Business model innovation: Unravelling the potential of technologies enabling digital transformation

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Abstract

Technologies related to IIoT may have a huge potential to generate new value. We argue that in order to fully explore and exploit the potential of those technologies, the concept of business models needs to be applied. In doing so, a qualitative research approach is applied to understand how to explore and exploit technologies by means of business model innovation. We show that connectivity is an important extension of the business model in order to understand how to explore and exploit new technologies, especially in relation to IIoT. In addition, the interdependencies between the different business model dimensions are discussed.

Keywords: Business model innovation, technologies, industrial internet

Introduction

In search for new business, companies can apply an inside-out or an outside-in perspective (Lichtenthaler 2005). A typical starting point for a market-based outside-in search is to consider long-term global mega-trends (e.g. aging population) or evolving new technologies. Currently, many of the new technologies like machine learning, machine-to-machine communication or big-data analysis are part of the changes described as the industrial internet of things (IIoT), digital manufacturing or the fourth industrial revolution (i.e., Industry 4.0). In the paper at hand, we highlight the changes that industrial companies face in their aim to integrate these evolving technologies. One of the methods to describe such changes is the application of the business model decomposition (e.g., Chesbrough 2010). Thus, we aim to show how the concept of business model innovation enables companies to explore and exploit the potential of new technologies by answering the following research question: "How to explore and exploit the potential of new technologies related to IIoT?" Hence, this article seeks to unpack some of the complexities of digital transformation by examining the role of emerging technologies and firm interdependencies when implementing these technologies. The following sections covers the literature of business model innovation, IIoT, followed by the description of the research method. To analyse the changes, we summarise four different digital transformation cases of a Swiss manufacturing company. We discuss the gathered data based on the cross-case analysis and provide the conclusion.

Business model innovation

Business model innovation (BMI) is of ongoing interest for researchers and practitioners (e.g., Spieth et al. 2016; Zott et al. 2011). However, there is a continuing discussion of its constituent dimensions, sequences and contingencies (Spieth et al. 2016). In addition, different cases of well-known companies show that even a long-time established business model does not guarantee successful performance (Chesbrough 2007; Dillow 2017). Especially incumbent companies often struggle to find solutions to exogenous environmental changes. One possibility to analyse possible answers to exogenous changes is business model innovation. BMI describes the conscious renewal of a company's business logic (Chesbrough 2010; Schneider and Spieth 2013). However, similar to Christensen's (2013) innovator's dilemma, BMI may lead to the decision whether to explore new business models or to exploit the existing ones (Markides 2006). Schneider and Spieth (2013) provide an overview of existing BMI literature and derive three areas of research: (1) prerequisites of conducting BMI, (2) elements and process of BMI and (3) effects achieved through BMI.

Our study links the first and second research areas, as we focus on the elements of BMI while facing market changes triggered through the opportunities of the IIoT. Hence, we answer Schneider and Spieth's (2013) claim to pursue research analysing how companies can identify relevant trends and emerging opportunities under the consideration of the company's current situation in terms of resources and capabilities.

Not all changes in the business environment lead to changes in the business model. Only changes that affect the core processes of a company build the basis for business model innovation (Cavalcante et al. 2011). Cavalcante et al. (2011) distinguish between (1) business model creation; (2) business model extension; (3) business model revision; and (4) business model termination. Creation refers to the development of radically new core processes, which are bound to uncertainty and risks due to the newness of the business model. Extension and revision build upon the opportunities to enlarge existing business and to exploit associated commercial opportunities (Cavalcante et al. 2011).

Taking a look at possible business model dimensions shows that there is still a lack of agreement between researchers (e.g., Bankvall et al. 2017; Schneider and Spieth 2013; Spieth et al. 2016; Zott et al. 2011). Bankvall et al. (2017) provide an overview of well cited concepts. Summarising, the core questions cover "How to create value?", "How to make customers pay for that value?" and "How to convert payment through firm-internal operations into profit?" (Bankvall et al. 2017, p.197).

One of the triggers of business model innovation are emerging technologies, which force industrial companies to rethink their value proposition (Porter and Heppelmann 2014; Teece et al. 1997). Emerging digital technologies may disrupt the way industrial companies compete and offer products and services (Porter and Heppelmann 2014; Vendrell-Herrero et al. 2017). Hence, managers need to ask themselves the fundamental question if the new technologies allow them to improve their current business or if changes in the business model are needed (Porter and Heppelmann 2014). Companies not only need to develop their capabilities to come up with new technologies but in addition to be able to innovate their business models (Chesbrough 2010) in order to explore and exploit new technologies (Birkinshaw and Gibson 2004; Jansen et al. 2005).

