building up on the digitalization of processes, new product manufacturing possibilities like additive manufacturing are out into place. The technology also possesses an enormous potential to affect the entire supply chain by creating the ability to save costs and pare down process steps in several stages (Moreira, Ferreira and Zimmermann, 2018, p. 262)

In this paper, the most important models for the integration of processes will be listed in order to evaluate their suitability for the integration of disruptive technologies like blockchain and additive manufacturing along the following research questions:

- What requirements can be seen for the integration of process innovations, with emphasis on new technologies?
- In which areas do existing integration models have to be adapted, in order to achieve a structured integration of new technologies?

2 Theoretical background

2.1 Innovation

Innovation, as defined by Porter, includes both technological improvements and better methods or ways of doing things. This can manifest itself in product changes, process changes, new marketing approaches, new sales forms and new concepts on scope and reach. (Porter, 2014)

In the result-oriented view, innovations are consequently understood as "technological, economic, legal and social innovations in the form of products, processes, contract forms and distribution channels". (Corsten and Gössinger, 2016, p. 6 ff.) The various innovations are differentiated in more detail by describing the subject of innovation (performance, process, market or social), the degree of innovation (incremental or radical) and the reference unit for determining the novelty characteristic (business-oriented, customer-oriented, competitive) (Schallmo and Brecht, 2017, pp. 23–24).

2.2 Process Innovations

Process innovations can be described as process improvements which include product creation process procedures and/or information distribution procedures. This type of innovation focuses on technologies that make processes more effective and consistent (Winkler and Kaluza, 2008). In combining the terms "process" and "innovation", process innovations can thus be understood as the renewal of an entire process or of individual process components (e.g. tasks and services). With regard to the degree of innovation, it should be noted that both radical and incremental further developments of processes occur. (Schallmo and Brecht, 2017, p. 25)

To build the link to disruptive technologies, blockchain technology can be seen as a radical process innovation by influencing the entire settlement of payment processes that can be secured and automatized (Holotiuk, Moormann and Pisani, 2019, p. 199 ff.). Furthermore, a process innovation can be represented by the adoption of technically new or significantly improved production methods (OECD, 2005, p. 53; Raymond and St-Pierre, 2010, p. 48). Thus, the introduction of additive manufacturing can be seen as a radical process innovation for organizations and supply chains. (Marzi, et al., 2018, p. 185).

3 Methodology

To evaluate existing models for the integration of new process, in a first step, existing models are collected within a systematic review following the approach of Fettke & Loos. After the systematic collection, the models are documented, in order to evaluate them on the basis of set criteria. (Fettke and Loos, 2004, p. 3)

In a second step, the requirements to evaluate the models are collected. Therefore we take into account requirements for the integration of innovations in general and requirements of IT- or rather production technologies for their integration in supply chain processes. Based on those requirements, the existing models are compared in regard to their suitability for the integration of disruptive technologies in existing supply chain processes.

3.1 Existing models for process management

3.1.1 Allweyer

The business-process-management-cycle of Allweyer (Figure 1) is primarily focused on IT-related processes, but can also be simultaneously applied to different fields (Allweyer, 2012, p. 89).

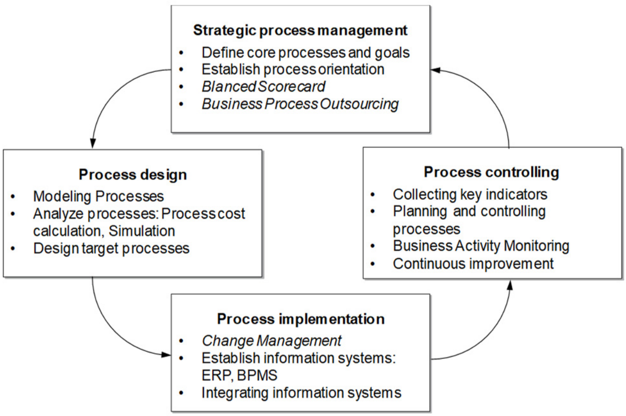

Figure 1: Business process management cycle (Allweyer, 2012, p. 91)

The first phase of the cycle, strategic process management, essentially refers to the design of the company and its relations with the environment. The next phase, "process design", has the task to identify, document and analyze the business processes of a company (Allweyer, 2012, p. 91 ff.). The third phase of the business process cycle deals with the question of how the designed business processes will be put into practice. (Allweyer, 2012, pp. 145, 314-315). The last phase, "process controlling", closes the business process management cycle. Essential tasks are the planning, monitoring and evaluation of the processes carried out during operation. (Allweyer, 2012, p. 385).

3.1.2 Brecht

Brecht's process model (Figure 2) contains five total phases, each of which is based on one another. These five phases are comprised of multiple subsections.

