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The Industrial Internet of Things from a Management Perspective: A Systematic Review of Current Literature

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Abstract
The Industrial Internet of Things (IIoT) refers to a novel manufacturing paradigm. In its core, it enables real-time, smart, horizontal, and vertical connection of machines, objects, and people resulting in a smart factory. To date, the IIoT has primarily been researched from a technical perspective, while economic research is still in its infancy. In order to promote scientific discussion from a management perspective, this paper aims at systematically analyzing and displaying the current state of economic IIoT research. Thus, research gaps can be identified and targeted future management research can be supported. A systematic literature review is chosen as research method since it is appropriate for the identification, evaluation, synthesis and discussion of existing academic works. A structured selection process with regard to high quality and subject relevance revealed 52 publications published between 2011 and 2016 to be further analyzed in detail. This examination identified four topics discussed in current management literature. Most of the identified articles address IIoT Ecosystem aspects. This includes IIoT-related strategic implications in terms of business partners and other stakeholders, e.g., non-governmental organizations. The topic IIoT Business Models deals with IIoT-triggered effects on established business models to ensure future viability as well as with novel, innovative business concepts. Literature focusing on IIoT Technology Adoption addresses strategic recommendations in terms of both manufacturing transition and adoption requirements. Lastly, IIoT Qualification articles dwell on implications of increasingly digitized work environments for appropriate job designs and qualification requirements. By providing a comprehensive and clearly displayed current state of research as well as showing respective research gaps, the findings are highly relevant for future economic IIoT research. Moreover, this article supports managerial practitioners in understanding the IIoT and its inevitable effects on industrial companies by presenting insights into strategic management in the era of digitized and connected industrial value creation and capture.

Keywords: Industrial Internet of Things, Industry 4.0, Industrial Value Creation, Industrial Manufacturing, Literature Review.

JEL classification: L00, L60, M15, O32

1. Introduction

The Industrial Internet of Things (IIoT) represents a novel paradigm of industrial value creation. At its core, the IIoT, which refers to 'Industry 4.0' in the German-speaking world, enables the real-time capable, intelligent, horizontal, and vertical connection of people, machines, and objects by employing cyber-physical systems (CPS) and the internet (Bauer et al., 2014). The equipment of machines and products with embedded systems like actuators, sensors, and microcomputers provides them with intelligence, resulting in a so-called smart factory. This autonomous factory enables a flexible and efficient execution of production and results in increased resource efficiency (Rehage et al., 2013), higher degrees of customization (Kagermann et al., 2013), highly profitable business models (Bauernhansl, 2014), and job designs suitable for future employee requirements (Hirsch-Kreinsen and Weyer, 2014; Spath et al., 2013). This new production approach aims at addressing arising challenges that manufacturing enterprises have to deal with. Among others, those companies have to face shortened technology and innovation cycles, the necessity of bringing highly customized products in accordance with the cost of a large-scale production, and intensified competition originating in Asia, in particular (Bauer et al., 2014; Bauernhansl, 2014; Dais, 2014).

The full exploitation of these IIoT-inherent benefits requires not only a targeted adjustment of associated operative processes with regard to economic optimization. To a greater degree, strategic implications related to the implementation of the IIoT have to be considered to ensure a reasonable and targeted IIoT application (da Rosa Cardoso et al., 2012). Due to its technical core, current scientific literature primarily concentrates on technological bases, challenges, and opportunities. Contrary, management research, particular with regard to strategic implications, is still in its infancy and has a lot of catching-up to do (Brettel et al., 2014; Emmrich et al., 2015; Krückhans and Meier, 2013). Hence, the present article aims at fostering scientific discussion regarding IIoT from a strategic management perspective by revealing the current state of research as well as identifying areas to be addressed by future research efforts. By doing so, the following research questions are pursued:

RQ1: Which research areas have been addressed by strategic management literature regarding the IIoT so far?

RQ2: Which research areas can be proposed for future management research in the context of the IIoT?

To answer these questions, a systematic review of relevant literature is applied. The next section presents the theoretical foundations of the IIoT before the proceeding of the systematic literature review is explained. The subsequent section elaborates on identified research areas in the context of the IIoT from a strategic perspective. Next, the current body of literature is discussed before, finally, future research areas to be approached are revealed.

