

Analysis of Adoption Processes in Industry 4.0

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Abstract. Nowadays digitalization is changing manufacturing and work in many companies. A keyword for the linkage between production systems and information and communication technology is the term Industry 4.0. Industry 4.0 affects the whole working environment and requires a cultural change of the organization. Currently many technological solutions are available because much research from an engineering perspective has already driven this topic. However, firms still struggle to implement this vision into their strategy. Companies need to know how to design and execute human centered decision processes. Thus, it is important to understand adoption processes to identify needs for action and prevent failures. Socio-technical perspectives are necessary to consider technological, human and organizational aspects. This position paper has the aim to show the need for research in this topic and present a research plan to solve this problem.

Keywords: Industry 4.0, Adoption Processes, Qualitative Research, Implementation Strategies

1 Motivation

Increasing digitalization affects industry and industrial processes. A new keyword conquers the field of the working world: The so called “future project” Industry 4.0 was launched by the German Federal Ministry of Education and Research in 2011 [1]. The basic idea of Industry 4.0 is often described as the linkage between production systems and information and communication technology [1]. The topic is also gaining more and more international interest. The idea of the digitalization of production industry has also come up in many other countries under different names. For example, in North America this idea is named Industrial Internet by General Electric [2] or in Japan it is called the “Industrial Value Chain Initiative” [3]. For this paper the term Industry 4.0 is used as a representative of the digital transformation in the manufacturing industry.

Many disciplines have to deal with this topic. Cooperation between electrical engineering, business administration, computer science, business and information systems engineering [4] is necessary. Until now, Industry 4.0 is still a very technology-driven topic [5]. A great amount of research is so far published mainly in the field of engineering. This leads to a push of the technologies whereas results regarding the socio-

technical perspective are rare. However, in order to execute the necessary change, people are the key factor to make Industry 4.0 a success [6]. Although the degree of automation is expected to increase, human work will not be eliminated but rather working models will change [7]. A higher interaction with machines and software is expected [8]. Therefore, it is crucial to carry out research from a socio-technical perspective to deduce solutions for a successful implementation of Industry 4.0. It is of great importance to understand the overall implications of digital technologies and to gain insights on successful realizations. Thereby the relation between technological, organizational and human components of the entire system in production needs to be considered [7].

The rapid development of the digital transformation in manufacturing companies leads to problems regarding the realization. The development, diffusion and implementation of new technologies in Industry 4.0 face many difficulties [5]. At the current stage of Industry 4.0 firms still struggle to implement existing technologies. It is difficult to identify and implement appropriate Industry 4.0 scenarios [9]. New possibilities for the production process, like the communication between machines, IT and people by using the Industrial Internet of Things or the connection of the virtual and the real world by cyber-physical systems, remain a wasted opportunity [6]. Decision-makers are overstrained by the rapid development. Research is missing recommendations for implementation processes because little is known about key drivers behind adoption processes. It is important to understand why firms push the topic of digitalization and why they adopt or why they reject the implementation of the specific technologies. Manufacturers need to know the adoption factors to design and develop suitable offers while users of these technologies need to understand important factors of adoption for their decision process. Incentives for the implementation and possible benefits for firms need to be clarified. Furthermore, it is important to analyze adoption processes at the individual level in order to understand the acceptance as well as the resistance of the involved humans. Both adoption levels, the organizational and the individual, are crucial for the success of Industry 4.0. The levels need to be analyzed and the interaction of both levels determined.

The aim of this position paper is to identify research questions describing the adoption processes of Industry 4.0. Moreover, ideas for prospective research are shown. In the next chapter the keyword Industry 4.0 is introduced and defined. Afterwards, a research plan is developed and finally an outlook is given.

2 Industry 4.0

Digitalization as well as Industry 4.0 in practice are more a vision than a clear action plan for enterprises. Nevertheless, three dimensions of the realization of Industry 4.0 are generally accepted: horizontal integration via value-added networks, vertical integration by automation hierarchy and end-to-end engineering across the entire value chain [10]. "Industrie 4.0 enables continuous resource productivity and efficiency gains to be delivered across the entire value network." [8]

Industry 4.0 is always attended by a change of common production and service processes as well as a merger of production and services. Though, the combination of production and service is regarded as an important advantage for whole economies [11]. The new digitalized way of production and service will lead to a different handling of machines [12]. So called intelligent technological systems enable the innovation that comes along with Industry 4.0. An intelligent technological system provides four different units: the basic system, sensor system, actuating elements and data processing [13]. The latter can be regarded as the central innovation. It enhances the interplay of the elements and makes technological systems “intelligent”. Furthermore, data processing allows the step from the embedded to the cyber physical systems [27], [28] which is closely related to RFID technologies [16]. This means they are able to communicate via global data networks such as the internet of things [27], [28] and the internet of data and services. The combination of these intelligent communication technological systems (such as cyber physical systems) and the digitalization of services via cloud computing as well as the ability to handle big data are the main technical drivers of Industry 4.0.

The implementation can affect almost all fields in a company. Changes of individual workplaces are expected [7]. This means, Industry 4.0 does not only represent a technological change. The focus of Industry 4.0 was formulated in 17 theses from a research committee engaged by the German government. Thesis number two states that Industry 4.0 is defined as a socio-technical system [17]. A cultural change of the organization is necessary to make it a success [18]. People need to get involved in decisions and in the execution of Industry 4.0. Thus, technological advancements in this field have a powerful effect on the whole organization with its employees and need to be considered for a company’s strategy. This leads to structural changes in the operative design of work systems [19]. Humans, technology and organization need to be analyzed in an overall context to be able to design new work systems [20].