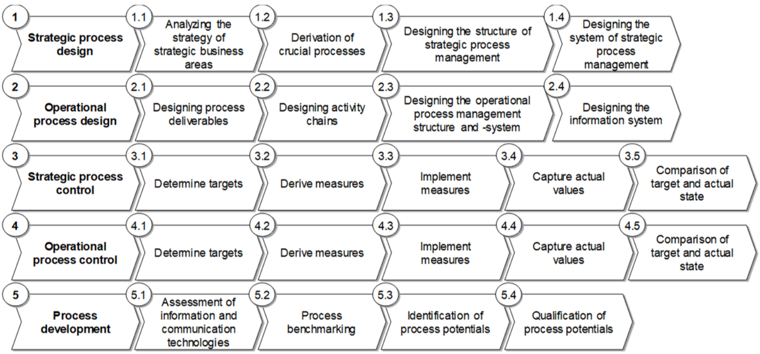

Figure 2: Procedural model by Brecht (Schallmo, Brecht and Ramosaj, 2018, p. 38)

In the first phase of strategic process design, the strategic business areas of the company are analyzed with the help of process architecture planning. In the second step, the strategic process design is refined until it is possible to collect the necessary reference variables needed to measure the new process performance. This is done so that not only will the processes of the developed process map be implemented as far as possible in the strategic process control phase, but they will also be regularly examined with regard to their output. In the phase of operational process control, the developed processes of process design are planned and implemented (Brecht, 2002, p. 207 f.). The process development phase represents the activities that evaluate the process potential gained while also initiating possible process optimizations. (Brecht, 2002, p. 202)

3.1.3 Davenport

The process model of Thomas H. Davenport can be divided into five phases, as shown in the figure below (Figure 3).

Figure 3: Procedural model by Davenport (Davenport, 1997, p. 25)

In the first phase, the processes that are to be improved or adapted must be identified. As such, all processes of the process map are examined with regard to this aspect. In the second phase the central question is where to start improving and changing processes in order to achieve the greatest possible effect. (Davenport, 1997, p. 36).

In the third phase, the goal is to determine the future characteristics of processes and then generate specific, measurable criteria for said processes. It thus links the strategic corporate goals with the operational procedures (Davenport, 1997, p. 119). Before the new process can be created, the existing process is first evaluated on the basis of the created process vision in the fourth phase. (Davenport, 1997, p. 137). The final phase, development and prototyping, elaborates the new processes and introduces them into the company. In addition, the organizational structure for the new process is determined (Davenport, 1997, p. 153).

3.1.4 Österle

The process model for the introduction of process innovations by Österle is divided into a total of eleven phases (Figure 4).

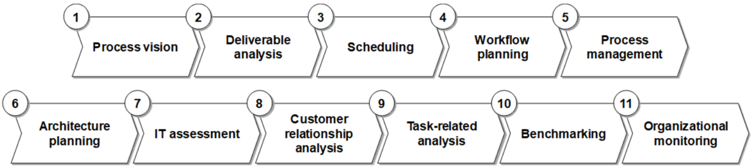

Figure 4: Procedure model by Österle (Schallmo and Brecht, 2017, p. 42)

The first phase, the creation of a process vision, aids the process design in searching for fundamentally new solutions and subsequently outlines the new process. (Österle, 1995, p. 63 ff.). A further performance analysis has the function of recording, evaluating and documenting services in detail (phase two). The next phase of the process planning aims at determining the tasks of a process and their sequence by assigning them to organizational units. (Österle, 1995, p. 85) In phases four and five, workflow management systems are presented to support the process control (Österle, 1995, pp. 100–101).

One level below, we have architecture planning as the focal point. According to the definition, this is a part of strategy development (Österle, 1995, p. 128). In phase seven, the IT Assessment focuses on the search for new potentials in the IT field. Phase eight, focuses on the analyzation of the co-operation between customer and supplier in order to increase customer benefits. Furthermore, the "task-related analysis" deals with the search for improvement potentials in the respective processes on the basis of the process characteristics or command variables. Prior to the last phase, standards are set for the process including all its components, until the procedure model finally deals with organizational monitoring (Österle, 1995, p 159ff.).

3.1.5 Schallmo & Brecht

The Schallmo and Brecht model is the most up-to-date procedural model of our selection, with respect to time. The authors often refer to the explanations of the Österle. However, in their own model, they limit themselves to a total of seven phases (as opposed to the eleven phases seen in the Österle model) as shown below (Figure 5).

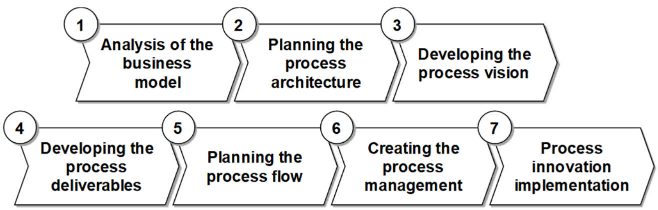

Figure 5: Procedure model by Schallmo and Brecht (Schallmo and Brecht, 2017, p. 67)

In the first phase of the "Business Model Analysis" model, the foundation is laid for future phases of the process model (Schallmo and Brecht, 2017, p. 85). The second phase of the procedural model deals with the planning of the process architecture. (Schallmo and Brecht, 2017, p. 103). The third phase of the procedural model focuses on the development of a process vision. (Schallmo and Brecht, 2017, p. 126). In the fourth phase, process services are to be developed. Important activities are the creation of a clear presentation of the process to be considered in interaction with other processes. (Schallmo and Brecht, 2017, p. 148). The fifth phase of the procedure model focuses on the creation of process flow diagrams and the necessary steps for the creation of such a flow chart (Schallmo and Brecht, 2017, p. 158). In the sixth phase of the procedure model the process control is created. (Schallmo and Brecht, 2017, p. 170). The last phase deals with techniques for the implementation of process design (Schallmo and Brecht, 2017, p. 180).