2. Theoretical foundations: Industrial Internet of Things

Since the official introduction of the German equivalent of the term IIoT, i.e., 'Industry 4.0', in 2011, an increasing amount of research has been published in the recent years. Nevertheless, academic discussion still did not agree on one definition of the term 'Industrial Internet of Things' (Hermann et al., 2015). This indeterminacy is reasoned by the fact that the IIoT comprises various technical development steps, which are well-known. However, in combination and connected via networks like the internet, allowing for interactions, they have the potential to create significant innovations (Bienzeisler et al., 2014; Hermann et al., 2015). This results in different definitions of IIoT, depending on the respective author's focus and perspective.

According to Spath et al. (2013), a smart and self-controlling production environment is the key element of the IIoT. The upgrading of objects and systems to CPS is the crucial technology that facilitates the autonomous steering of objects through the value chain. In the core, this definition is congruent with those of the BMBF (2014) and Windelband (2014), who argue for CPS as the key enabler of a smart, self-controlling production as well. Emmrich et al. (2015) expand CPS as an elementary technology by embedded systems, cloud computing, and the smart factory. Furthermore, they regard the development of software services as a key element of the IIoT. Bienzeisler et al. (2014) are in line with these definitions by arguing that upgrading machines and products to intelligent objects is the core of the IIoT. According to them, manufacturing orders guide themselves through the production by considering real-time information about employees' capacities and competencies. Beyond that, they also see potential for novel business models based on smart products, particularly with regard to new service offerings. This is quite similar to Kaufmann's (2015) definition, who emphasizes, besides an autonomous and self-controlling production, the importance of real-time feedback of information provided by downstream processes for real-time process improvements. Based on the strong linkage of smart products and novel service offerings, service plays a crucial role for the IIoT (Kaufmann, 2015). In line with the already stated definitions, Feld et al. (2013)

describe the IIoT as the opportunity for companies to create new technologies and services. In addition, they separate the IIoT into the two key parts 'smart products' and 'smart production'. Contrary to the previous definitions, Sendler (2013) puts software in the center of his definition. He argues that the application of software in the production, products, and services as well as their interconnectedness is the core of the IIoT. In accordance with the above-mentioned definitions, he also recognizes the high potential for new products and services. Bauer et al. (2014) have a broader view on the topic and identify horizontal and vertical value chain connections, which are both characterized by real-time capability and intelligence. This is not limited to just objects, but also includes human beings and entire information and communication systems. This is supported by Bischoff et al. (2015), who view the IIoT as a further development of production and value creation systems by linking the real world to the digital world. Kempermann and Lichtblau (2014) are going even further and define the IIoT as the opportunity for all participants in the value-adding process to communicate in real-time using web technologies in order to achieve an autonomous and intelligent value chain.
In conclusion, these definitions comprise three essential topics: The first group of authors is focused on causal technologies like CPS, smart factory, and cloud computing. The second group of authors expands this approach by the creation of novel services. The third group of authors includes the entire value chain and the potential of vertical and horizontal interconnection and integration. For the further proceeding of this study, the various existing definitions are combined in the following definition:
The IIoT refers to the progressing digitization and smart connection of industrial manufacturing including all company functions, across all products and services, by integrating the entire value chain, resulting in novel business models, and by means of new digital technologies.