To sum up, for this research Industry 4.0 is defined as *a vision that is based on present and future technologies that will totally change the way of value generating processes in enterprises. The use of internet technologies which enables machines to communicate with each other and to adapt their processes self-contained is a key characteristic of Industry 4.0. This vision impacts the whole organization in terms of technologies, processes and humans.*

3 Research Plan

As Industry 4.0 can bring enormous change to companies and rearrange processes and workplaces there is a need to investigate the factors that impact adoption processes. Impacts on organizational performance and on the individual level need to be investigated. Companies are not yet able to see the efficiency they could gain from Industry 4.0 and are missing possible scenarios and recommendations for the realization [10]. Overall, the working environment in industrial companies will change radically. Implementation strategies and realization possibilities besides the technological innovations are needed. These considerations lead to the main research questions:

*RQs: How is Industry 4.0 implemented? How can adoption processes be described?
What changes are necessary on the organizational and on the individual level?*

To explore the defined question, appropriate methodologies have to be consulted. Due to the weak empirical basis in the field a qualitative approach seems to be appropriate. In order to explore new constructs, semi-structured interviews will be used to collect data. A guideline will be developed to support the conversations [21]. To gain valuable insights from different perspectives experts with experience in Industry 4.0 projects should be consulted. These experts have to be carefully identified. First of all, companies which are working on the digital transformation of their manufacturing processes need to be found. In the companies it is important to talk to people working in different hierarchies. The goal is to receive the best possible overview of the current status and of future plans. Besides, an understanding of changes at individual workplaces is important. Barriers and challenges need to be identified. Thus, managers as well as workers will be interviewed. As soon as data are at hand, the interviews will be transcribed and encoded. A grounded theory approach will allow structuring the analysis of the data. Glaser and Strauss developed this inductive methodology to systematically generate theories from research [22]. Hence, the approach is very useful for fields which are not well explored yet. It can be used for analyzing text material, such as interviews, though it is not limited to qualitative research methods [23]. The overall aim of this research is the development of theories from the empirical material. The text material will be analyzed with an open coding procedure which means that the researchers are not influenced by other theories. Results can be compared to existing theories after finishing the coding process [22]. The planned research process is shown in Figure 1. Firstly, a small amount of interviews will be conducted. After transcribing the data, a team of researchers will use the open coding method to identify core variables which describe the central variables of a possible new theory. As a next step further experts might provide additional variables until saturation is reached. Last but not least a coding scheme is derived from the material which allows selective coding of all interviews. Relationships between the variables will be identified during the process. As a result a theory is developed which needs to be tested in further steps.

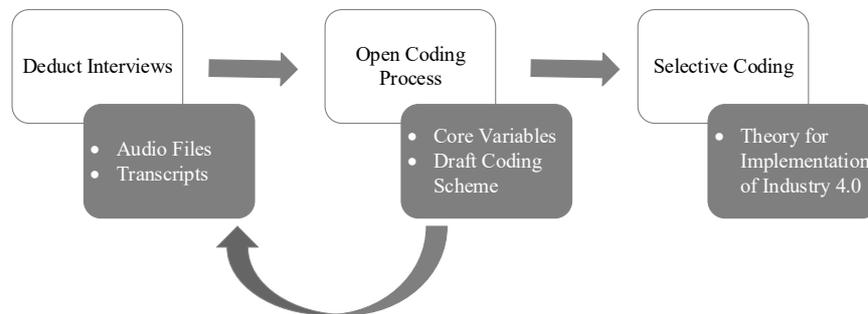


Fig. 1. Research Approach

To start with, processes which are changing due to Industry 4.0 need to be identified. An intermediate goal is to disassemble these processes on various levels. The levels derived during the analysis of the interviews will be compared with popular adoption approaches from research such as the TOE framework by Tornatzky and Fleischer which considers the levels Technology, Organization and Environment [24]. By means of identified levels, specific implementation strategies will be developed. Barriers and challenges of Industry 4.0 will be detected by the presented analysis. Further research steps need to be formulated.

4 Outlook and Implications

A few interviews were already conducted. Uncertainties with many keywords used in the context of digitalization in manufacturing firms became apparent. One interviewee from the middle management put forward that: "For us Industry 4.0, as I see it, is primarily an important and modern keyword while we still fight for a clear focus of what this actually means for us." The statement also shows that at the moment people perceive the topic as totally firm specific. Another system administrator from a different company of a different branch states it as follows: "Industry 4.0 is a keyword announced at the Hannover Fair and by the end of the day many opinions exist regarding what it could be and what it should be." These first insights show that there is a need for research from a business perspective to further clarify upon opportunities of digitalization. Implementation strategies have to be identified. The challenge is to support the realization of digital transformation topics. Without standardized processes and methods for implementation the potential of Industry 4.0 is going to be lost.

To sum up, the idea of the research plan is to identify the current status of Industry 4.0 implementations and to explore the involved adoption processes in companies. Furthermore, recommendations can be provided to plan and design this vision. The findings from the presented research can support developing Industry 4.0 solutions. After predominantly gaining results from engineering disciplines, it is important to drive socio-technical perspectives on Industry 4.0 that allow to integrate human, social and organizational factors in system design. This results in a higher acceptance of technologies. Baxter and Sommerville argue that there is a need to design more concrete socio-technical system engineering approaches [25]. The execution of the research plan has the goal to identify specific approaches for Industry 4.0 implementations.

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