3.1.6 Becker

The procedure model according to Becker et al. is comprised of the seven phases shown below. (Figure 6)

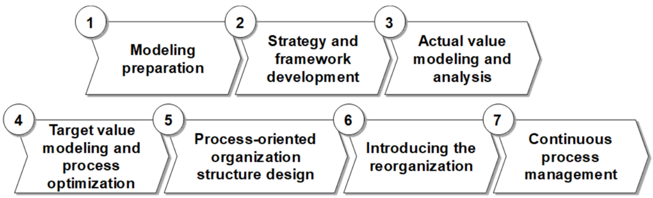

Figure 6: Procedure model by Becker et al. (Schallmo and Brecht, 2017, p. 37)

In the first phase of the procedure model all measures are taken to ensure the creation of high-quality process models (Becker, Kugeler and Rosemann, 2012, p. 51). The focus of the second phase deals with either the creation of a new process or the modification of an existing framework. (Becker, Kugeler and Rosemann, 2012, p. 113). In the third phase, the actual state of the company or process must be presented and modelled. (Becker, Kugeler and Rosemann, 2012, p. 166).

Based on the third step, the fourth phase can be used to initiate target modeling and process optimization. (Becker, Kugeler and Rosemann, 2012, p. 197). The fifth phase of the procedure model aims to efficiently optimize business processes with regard to the criteria time, quality, and costs (Becker, Kugeler and Rosemann, 2012, p. 229).

The penultimate stage deals with the implementation of the created processes in the company, while the seventh and final stage of the Becker process model deals with continuous process management (Becker, Kugeler and Rosemann, 2012, 8 ff.).

3.1.7 Schmelzer & Sesselmann

The business process model of Schmelzer und Sesselmann consists of four phases (Figure 7). A communication and training program runs parallel to phases one through four.

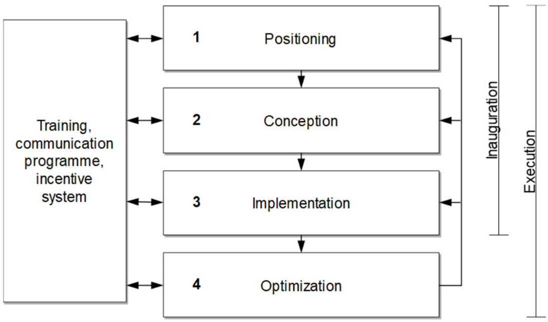

Figure 7: Procedure model by Schmelzer & Sesselmann (Schmelzer and Sesselmann, 2013, p. 545)

In the first project phase of the business process management, the initial situation is analyzed and the strategic orientation of the organization is reviewed. The focus of the conception phase is the identification and definition of business processes with their sub-processes as well as the framework decisions for the implementation phase (Schmelzer and Sesselmann, 2013, p. 551 ff.).

The third project phase essentially follows the milestones of the action plan adopted in a management workshop. These three phases all work together to reach the final project phase, which has the highest priority in the project. (Schmelzer and Sesselmann, 2013, p. 566 ff.).

3.2 Requirements of technology integration

Technology integration is a special challenge to most organizations, both in terms of activity volume and period of time. In particular the integration of innovations offers several requirements. These requirements will be summarized in the following chapters and categorized following the human-technology-organization-approach (HTO) (Karltun, et al., 2017).

3.2.1 Human-centered requirements

Motivation of the staff

As a first point to address human-centered aspects, it is imperative that the organization is able to motivate their staff to comply with the necessary technology. Following (Delany and D'Agostini, 2015, p. 10), it can be differentiated between promotion- or prevention-focused employees, that each need a different motivational approach.

Thus, the entire technological change process should be designed openly and transparently during its course. This allows employees to participate in the content of the project. (Ahsen, 2010, p. 10; Wellbrock and Göpfert, 2015, p. 285). In addition to transparency issues, knowledge management should also be taken into account for staff in innovation projects. (Hervas-Oliver, Sempere-Ripoll and Boronat-Moll, 2014, p. 882)

Strategy to adapt changes

The change process of the organization is of great importance in the context of technology integration. The corporate environment in which the integration is carried out, has to be adapted in such a way that the result of the integration can be used successfully. (Pleschak and Sabisch, 1996, pp. 128–129; Hervas-Oliver, Sempere-Ripoll and Boronat-Moll, 2014, p. 882)

Human factors play an especially important role when integrating emerging technologies into modern supply chain processes. Since employees of different supply chain partners will be affected by the integration, a clear overarching strategy needs to be developed and integrated in a flow-oriented way. (Wellbrock and Göpfert, 2015, p. 291)