New digital technologies and the respective digital transformation of businesses re-shape consumer preferences and consumption (Vendrell-Herrero et al. 2017). As digitisation is becoming the new norm, companies change customer relationships, processes and value propositions (Lusch et al. 2010; Vendrell-Herrero et al. 2017).

Industrial Internet of Things, Industry 4.0, Digital Manufacturing

New technologies influence the way industrial companies compete. The changes are labelled industrial internet, digital manufacturing or industry 4.0. The main approach of the industrial internet is to bring software and machines together (Bruner 2013). The term stems from the US and was first introduced by General Electric. Industrial internet enfolds initiatives belonging to a higher degree of intelligence with the power of advanced computing, analytics, low-cost sensing, and new levels of internet connectivity (Posada et al. 2015). Posada et al. (2015) highlight three key elements of industrial internet: (1) intelligent machines, (2) advanced analytics and (3) people at work.

Industry 4.0 belongs to a similar initiative, mainly pushed from Germany. The core elements of Industry 4.0 are embedded systems, smart objects, cyber-physical systems (CPS), the concept of a Smart Factory, robust networks, cloud computing, and IT-security (Bauer et al. 2014). The coexistence of the physical and virtual worlds, with the use of emerging ICT, opens possibilities such as "enhanced human-machine cooperation (including human interaction with robots and intelligent machines), connected machine networks that follow paradigms of internet connectivity and social networks, improved human-in-the-loop interaction between the cyber and physical worlds, networked and decentralised value chain transnational scenarios, and emergence of product-service networks based in intelligent, smart products, and associated services" (Posada et al. 2015, p.27).

Another definition, not receiving as much attention as industrial internet of things (IIoT) or industry 4.0, refers to opportunities of new technologies in digital manufacturing. Digital manufacturing describes the use of an integrated, computer-based system that enfolds simulation, three-dimensional (3D) visualisation, analytics and various collaboration tools to create product and manufacturing processes simultaneously (Wang and Wang 2016).

One commonality of the concepts is the internet of things (IoT) (Annunziata and Evans 2012). Although there is not yet a common definition, the core concept is "that everyday objects can be equipped with identifying, sensing, networking and processing capabilities that will allow them to communicate with one another and with other devices and services over the internet to achieve some useful objective" (Whitmore et al. 2015, p.261). Hence, central to this perspective is the connectivity or interconnection (Hermann et al. 2016). In a survey Whitmore et al. (2015) summarises 127 articles on IoT, based on six dimensions: (1) technology (hardware, software and architecture), (2) applications, (3) challenges, (4) business models, (5) future directions and (6) overview, survey. With 53 articles, the majority focuses on the technical side of IoT. The hardware upon which the IoT is being built include for example radio-frequency identification (RFID), near field communication (NFC) and sensor networks.

In addition, software enables the interoperability between the numerous heterogeneous devices and searches the data generated by them (Whitmore et al. 2015). Thus, another central dimension of each of the described concepts is the generation, analysis and storage of data (Hermann et al. 2016; Posada et al. 2015; Whitmore et al. 2015).

Analysing the new technologies relevant to industry 4.0, industrial internet of things and digital manufacturing highlights other similarities. For example, visual analytics, human-machine interfaces, augmented reality, or simulation/visualisation (Posada et al. 2015). Besides the similarities in technologies, another cross-cutting theme is the people at work, enfolding the changes in capabilities or human-machine cooperation (Hermann et al. 2016; Posada et al. 2015; Whitmore et al. 2015). Although the main vision of the concepts differ, the underlying technologies and capabilities provide similarities and thus, serve as triggers for business model innovation (Westerman et al. 2014).

Industrial Internet of Things Business Model Decomposition

Based on the core concepts of business model innovation, three central questions about value creation, customer payment for created value, and transformation from value into profit (Bankvall et al. 2017, p.197) need to be answered in order to understand how new technologies related to IIoT can be explored and exploited.