3. Methodology

A systematic and integrative literature review serves as an appropriate methodological approach for the achievement of this article's objectives for two reasons. Firstly, it is systematic, scientific, transparent, elaborate, and replicable for the identification, evaluation, synthesis, and discussion of existing works (Fink, 2013; Tranfield et al., 2003). Secondly, the exemplary collocation of several studies serves not only the presentation of the state-of-knowledge, but also the disclosure of critical and disregarded aspects or unsolved problems enabling the derivation of needs for further research (Fink, 2013). The methodological approach used in this article follows the works of Hohenstein et al. (2014), Rashman et al. (2009), Soni and Kodali (2011), and Winter and Knemeyer (2013).
For the review and evaluation process, literature published between 2011, i.e., the first time the German term 'Industry 4.0' emerged, and 2016 was considered. Keywords to be searched in the databases Business Source Complete (EBSCO), ScienceDirect, ABI/Inform, and Google Scholar were derived from existing literature and enriched by the results of discussions with independent research colleagues. Eventually, the search queries comprised a combination of several keywords describing the IIoT as well as topical related terms, e.g., connected, smart, factory, manufacturing, industry, industry 4.0, and industrial internet of things. These were extended by their respective German synonyms since the IIoT was first defined in Germany. The single search terms were linked by "AND" and "OR", which is recommended by Theisen (2013).
Regarding journals to be considered in a literature review, there is wide consensus that the integration of frequently cited papers results in an enhanced quality of a literature review (e.g., McKinnon, 2013). Nevertheless, Cooper (1989, p. 58) argues that relying on only journal articles is appropriate "when the published research contains several dozen, or in some cases

several hundred, relevant works". As this is not applicable to the term IIoT due to its degree of novelty in research, reliable and relevant collected editions, book chapters, and other studies extended journal articles.

The database research and scan of the results' titles initially identified 186 articles, which contained at least one of the keyword combinations in the title or abstract, were published between 2011 and 2016, and were relevant for the purpose of this study. After removing duplicates, their abstracts and conclusions were further assessed regarding their relevance to the research questions. Additionally, the relevant publications' bibliographies were scanned (snowball method) to avoid leaving out potential relevant articles not registered in the searched databases. This procedure is widely accepted and has been employed in existing literature reviews (e.g., David and Han, 2004; Franke and zu Knyphausen-Aufseß, 2014; Soni and Kodali, 2011; Webster and Watson, 2002; Winter and Knemeyer, 2013). This resulted in a sample of 79 articles to be subsequently read in their entirety. Finally, the articles' relevance and quality was evaluated, particularly with regard to research goals, definitions of key terms, methodological rigor, and results. Non-relevant documents were consequently extracted resulting in a final list of 52 articles, which represented the data corpus of the subsequent integrative literature review. Thereby, the high quality and comprehensiveness of the article at hand is ensured. Figure 1 gives an overview of the article selection process in order to ensure a systematic, transparent, and replicable literature review.

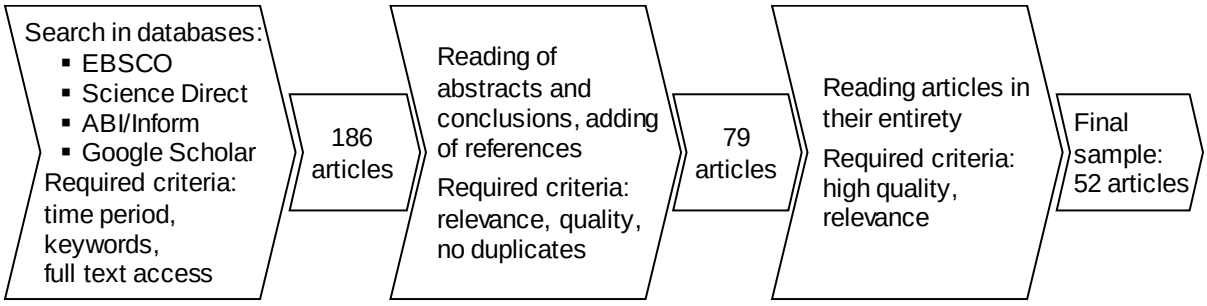

Figure 1. Article selection process

The final sample of 52 documents was analyzed in depth and classified according to the inductively developed categories *IIoT Business Models, IIoT Technology Adoption, IIoT Ecosystems*, and *IIoT Qualification*. In the final step, the classified articles were compared, critically reflected, and discussed to work out the current state of IIoT-related strategic management research. This facilitates the revealing of research areas, which are still underrepresented and in need of further examination.

4. Findings

In the following, the results of the present literature review are broken down by explicitly describing the four developed research areas.