3.2.2 Technology-centered requirements

Consideration of challenges and opportunities

Integration challenges and opportunities can be identified by the organization through an assessment of the existent technologies and their environment. For IT technologies this would also include business applications and supporting infrastructure. Required for a consideration in terms of challenges, it is necessary to raise one-time and time-phased costs, as well as risk related information(Nahass, Smith and Curragh, p. 4)

Technical decisions

As a further requirement category, the organization needs to take professional decisions regarding the actual technical integration. Therefore, it is necessary to consider adaptions to the current technological infrastructure and possible upgrades to be applied in order to fulfill future needs. (Delany and D'Agostini, 2015, pp. 22–25) Another aspect of interest would be the degree of autonomy that plays a particularly important role for IT technologies. Therefore, (Hasselbring, 2000, p. 35) it is a frequent requirement to have technologies that are about to be integrated, remain autonomous. (Nahass, Smith and Curragh, p. 4).

Process and product innovation

In many areas where innovations take place, they do not take place independently. Various innovations are mutually dependent. This applies in particular to the implementation of process innovations. Thus, the introduction of new process technologies, such as additive manufacturing, is a component of process innovations. (Pleschak and Sabisch, 1996, pp. 20–23). "Process and product technologies often are equal partners in innovation because process technology has to be in place to support new product innovations and without this capability new product developments will fail." (Brown, 2001, p. 467) Under this assumption it follows that a profound coordination between product and process innovation is necessary in a reciprocal relationship (Lischka, 2011, pp. 18–23).

Strategy to integrate the technology

In order to finally introduce and manage new technologies, it is important to develop a vision that is easily transferable to a technological strategy. This strategy will also strongly support the aforementioned aspect of staff involvement, because only those who know the purpose and the goal of process change will fully support the integration process (Harrison, 1990, p. 165). Furthermore, a technological edge over competitors can only happen if the supply chain is formulated with a broad production strategy and is implemented together with all its partners (Birasnav and Bienstock, 2019, pp. 143–144).

3.2.3 Organizational-centered requirements

Planning and structured approach

First and foremost for the organizational aspects, early planning activities and a clear understanding of the technology's attributes and functions are essential requirements for a successful integration. This stage is strongly connected to the organization's business model and builds the basis for several existing integration approaches to be chosen from. (Hasselbring, 2000, pp. 33–36)

To get a clear understanding of the technology, the organization should examine key attributes, considering all areas from which various requirements may possibly originate. Following Gollapudi, these ten attributes are key for an examination of the proposed technology: usability, interoperability, common business views, agility, scalability, reliability, openness, manageability, infrastructure and security (Gollapudi, Jangeti and Kotapati, 2012).

Holistic approach

Moreover, an important aspect is that the integration approach supports all aspects of the process innovation: from planning to introduction phase. A holistic approach to the integration of disruptive technologies is necessary.

Through a holistic approach and thus given transparency throughout all phases of the innovation project, necessary corporate structures that are affected by the innovation are taken into account and can be included in the transformation process (Wilfling, 2013, p. 44).

Complexity reduction

For most companies, innovation processes are unique because they cannot be structurally located in the normal organizational structure. They run parallel to most processes and usually affect several departments. As a result, projects and especially innovation projects are conspicuously complex due to their structure (Ahsen, 2010, p. 10). Finding the right measure of complexity is therefore a major challenge. An important aspect of complexity control is therefore to break down the core task and divide it into several sub-tasks. (Pleschak and Sabisch, 1996, p. 29)

Control mechanism

Control of the process is an important instrument in process management and in every management task. Controls are used to check the effectiveness of actions and ensure the quality of results. Often, the control of an activity takes place after its completion. Due to the long period of strategic processes, such as innovation processes, a final check alone is not sufficient. Further controls during the course of the project are necessary (Hungenberg, 2014, p. 369; Wellbrock and Göpfert, 2015, p. 291). So-called milestones in the course of the project are planned as control points. These can be seen as points at which sub-sections are completed. Hence, these milestone checks are necessary to determine if there is satisfactory progression within the project (Hungenberg, 2014, p. 306).

Methodological instruments

Methodological competence is particularly important in project management. Project planning and controlling instruments must be understood and applied. These competencies are a particularly important means of achieving project goals and adhering to time and resource constraints. (Hölzle, 2007, pp. 15–17). A well planned, methodological approach to problems aids in both reducing and structuring the workload (Ahsen, 2010, p. 72). The importance of sufficient planning and targeted control methods in project management can be statistically proven in most cases (Albers and Gassmann, 2011, p. 494).

Flexibility Enhancement

Another evaluation criterion is the freedom associated with a flexible innovation process design. In general, many different solutions can be applicable in this regard. However, in order to achieve the best possible solution, subject-specific decisions are necessary (Pleschak and Sabisch, 1996, p. 57). Thus, an ongoing adaptation of the project to the developing conditions is essential in order to prevent disruptions over the course of the project (Pleschak and Sabisch, 1996, p. 168). It is often a challenge to find the balance between the necessary freedom and the necessary room for maneuvering. Additionally, a sufficient structure with measurable and tangible goals helps to achieve the best possible project result.