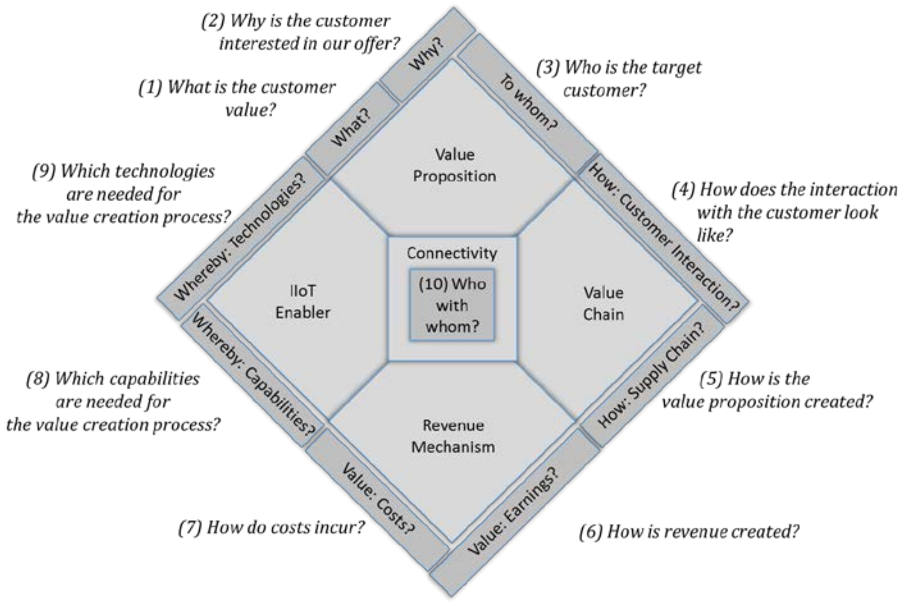

Figure 1 – IIoT Business model decomposition

The central theme of value creation is split into three dimensions: (1) *what* value (product, service, …) is offered, (2) *why* does the customer want to buy the offer and (3) *who* is the customer (customer segmentation, personas)? Due to changes based on IIoT, customer relationships as well as internal processes need to be changed in order to fulfil the new value propositions, such as, for example, data-based services (i.e., predictive maintenance). Hence, in order to understand how to create value and how to convert payment through firm-internal operations into profit, we need to analyse changes of the *customer interaction* (customer touch points) (4) and those along the *internal supply chain* (5) (value chain). As customer interaction is strongly influenced through the coexistence and interaction of the physical and virtual world, we need to get insights which customer interactions occur still physically and which shift into the virtual world. Common to each of the business models is the understanding of the revenue mechanism, i.e. where *money is earned* (6) and where *costs* (7) occur.

Finally, there is a need to understand the IIoT enabler with respect to *capabilities* (8) and *technologies* (9). As described above, one of the most crucial dimension of IIoT is its connectivity and the respective data transfers. Thus, we add the dimension *connectivity* (10) to the business model.

Research Method

As we aim at understanding how to explore and exploit technologies related to IIoT, we need to gain profound understanding of different business model innovations related to IIoT. Subsequently, we follow a qualitative research approach (Eisenhardt 1989). The advantage of gaining deep insight into IIoT ideas of one company was more important than having a broad but superficial data set. In doing so, the business unit serves as unit of analysis. The company chosen for analysis is a leading European manufacturer, that occupies 115 employees. The company was chosen because of its qualification to generate usable results rather than because of its representativeness (Firestone 1993; Miles and Huberman 1994). Eisenhardt and Graebner (2007) recommend that the case study approach is particularly suitable for topic areas not well documented and rather unknown, which suits our topic of interest. We have conducted an explanatory research approach (Eisenhardt 1989; Eisenhardt and Graebner 2007; Stuart et al. 2002) that started in January 2016 and is still ongoing. It involved so far 9 semi-structured group interviews with the general manager, the R&D manager, the production manager, the service manager and the responsible for IIoT. All interviews were attended by three researchers of the field of operations management to gain as much objectivity in result interpretation as possible. The interviews lasted between two and four hours. In addition to the interview data, we used multiple data sources such as archival data, industry publications, manuals, and company documentation.