4.1. Research area 1: IIoT Business Models

Proceeding digitization and interconnection of industrial manufacturing has not only the potential to adjust and innovate manufacturers' business models, but to a greater degree even premises novel business models. Accordingly, several authors argue that a company's survival in an industrial environment characterized by highly digitized and interconnected factories, products, machines, and humans can only be ensured by means of new business models (Bauernhansl, 2014; Buhr, 2015; Rudtsch et al., 2014). This is reasoned by a radically changing behavior of customers in terms of increasing orientation towards using instead of possessing a product, intensified competition emanating from new players mastering the new digital

environment, and new disruptive technologies like virtual reality, blockchain, and mobile computing that represent the impetus of the present and future digitization (Gassmann and Sauer, 2016). Similarly, Hartmann and Halecker (2015) emphasize the danger of new players, which will innovate and dominate the customer interface, using the example of the automotive industry. Hence, automobile manufacturers are forced to adjust the customer perspective of their business models. Otherwise, the IT industry will make advantage of the transition from traditional to electric engines and occupy the customer interface while degrading traditional manufacturers to mere suppliers. These changes do not necessarily result in radically, i.e., disruptively new products or services, but can also be an evolutionary further development of respective offers (Emmrich et al., 2015).

Academic literature seems to agree on the importance of an increasing service-orientation as a fundamental characteristic of novel, future-oriented, and viable business models since the previously dominant separation of product and service businesses will increasingly disappear (Fleisch et al., 2014; Kagermann, 2014; Lasi et al., 2014; Rennung et al., 2016; Wolter et al., 2015; Xu, 2012). Consequently, manufacturing companies being focused on their products have to adjust their value offers with reference to a combination of products and services, so-called hybrid solutions. This enables a greater range of offers, which represents a crucial element in terms of facing increasing competition (Bollhöfer et al., 2015; Kans and Ingwald, 2016). Such new services are predominantly based on the utilization of data, which represent an important part of new, IIoT-related business models (Kaufmann, 2015). Moreover, the application of data enables novel billing models based on real usages and performance demands (Kaufmann, 2015; Xu, 2012).

Besides increasing service-orientation, ecosystem integration plays another important part in new business models for the IIoT. According to Leminen et al. (2012), new business relationships based on adjusted business models will result in a more and more collaborative business ecosystem. This is supported by Iivari et al. (2016), who argue that the IIoT necessitates novel ecosystem-capable business models, particularly with regard to increasing value co-creation and co-capturing.

Regarding precise implications of the IIoT on established business models respectively for novel business models, Obermaier (2016) points out the importance of distinguishing between users, who apply IIoT technologies to increase process efficiency, and providers, who aim at establishing innovative, intelligent, and connected products. Independent of this differentiation, IIoT-specific business models have the potential to transform entire industries (Bauernhansl, 2014). Thus, Emmrich et al. (2015) emphasize the importance of regarding business models due to their complexity always in their entirety. Finally, Burmeister et al. (2016) as well as Rudtsch et al. (2014) provide concrete assistance for managers to innovate their companies' business models.

4.2. Research area 2: IIoT Technology Adoption

The review of relevant publications revealed that a successful implementation and utilization of the IIoT is in need of strategic support by companies' top management. Nevertheless, companies still feel uneasy with regard to the adoption of advanced manufacturing technologies like the IIoT due to high investments, lack of expertise, and unclear benefits (Khan and Nasser, 2016). Similarly, Hartmann and Halecker (2015) argue that industrial manufacturers have no clear understanding about successful implementation of CPS, i.e., a core technology of the IIoT. However, as Saberi and Yusuff (2011) ascertain, the adoption of advanced manufacturing technologies results in enhanced performance, e.g., in terms of increased flexibility and reaction time, making IIoT adoption of strategic importance. Hence, Ganzarain and Errasti (2016) emphasize the need of a strategic process for a successful

implementation of the IIoT. Therefore, it is important to consider a company's production in its entirety and not focusing on only single parts of the production (Becker, 2015; Hirsch-Kreinsen, 2014). Otherwise, it might come to problems regarding the coordination and communication within the production, which outweigh potential benefits and advantages. This does not mean that it is always reasonable to implement the IIoT in the whole production. A company's management always has to identify suitable areas to be upgraded by the IIoT against the background of the company's specific situation, strategic orientation, and aims (Krückhans and Meier, 2013).