As a final step of the chapter, the requirements can be summarized and assigned to the higher level HTO-categories, as can be seen in Figure 8.

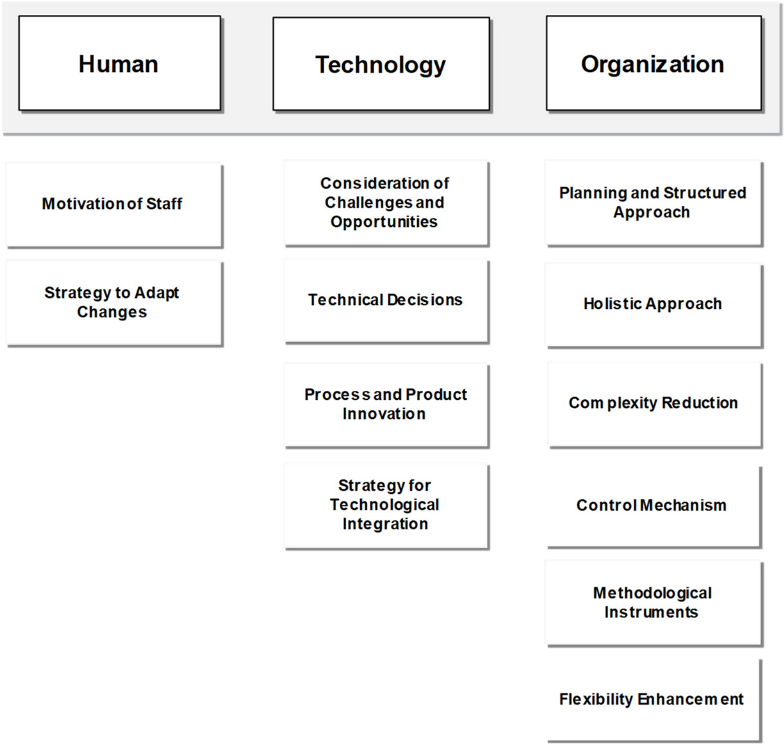

Figure 8: Summary of requirements

The integration of technological process innovations requires employees within the entire supply chain to develop a precise understanding of the technological components and their characteristics. Furthermore, it is important to pursue a clear integration strategy to consider challenges and opportunities. On the organizational side, a clear determination of existing processes and responsibilities has to be achieved. How these aspects are addressed by current models will be analyzed in the next chapter.

4 Model Evaluation

In order to examine the different models and make them comparable, the following table compares them with regard to the requirements for the integration of technologies as process innovations in corporate structures. The evaluation is based on the above-mentioned literature sources, which were also used for their brief introduction.

Three categories are used in the evaluation in order to ensure the clarity of the valuation and to obtain unambiguous evaluations without much dispersion (Ahsen, 2010, p. 49f). The three evaluation categories for the models are "fully satisfied" (+), "partially satisfied" (0) and "not satisfied" (-).

Table 1: Model Evaluation

	Allweyer, 2012	Brecht, 2002	Becker, 2012	Davenport, 1997	Österle, 1995	Schallmo, Brecht, 2017	Schmelzer, Sessel-mann, 2013
Motivation of the Staff	-	-	+	0	-	0	+
Strategy to Adapt Changes	-	0	+	-	0	0	0
Considera-tion of Challenges and Oppor-tunities	-	-	0	+	+	+	-
Technical Decisions	-	0	+	0	+	+	0
Process and Prod-uct Innova-tion	-	0	+	-	0	0	0
Strategy for Technologi-cal Integra-tion	0	-	-	-	+	+	-

	Allweyer, 2012	Brecht, 2002	Becker, 2012	Davenport, 1997	Österle, 1995	Schallmo, Brecht, 2017	Schmelzer, Sesselmann, 2013
Planning and Structured Approach	+	0	+	+	+	+	0
Holistic Approach	+	0	+	0	0	+	+
Complexity Reduction	-	-	-	-	0	0	0
Control Mechanism	+	+	0	+	+	+	+
Methodological Instruments	+	+	+	+	+	+	+
Flexibility Enhancement	0	0	-	-	0	-	0

5 Findings

The evaluation table shows that a model, holistically oriented towards technological process innovations, is not yet available.

It becomes obvious that especially aspects from the technology cluster are underrepresented in current models. Especially in terms of challenges and opportunities, as well as technological decisions to be made, organizations have to consider much more far-reaching aspects. In particular blockchain technology contrasts with traditional technologies that used to aim at the optimization on operational level. In contrast, technical decisions related to the blockchain architecture, rights and obligations of the network nodes and the related consensus algorithm affect the supply chain on a much more strategical level. (Vasilievich Babkin, et al., 2018; Queiroz, Telles and Bonilla, 2019)

Also when considering the integration of additive manufacturing, it is particularly important to formulate technical decisions precisely in advance and to select a suitable processing method on that basis. (Dwivedi, Srivastava and Srivastava, 2017, pp. 975-977) In addition to the processing method, the procurement structure of materials in the supply chain, as well as the after-sales services, the logistics and expenses are further aspects integration models would need to consider. (Lindemann, et al., 2012, p. 179) Above all, the integration challenges of additive manufacturing lie in the production process itself. It is important to note that production speed and quality cannot be compared with other processing methods. (Dwivedi, Srivastava and Srivastava, 2017, p. 975)