We used Miles and Huberman's (1994) four-step approach to analyse the collected data. First, we developed a contact summary sheet in which the main themes of each interview were recorded. One researcher identified the main themes, while the other two researchers checked these themes using the interview minutes. The themes covered, for example, the current situation in each relevant function, the idea generation procedure, the discussion of the content of the business model innovation and respective measures to implement it. Second, a complete theme list was developed based on the contact summary sheet. Third, all interviews were coded using selective coding (Strauss and Corbin 1990) to categorise the answers into the main themes. One researcher was responsible for coding the interview minutes, while the other two researchers checked the coding. In the event of disagreement, the point was discussed until agreement was reached. If no agreement was reached, the point was referred to the interviewee for clarification. This procedure ensured a high level of inter-rater reliability (Voss et al., 2002). Fourth, we wrote the case study and performed a final validity check, which was done by presenting the results to the interviewees and to the top management of the company.

Description of Industrial Internet of Things

The company under investigation currently aims to implement four business model innovations (BMI) based on the new technologies available. Table 1 highlights the changes of the four BMI's. The dimension "value chain" summarises changes in the core processes. The interaction with the customer differs due to the possibility to interact virtually (e.g. automatically generated warning signs on dashboard and virtual first level support). Internally, there is a need to build up processes focusing on the development of customer specific guarantees.

Additionally, a new unit is needed which focuses on data analysis (e.g. the development of algorithm). These changes are directly linked to the need to build up data analysis capabilities as well as the respective software, data storage and secure connectivity.

Table 1 - Business model decomposition

Business Model Innovation		Case 1 Guaranteed machine availability	Case 2 Pay per use	Case 3 Smart Services	Case 4 Smart factory of the customer
Value Proposition	(1) What?	Insurance contract	Produced product (not machine)	Service contracts	Machines with interface to allow digital integr. into customer's production process
	(2) Why?	Reduction of unsceduled down-time; risk transfer	Calculable manufacturing costs; no upfront investment costs; no maintenance costs	Garantied reaction time, 24/7 virtual support, optimisation of Overall Equipment Effectiveness	Process security; flexibility; reduction of change over time
	(3) To Whom?	OEM (with high volume)	Job shopper, project based investments	OEM (with high volume)	OEM with high level of automatisation
Value Chain	(4) Customer Interaction	Remote access; machine monitoring and data transfer; dash-boards; chats with support	Remote access; machine monitoring and data transfer; first- and second level customer support	Virtual first and physical second level support (incl. visual online support); webbased real time communication; online ordering of spare parts	App-supported operator identification and communication; identification of workpiece and workpiece carriers; maintenance based on first and second level support
	(5) Supply Chain	Development and offering of insurance contracts; remote diagnostics and maintenance; data analysis	- Development of 24/7 machine surveillance; remote diagnostics and maintencance; data analysis - Refurbishing of used machines; sales of pay per use contract	- Sales of service contracts - storage of spare parts (change of production); virtual first level support, physical second level support	- Development of interfaces; connectivity; first and second level support; smart services (e.g. App); analysis tool for action management - Sales of smart services (i.e. feasibility study)
Revenue Mechanism	(6) Earnings	Insurance fee: periodic income	Earnings based on produced goods (use, ..)	Service contracts: periodic fees	Earnings based on virtual feasibility studies; smart services (contracts)
	(7) Costs	One time development costs (e.g. insurance, remote diagnostics) Ongoing costs for insurance offering, technical evaluation, data analysis, service. Guarantee costs.	One time development costs (e.g. remote diagnostics, 24/7 surveillance) Ongoing costs for monitoring and data analysis, service	One time development costs (e.g. virtual service) Ongoing costs for contract offering, first and second level support	One time development costs (e.g. interfaces; connectivity). Ongoing costs for feasability study; connectivity, service support
Enablers	(8) Technologies	Data analysis software; data storage; secure connectivity between devices; digital twin; Web-applications (e.g. dash-board for operator)	Condition monitoring (sensors); data analysis-software; data storage; secure connectivity between devices; digital twin; Web-applications (e.g. dash-board)	Web-technologies (incl. dash-board for virtual support); online spare parts catalogue; data analysis software; data storage; secure connectivity of devices	Interfaces and connectivity; data analysis software; augmented reality; App
	(9) Capabilities	Data analysis; development of algorithms; insurance statistics	Data analysis; development of algorithms; sales capabilities	Data analysis; development of algorithms; virtual support; sales capabilities	Data analysis; development of algorithms; virtual support; augmented reality; sales capabilities
Connectivity	(10) Systems linking data exchange between customer processes (e), internal processes (i)	Connectivity between Machine usage (e) –> data storage –> data analysis (i) data analysis (i) –> functions (development, service, ...) (i)	Connectivity between Machine usage (e) –> data storage –> data analysis (i) data analysis (i) –> functions (development, service, ...) (i)	Connectivity between Machine usage (e) –> data storage –> data analysis (i) data analysis (i) –> functions (development, service, ...) (i) Customer order (e) –> customer portal (e) –> ERP (i)	Connectivity between Machine usage (e) –> data storage –> data analysis (i) data analysis (i) –> functions (development, service, ...) (i) machine usage (e) –> operator interface (e)