When a manufacturer's top management has decided to adopt the IIoT, Binner (2014) argues that it is crucial to not concentrating exclusively on a technological implementation. It is decisive for the success to consider the three dimensions human, organization, and technology in a balanced manner. Employees have to be motivated to implement and apply the new production approach, required IIoT technologies have to be developed or acquired and integrated, and the entire organization and its structures have to be adjusted to support the first two dimensions. Erol et al. (2016) and Hartmann and Halecker (2015) developed a process to support companies' top management in adopting the IIoT. They consist of three respectively five steps, both starting with the generation of an understanding of the IIoT and novel business dynamics. This is followed by the development of new business models and the adjustment of business strategies before, finally, these new strategies and business models are translated into concrete projects.

4.3. Research area 3: IIoT Ecosystems

According to several publications, the IIoT is closely linked to a change in the business ecosystems of affected companies (Iivari et al., 2016; Lasi et al., 2014). The IIoT enables increased transparency of production and data as well as data processing and transfer, which are a prerequisite for the intensified integration of a company's ecosystem (Schließmann, 2014; Schuh et al., 2015). Kleinemeier (2014) describes that the IIoT in general will supersede the rigid structures of the traditional atomization pyramid by interconnected, decentralized, and self-organizing services. Consequently, future networks and business ecosystems are characterized by their ability to quickly establish and break up (Lasi et al., 2014; Pau, 2012).

In their study, Hartmann and Halecker (2015) conclude that in many cases, managers are not yet aware of potential benefits associated with an intensified integration of their business ecosystems, although they are manifold. The IIoT does not only facilitate cross-company connection and information exchange, but also necessitates an increasing cooperation and collaboration between different ecosystem participants. Manufacturing companies have to draw on partners supplying them with unavailable resources and complementing products and services to be able to offer novel hybrid solutions that are enabled by the IIoT (Kagermann et al., 2013; Spring and Araujo, 2013; Weill and Woerner, 2015). Hence, such cooperations are crucial for the long-term success of manufacturers (Shermann and Chauhan, 2016). As a result, the IIoT leads to novel collaborations between different companies, which did not exist before (Diemer, 2014; Wischmann et al., 2015). Participants in these new ecosystems can be, among others, companies from other industries (Bermann and Korsten, 2014, Geisberger and Broy, 2012), governments as well as non-governmental organizations (Bermann and Korsten, 2014), industrial associations (Rong et al., 2015), and providers of new platforms, applications, services, and cloud technologies (Sendler, 2016). In this context, Rong et al. (2015) emphasize the particular strategic importance of partners possessing software-related competencies and technologies for manufacturing companies. Of course, the integration of a company's ecosystem and associated increasing cooperation with novel partners is not without challenges, which have to be addressed on a strategic level. In this regard, literature instances lack of trust

(Brettel et al., 2014), missing standardization (Köhler et al., 2015), and uncertainty regarding IT responsibilities (Hornung, 2016).

4.4. Research area 4: IIoT Qualification

Finally, various authors deal with strategic IIoT-related issues regarding employee qualifications. In general, the analyzed literature agrees on a higher level of qualification as a prerequisite of IIoT application (Ahrens and Spöttl, 2015; Dombrowski et al., 2014). According to Hirsch-Kreinsen (2016), this development can be traced back to two reasons. On the one side, easy tasks that can be performed autonomously by computers based on algorithms and rules will disappear. Consequently, only jobs, which require better skilled employees, will remain. On the other side, associated with the IIoT, IT increasingly finds its way into all jobs. This necessitates a general adjustment of workforce qualifications. In particular, the IIoT results in increasing knowledge-based work (Arnold et al., 2016; Ecker and Weyerstraß, 2016) and the need to control more complex machinery (Khan and Nasser, 2016). In particular, IIoT-ready jobs are in need of employees, which master complexity, uncertainty, and a flexible handling of changing conditions (Bonekamp and Sure, 2015; Pfeiffer and Suphan, 2015). In addition, Bochum (2015) emphasizes the more than ever importance of life-long learning.