Another aspect that should be highlighted in the technical cluster is "product and process innovation" and "strategy for technological integration". In this context, it is necessary that processes and their assignment to specific areas of the organization are clearly determined and recognized in the integration procedure. In particular when it comes to blockchain technology, its integration has to be accompanied by a necessary restructuring and reorganization of processes. This is because the technology affects multiple different processes in the company and beyond. Its impact hence, has the ability to automatize and change payment-, procurement- and data sharing processes radically. The involvement of supply chain partners therefore, plays a significant role for integration models that still lack a systematic concept in this context. (Toma et. al, 2019, pp. 288-299; Kamble, Gunasekaran and Arha, 2019)

Additive manufacturing has an impact on both product and process innovations like the spare parts management of after-sales services. This relationship becomes particularly visible in the design process where the new manufacturing process and its design liberties but also limits have to be established. (Dwivedi, Srivastava and Srivastava, 2017, p. 976)

Further organizational aspects that are noticeable in the evaluation of the models, are the lack in complexity reduction mechanisms and flexibility. However, the development of new and disruptive technologies makes it necessary to bring the more complex and interconnected change processes into manageable modules capable of processing. Innovations also lead to new requirements for the flexibility of change processes. A simultaneous change and adaptation process should be implemented into newly developed models. Flexibility is particularly necessary in the area of blockchain and additive manufacturing, because the technologies not only offer the possibility to use one specific application, but offers multiple application fields and possibilities throughout the entire product life cycle. It is therefore particularly important to not only remain on one path of change, but also to include changes in related fields and use scaling effects. (Lindemann, et al., 2012, pp. 177-180)

The involvement of employees and their needs, as the last cluster, already works very well for the most models. Above all, the Sesselmann & Schmelzer model best represents the integration of the employee into the change process with a continuous communication and information module. Also a practical control mechanism is available in most of the models. Only in this way investments can be tracked and justified, in order to strengthen management support for further process innovation activities.

6 Conclusion

To return to the initial research questions, chapter 5 already presented requirements that are relevant for the integration of technological process innovations. Through the exemplary investigation of blockchain technology and additive manufacturing, also special requirements for IT- and production technologies were highlighted.

To answer the second research question on how models for the integration of technological process innovations have to be adapted, it can be stated that the systematic review focused generic models for process integration, which did reflect some, but not all the requirements needed for the integration of technological process innovations. Further steps in conducting research therefore should include the development of a technology-centered model for the integration of technological process innovations. Following the principle of flexibility, the model should have possibilities to revise a transformation path and offer different modules for different types of innovations, as in our example IT- or production related technologies.

Above all, the evaluation also showed that the aspect of network integration is not yet considered in most models. However, the increasingly interconnected cooperation of companies in different value-added stages along the supply chain makes it necessary to integrate new technologies across companies.

In particular, considering the integration of blockchain technology, it has become clear that existing models do not currently meet the necessary requirements needed in the overall integration planning. In particular, the far reaching strategical consequences for the organization have to be addressed correctly, while existing models still aim at technologies that can be controlled on an operational level. Moreover, the increased technical complexity leads to a greater importance of initial technical decisions to be made, like the blockchain architecture type, the consensus algorithm and scalability approaches. Apart from that perspective, institutional and legal norms also emerge as highly applicable integration problems and do not find enough recognition in existing models. Likewise, we a have similar outcome for the integration of additive manufacturing. Here, it should be particularly important to consider both product and process innovations. This is because an appropriate utilization of 3D printers can usually only occur if the design liberties are taken into account.

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References

Ahsen, A., 2010. Bewertung von Innovationen im Mittelstand. [e-book]. Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg. <http://gbv.eblib.com/patron/FullRecord.aspx?p=510417>.

Albers, S. and Gassmann, O., eds., 2011. Handbuch Technologie- und Innovationsmanagement. 2nd ed. Wiesbaden: Gabler.

Allweyer, T., 2012. Geschäftsprozessmanagement. Strategie, Entwurf, Implementierung, Controlling. 5th ed. Herdecke, Bochum: W3L-Verl.

Becker, J., Kugeler, M. and Rosemann, M., eds., 2012. Prozessmanagement. Ein Leitfaden zur prozessorientierten Organisationsgestaltung. Berlin, Heidelberg: Springer Gabler.

Birasnav, M. and Bienstock, J., 2019. Supply chain integration, advanced manufacturing technology, and strategic leadership: An empirical study. Computers & Industrial Engineering, [e-journal] 130, pp. 142–157. http://dx.doi.org/10.1016/j.cie.2019.01.021.

Brecht, L., 2002. Process leadership. Methode des informationssystemgestützten Prozessmanagement. Zugl.: St. Gallen, Univ., Habil.-Schr., 2000. Hamburg: Kovač.