The first BMI covers "*guaranteed machine availability*". This service offering is especially important for customers which are highly integrated (e.g. automotive suppliers) and produce high volumes. In essence, the higher the costs related to machine down-times, the higher the interest to insure machine availability.
Underlying to the concept is predictive maintenance and the respective technologies and capabilities. Although the company could offer an insurance without having predictive maintenance installed, the risk to have to pay a claim due to unexpected machine down-time would be too high. Thus, the technologies need to enable the 24/7 machine surveillance (incl. sensors and connectivity), data transfer, storage and analysis as well as interaction with the operator (i.e. dashboard).

The main driver of the BMI "guaranteed machine availability" was the technological perspective. Based on the possibilities of the 24/7 surveillance of the machine, data analysis and predictive maintenance, new offerings to the customer were possible. Although the company has already installed various sensors which monitor the condition of the machine, the access (connectivity) to the data was not yet possible due to customer reluctance (security) and missing added value. The offering is constructed as an additional service.

"Pay per use" is the second BMI the company is setting up. Instead of selling the machine to the customer, the company sells a metered service. Thus, customers who are struggling with investment costs are most likely the ones asking for this business model (i.e. job shopper, project based investments). The assets (i.e., the installed based/machines in field) remain at the company. Payment is received for each good produced. Hence, the main change is visible in the revenue mechanism; costs occur during production and earnings during the use of the machine. Central to this business model is machine availability. Therefore, predictive maintenance is central for the company, as any down-time of the machine prevents the production of products and thus income. The key changes in the customer interaction are the continuous monitoring of the machine and the respective warning alerts for the operators in order to avoid down-time of the machine. Besides investments in data analytics and the development of needed technologies, the refurbishing of the machines becomes more important. The "pay per use" business model was mostly driven from changes in the business environment as other industrial companies (e.g. Rolls-Royce) started to implement such models.

The third business model, *"smart services"*, is more reactive than guaranteed machine availability. New technologies, such as web-technologies (incl. dashboard for virtual support), online spare parts catalogue and data analysis software, focus on solving the customer's problem without the support of service employees (virtual and automated trouble shooting). Hence, the company aims to move from customer support with mainly physical interaction to virtual, and in addition, automated interaction. The implementation of the automated and virtual trouble shooting enables the company to offer a 24/7 trouble shooting support. To do so, the company needs to gather utilisation data in order to be able to develop software algorithms in conjunction with machine-learning, which allows the autonomous derivation of first level support solutions.

The idea of this business model adaptation stems from the time-consuming customer support. Hence, the need to change internal processes led to the adaptation of new technologies and with that to service offerings at reduced costs.

"Smart factory of the customer" is the fourth business model innovation. The goal is to offer a machine with an interface to allow the digital integration into a customer's production process. The focus moves from the machine to the process in which the machine is integrated. Hence, the development of interfaces is crucial. The interfaces can be human-operator (i.e. App-supported operator identification and communication) or

machine-machine-interfaces (identification of workpiece and workpiece carriers). Besides the need to build up the described technologies and respective capabilities, the company can also offer a feasibility study of device connectivity and process integration to the customer due to process competences. Central to this business model is the connectivity as described above with the human-operator and machine-machine interfaces. The trigger of this business model was the business environment or put more specifically, the ongoing digital transformation of the company's customers.

Discussion

The analysis of the IIoT BMIs shows that the decomposition of the business model enables to understand the interdependencies between technologies, capabilities, core processes, the connectedness between the dimensions and the value proposition. In addition, similarities between different business models are made transparent. The business models "guaranteed machine availability" and "pay per use" are both dependent upon the successful implementation of predictive maintenance and the respective technologies and capabilities. However, the two models focus on different customer groups. Therefore, the simultaneous pursuit of both business models is possible.