5. Concluding discussion

The following section briefly and concisely addresses the research goals defined in the introduction, i.e., the identification of IIoT-related research areas in management literature and research gaps, which put themselves forward for further research activities.

Regarding the revealing of recent research topics covered by IIoT literature from a strategic perspective, i.e., research question 1, the review at hand identifies four areas. Most of the examined articles are concerned with *IIoT Ecosystems* (20 out of 52 articles) closely followed by *IIoT Business Models* (19 out of 52 articles). With reference to the first, literature shows that the IIoT enables the intensified integration of business ecosystems that are more dynamic and flexible than ever before. Associated with this dynamization and increasing integration of the entire ecosystem into a company's own production processes, manufacturers have the potential to take advantage of several benefits. Therefore, companies have to collaborate with completely new ecosystem participants. This allows the access to required but not internally available resources to offer novel hybrid IIoT solutions. With regard to the latter, the IIoT not only fosters new, innovative business models, but also requires established companies to innovate their current business models. Literature reasons this by changing business environments as well as the danger of novel players new to the industry. What these new business models all have in common is their consequent service orientation, which is predominantly based on the utilization of data. Furthermore, as already outlined above, the integration of a company's business ecosystem into its business model is ever more crucial for its future success and viability.

Literature dealing with *IIoT Technology Adoption* and *IIoT Qualification* follows, both addressed by 9 out of 52 articles. Referring to the first, literature agrees that the adoption of the IIoT is associated with increased firm performance. Nevertheless, many companies still feel uneasy regarding the adoption of IIoT-related technologies. As emphasized by some authors, companies have to consider their entire production process, but identify and focus on suitable areas, where the implementation of this new production approach is promising. Moreover, literature argues that it is important to concentrate not only on technology when it comes to IIoT adoption, but also to consider human and organizational aspects. Regarding the latter, contrary to the fear of many people, the IIoT will not result in completely autonomous factories without any human being involved. Employees are still necessary for future production, but

require a higher level of qualification since easy tasks will be performed autonomously. In particular, literature indicates that future employees have to be skilled in terms of IT know-how and problem-solving.

The following table 1 gives an overview of the identified literature in the context of strategic IIoT research, their assessment regarding the allocation to the four developed research areas, as well as the frequencies of each of the research areas.

	Research areas			
Author(s)	IIoT Business Models	IIoT Technology Adoption	IIoT Ecosystems	IIoT Qualification
Overall results	19	9	20	9
Ahrens and Spöttl (2015)				X
Arnold et al. (2016)				X
Bauernhansl (2014)	X			
Becker (2015)		X		
Berman and Korsten (2014)			X	
Binner (2014)		X		
Bochum (2015)				X
Bollhöfer et al. (2015)	X			
Bonekamp and Sure (2015)				X
Brettel et al. (2014)			X	
Buhr (2015)	X			
Burmeister et al. (2016)	X			
Diemer (2014)			X	
Dombrowski et al. (2014)				X
Ecker and Weyerstraß (2016)				X
Emmrich et al. (2015)	X			
Erol et al. (2016)		X		
Fleisch et al. (2014)	X			
Ganzarain and Errasti (2016)		X		
Gassmann and Sauer (2016)	X			
Geisberger and Broy (2012)			X	
Hartmann and Halecker (2015)	X	X	X	
Hirsch-Kreinsen (2016)				X
Hirsch-Kreinsen (2014)		X		
Hornung (2016)			X	
Iivari et al. (2016)	X		X	
Kagermann (2014)	X			
Kagermann et al. (2013)			X	
Kans and Ingwald (2016)	X			
Kaufmann (2015)	X			
Khan and Nasser (2016)		X		X
Kleinemeier (2014)			X	
Köhler et al. (2015)			X	
Krückhans and Meier (2013)		X		
Lasi et al. (2014)	X		X	
Leminen et al. (2012)	X			
Obermaier (2016)	X			
Pau (2012)			X	
Pfeiffer and Suphan (2015)				X
Rennung et al. (2016)	X			
Rong et al. (2015)			X	
Rudtsch et al. (2014)	X			
Saberi and Yusuff (2011)		X		
Schließmann (2014)			X	
Schuh et al. (2015)			X	
Sendler (2016)			X	
Shermann and Chauhan (2016)			X	