Brown, S., 2001. Managing process technology — further empirical evidence from manufacturing plants. Technovation, [e-journal] 21(8), pp. 467–478. http://dx.doi.org/10.1016/S0166-4972(00)00074-2.

Corsten, H. and Gössinger, R., 2016. Produktionswirtschaft. Einführung in das industrielle Produktionsmanagement. 14th ed. [e-book]. Berlin, Boston: De Gruyter Oldenbourg. <http://www.degruyter.com/search?f_0=isbnissn&q_0=9783110452778&searchTitles=true>.

Davenport, T. H., 1997. Process innovation. Reengineering work through information technology. Boston, Mass.: Harvard Business School Press.

Delany, R. and D'Agostini, R., 2015. The Challenges of Integrating New Technology into an Organization. La Salle.

Dwivedi, Gourav; Srivastava, Samir K.; Srivastava, Rajiv K. (2017): Analysis of barriers to implement additive manufacturing technology in the Indian automotive sector. In: Int Jnl Phys Dist & Log Manage 47 (10), S. 972–991. DOI: 10.1108/IJPDLM-07-2017-0222.

Fettke, P. and Loos, P., 2004. Systematische Erhebung von Referenzmodellen - Ergebnisse der Voruntersuchung. Working Paper of the Research Group Information Systems & Management. Mainz.

Gollapudi, K., Jangeti, S. K. and Kotapati, A. R., 2012. ANALYSIS OF USING A BUSINESS INTELLIGENCE TOOL (COGNOS) IN A COMPANY TO RESULT IN MORE EFFICIENT AND INTUITIVE COMPANY IN THE CURRENT ERA. Business Intelligence Journal, 5(2), pp. 405–409.

Harrison, M., 1990. Advanced manufacturing technology management. London: Pitman.

Hasselbring, Wilhelm (2000): Information System Integration // Information system integration. In: Commun. ACM June 2000/Vol.43, No. 6 // 43 (6), S. 33–38. DOI: 10.1145/336460.336472.

Hauschildt, J., 2016. Innovationsmanagement. 6th ed. [e-book]. München: Franz Vahlen. <https://ebookcentral.proquest.com/lib/gbv/detail.action?docID=4688806>.

Hervas-Oliver, J.-L., Sempere-Ripoll, F. and Boronat-Moll, C., 2014. Process innovation strategy in SMEs, organizational innovation and performance: a misleading debate? Small Business Economics, [e-journal] 43(4), pp. 873–886. http://dx.doi.org/10.1007/s11187-014-9567-3.

Holotiuk, F., Moormann, J. and Pisani, F., 2019. Blockchain in the Payments Industry: Developing a Discussion Agenda Based on Pain Points and Opportunities. In: H. Treiblmaier, and R. Beck, eds. 2019. Business Transformation through Blockchain. Volume I. Cham: Springer International Publishing; Imprint: Palgrave Macmillan, pp. 197–231.

Hölzle, P., 2007. Projekt-Management. Kompetent führen, Erfolge präsentieren. 2nd ed. [e-book]. München: Rudolf Haufe Verlag GmbH & Co. KG. <https://www.wiso-net.de/document/HAUF,AHAU,VHAU__9783448075021191>.

Hungenberg, H., 2014. Strategisches Management in Unternehmen. Ziele - Prozesse - Verfahren. 8th ed. [e-book]. Wiesbaden: Springer Gabler. <http://dx.doi.org/10.1007/978-3-658-06681-9>.

Kamble, Sachin; Gunasekaran, Angappa; Arha, Himanshu (2019): Understanding the Blockchain technology adoption in supply chains-Indian context. In: International Journal of Production Research 57 (7), S. 2009–2033. DOI: 10.1080/00207543.2018.1518610.

Karltun, Anette; Karltun, Johan; Berglund, Martina; Eklund, Jörgen (2017): HTO - A complementary ergonomics approach. In: Applied ergonomics 59 (Pt A), S. 182–190. DOI: 10.1016/j.apergo.2016.08.024.

Kianian, Babak; Tavassoli, Sam; Larsson, Tobias C. (2015): The Role of Additive Manufacturing Technology in Job Creation: An Exploratory Case Study of Suppliers of Additive Manufacturing in Sweden. In: Procedia CIRP 26, S. 93–98. DOI: 10.1016/j.procir.2014.07.109.

Lindemann, Christian; Jahnke, Ulrich; Habdank, Mattthias; Koch, Rainer (2012): Analyzing Product Lifecycle Costs for a Better Understanding of Cost Drivers in Additive Manufacturing. In: Conference: Solid Freeform Fabrication Symposium - An Additive Manufacturing ConferenceAt: Austin, TX, USA 23, S. 177–188. Online verfügbar unter https://sffsymposium.engr.utexas.edu/Manuscripts/2012/2012-12-Lindemann.pdf.

Lischka, J.-M., 2011. Management von Prozessinnovationen. Ein empirisch gestütztes Erfolgsfaktorenmodell. Zugl.: Berlin, Techn. Univ., Diss., 2010. [e-book]. Wiesbaden: Gabler Verlag / Springer Fachmedien Wiesbaden GmbH Wiesbaden. <http://dx.doi.org/10.1007/978-3-8349-6207-2>.

Marzi, G., Zollo, L., Boccardi, A. and Ciappei, C., 2018. Additive Manufacturing in SMEs: Empirical Evidences from Italy. International Journal of Innovation and Technology Management, [e-journal] 15(01), p. 1850007–1850007. http://dx.doi.org/10.1142/S0219877018500074.

Moreira, A. C., Ferreira, L. M. D. F. and Zimmermann, R. A., 2018. Innovation and Supply Chain Management. Cham: Springer International Publishing.

Nahass, G., Smith, J. and Curragh, M. Information Technology Integration. Putting IT to work in driving deal success. In: PwC's Deals M&A Integration practice.

Organisation for Economic Co-operation and Development and Statistical Office of the European Communities, Luxembourg, 2005. Oslo Manual. Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition. [online]. Paris. Available at: <http://dx.doi.org/10.1787/9789264013100-en>.

Österle, H., 1995. Business Engineering Prozeß- und Systementwicklung. Band 1: Entwurfstechniken. [e-book]. Berlin, Heidelberg, s.l.: Springer Berlin Heidelberg. <http://dx.doi.org/10.1007/978-3-662-06188-6>.

Pleschak, F. and Sabisch, H., 1996. Innovationsmanagement. Stuttgart: Schäffer-Poeschel.

Porter, M. E., 2014. Wettbewerbsvorteile. Spitzenleistungen erreichen und behaupten. 8th ed. [e-book]. Frankfurt, New York: Campus. <http://www.content-select.com/index.php?id=bib_view&ean=9783593423289>.

Queiroz, Maciel M.; Telles, Renato; Bonilla, Silvia H. (2019): Blockchain and supply chain management integration: a systematic review of the literature. In: Supp Chain Mnagmnt 12 (1), S. 671. DOI: 10.1108/SCM-03-2018-0143.

Raymond, L. and St-Pierre, J., 2010. R&D as a determinant of innovation in manufacturing SMEs: An attempt at empirical clarification. Technovation, [e-journal] 30(1), pp. 48–56. http://dx.doi.org/10.1016/j.technovation.2009.05.005.

Schallmo, D. and Brecht, L., 2017. Prozessinnovation erfolgreich anwenden. Grundlagen und methodisches Vorgehen: Ein Management- und Lehrbuch mit Aufgaben und Fragen. 2nd ed. [e-book]. Berlin, Heidelberg: Springer Gabler. <http://dx.doi.org/10.1007/978-3-662-54504-1>.

Schallmo, D. R. A., Brecht, L. and Ramosaj, B., 2018. Process Innovation: Enabling Change by Technology. Basic Principles and Methodology: A Management Manual and Textbook with Exercises and Review Questions. [e-book]. Berlin, Heidelberg: Springer Berlin Heidelberg. <http://dx.doi.org/10.1007/978-3-662-56555-1>.

Schmelzer, H. J. and Sesselmann, W., 2013. Geschäftsprozessmanagement in der Praxis. Kunden zufriedenstellen, Produktivität steigern, Wert erhöhen: [das Standardwerk. 8th ed. München: Hanser.

Sealy, W., 2012. Additive manufacturing as a disruptive Technology: How to avoid the pitfall. American Journal of Engineering and Technology Research, 12(1), pp. 86–93.

Vasilievich Babkin, Aleksandr; Dmitrievna Burkaltseva, Diana; Viktorovich Betskov, Aleksandr; Shapievich Kilyaskhanov, Hizri; Sergeevich Tyulin, Andrey; Vladimirovna Kurianova, Irina (2018): Automation Digitalization Blockchain: Trends and Implementation Problems. In: IJET 7 (3.14), S. 254. DOI: 10.14419/ijet.v7i3.14.16903.

Wellbrock, W. and Göpfert, I., 2015. Innovative Supply-Chain-Management-Konzepte. Branchenübergreifende Bedarfsanalyse sowie Konzipierung eines Entwicklungsprozessmodells. [e-book]. Wiesbaden: Springer Gabler. <http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&AN=969012>.

Wilfling, S., 2013. Management organisationaler Anpassungsprozesse. Transformationsvorhaben durch geeignete Informationsbasis erfolgreich planen und umsetzen. Zugl.: Hagen, FernUniv., Diss., 2011 u.d.T.: Wilfling, Sabine: Entwicklung eines Informationsmodells zur Gestaltung organisationaler Anpassungsfähigkeit. [e-book]. Wiesbaden: Springer. <http://dx.doi.org/10.1007/978-3-658-00676-1>.

Winkler, H. and Kaluza, B., 2008. Einsatz einer Wertschöpfungsrechnung zur Erfassung und Bewertung von Produkt- und Prozessinnovationen in Wertschöpfungsnetzwerken. In: D. Specht, ed. 2008. Produkt- und Prozessinnovationen in Wertschöpfungsketten. Wiesbaden: Gabler, pp. 1–31.

Xu, W., Weber, I. and Staples, M., 2019. Architecture for block chain applications. Cham, Switzerland: Springer.