Spring and Araujo (2013)			X
Weill and Woerner (2015)			X
Wischmann et al. (2015)			X
Wolter et al. (2015)	X		
Xu (2012)	X		

Table 1. Overview of the 52 analyzed articles

The focus of strategic management literature on these four research areas in combination with the fact that the IIoT still represents a rather young research field emerged not before 2011 emphasizes the need for further research. Since IIoT research from a management perspective is still in its early stages, it is one aim of the present article to identify possible starting points for future studies. Hence and with regard to the second research question, the following directions of further research are derived from the findings elaborated on above:

1. Current literature agrees that established business models have to change due to the IIoT resulting in novel business models characterized by an increasing service-orientation. Over and above this, the body of literature lacks details about concrete business model changes and the characterization of IIoT-adapted business models. Hence, future research should address this gap by conducting qualitative, exploratory studies, which analyze in general how single business model components are changing due to the IIoT and how these changes are linked. Here, it is important to examine the business models in their entirety and not only single parts of them. Additionally, future studies should also consider industry-specific differences in terms of business model changes. By identifying those changes that are particularly true for single industry sectors, this would serve as valuable and helpful support for companies from respective industry sectors.

In addition, future research efforts should address not only potentials and possibilities of the IIoT for the change of established business models, but also for completely new, innovative business models. In this context, it is very interesting to examine, which players will operate these innovative business models: established companies or new companies, e.g., from other industries.

2. The review of current literature dealing with strategic aspects of the IIoT clearly shows that affected companies still feel very uneasy regarding the decision as to whether adopt the IIoT and if yes, in which areas of the company to adopt it to what extent. In order to shed some light on this aspect, researchers are recommended to examine different potential IIoT adoption factors and consequently identify those factors, which either are an obstacle to IIoT adoption or facilitate IIoT adoption in a first step. Based on this and against the background that literature appreciates the necessity of a strategic adoption process, further research can subsequently develop a detailed process that considers relevant factors determining the adoption of the IIoT. In this context, future studies should additionally consider different roles of respective companies, e.g., IIoT providers and users, firm sizes, and business models.
3. Current research emphasizes the strategic importance of business ecosystems for companies in the context of the IIoT and the associated necessity of intensified ecosystem integration. Although some publications identify single players that are new in IIoT ecosystems, literature lacks a comprehensive examination of ecosystem changes. Consequently, academics should investigate how business ecosystems of established companies are changing. This involves the examination of the emergence of entirely new participants, which so far did not play any role, as well as the changing importance of different, established roles. Moreover, it is interesting to analyze how the relationships between single ecosystem players are set up.

4. Regarding employees, literature agrees that they are in need of another profile of qualifications in the future, but respective authors stay on a rather general level. Thus, future research efforts are recommended to analyze the concrete roles of future employees and relating thereto which specific skills and know-how are required. Based on these qualification profiles, recommendations for strategic actions can be derived to both adjust and improve the skills of existing employees, whose qualifications are no longer adequate, as well as regularly adapt present skills and know-how to changing requirements in the context of the IIoT.
5. Finally, the present literature review shows that there exists rather little literature on strategic aspects of the IIoT in general and high-quality academic literature in particular, compared to other well-researched topics like business models, technology management, or human resource management. Therefore, future high-quality research is indispensable, not only with regard to the four highlighted research areas, but also above, to take a further step towards sufficiently examining the young research field of the IIoT.

In conclusion, the present systematic review and analysis of 52 publications from 2011 until 2016 contributes to a better comprehension of the state of research in the context of strategic aspects of the IIoT. Hence, the review provides scholars with a guidance for necessary future research approaches to gain a more comprehensive understanding of the IIoT from a strategic perspective. Furthermore, companies operating in the field of the IIoT obtain a thorough workup of existing literature dealing with strategic aspects of the digitized and interconnected industrial value creation. This fosters their understanding of possible implications for their own businesses and future viability.

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