Three out of the four described business models ("guaranteed machine availability", "pay per use" and "smart services") could be implemented without the described hard- and software. In the case of "guaranteed machine availability" and "pay per use", it would lead to higher risks and costs as the needed condition monitoring would be missing, allowing only preventive maintenance. The case of "smart services" is an addition to existing services. Hence, without the planned hard- and software, the company can offer similar services to higher costs (i.e. first-level support employees). The fourth model, "smart factory of the customer", needs the investments into the described technologies and capabilities. Without them, the value offering to the customer is not possible. The implementation of the business model is fully dependent upon the IIoT enablers. Table 2 summarises the findings.

Table 2: Influence of technologies and capabilities on business model outcome

	Guaranteed machine availability	Pay per use	Smart services	Smart factory of customer
Fully dependent on enablers				X
Lower level of enabler leads to…				
… lower customer value		X (less output due to machine down-time)	X (only autom. trouble shooting allows 24/7 support)	
… higher risk and costs	X (claims)	X (higher risk of down-time, lower income)		
… higher costs	X (preventive instead of pred. maintenance)	X (preventive instead of pred. maintenance)	X (costs of first-level support employees)	

IIoT business model innovation may be internally or externally triggered. "Pay per use" and "smart factory of the customer" are triggered through the business environment. More specifically, the idea "pay per use" arose after gaining knowledge of other industrial companies that successfully implemented such a business model. The "smart factory of the customer" is the answer to the ongoing digital transformation of the customer. "Guaranteed machine availability" was driven through the discussion of how to translate the new technologies into customer value. Hence, it is technology triggered. Finally, "smart services" resulted from the need to provide value to the customer based on lower costs. Thus, technologies were analysed in order to achieve a higher customer value (i.e. 24/7 service) at lower costs. None of the analysed cases led to radically new core processes. Instead, existing core processes needed to be adapted, new value offerings are proposed, thus leading to a business model extension.

Conclusion

Technologies are the foundation of business model innovation related to IIoT. However, there is a need to link the technologies to a clear value proposition. In addition, in order to fully explore and exploit the technologies, the customer interaction process and the internal supply chain need to be analysed, as well as the generation of earnings and costs. Each of the analysed business model innovation shows the need to adapt the whole business model. Solely implementing new technologies without analysing the whole business model does not fully exploit the potential of new technologies.

Technologies is one of the dimensions triggering business model innovation. It is similarly important to analyse the business environment and the internal situation in order to identify the need to innovate. However, taking into account the new technologies and capabilities is mandatory to reach the aspired business model innovation.

Connectivity is central to the concept of IIoT (Hermann et al. 2016). Each of the cases shows that data (generation, storage, analysis, visualisation) is crucial. Thus, there is a need to understand which dimensions of the customer process (i.e. devices, machines, systems) need to be connected through which means (i.e., sensors, data storage, systems) and linked to which internal processes (i.e. PLM system). Thus, compared to current business model decomposition (Bankvall et al. 2017; Gassmann et al. 2013; Zott et al. 2011), we add the connectivity dimension as one of the cornerstone to fully explore and exploit new technologies by means of business model innovation.

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References

Annunziata, M. and Evans, P. C. (2012), *The Industrial Internet@Work*, General Electric.

Bankvall, L., Dubois, A. and Lind, F. (2017), "Conceptualizing business models in industrial networks", *Industrial Marketing Management*, Vol. 60, pp. 196-203.

Bauer, W., Schlund, S., Marrenbach, D. and Ganschar, O. (2014), "Industrie 4.0: Volkswirtschaftliches Potenzial für Deutschland", *Studie von BITKOM und Fraunhofer-Institut (IAO. Abgerufen am 11.05. 2014, unter www.bitkom.org/files/documents/Studie_Industrie_4.0.pdf.*

Birkinshaw, J. and Gibson, C. (2004), "Building Ambidexterity Into an Organization", *MIT Sloan Management Review*, Vol. 45, No. 4, pp. 47-55.

Bruner, J. (2013), *Industrial Internet,* " O'Reilly Media, Inc.".

Cavalcante, S., Kesting, P. and Ulhøi, J. (2011), "Business model dynamics and innovation: (re)establishing the missing linkages", *Management Decision*, Vol. 49, No. 8, pp. 1327-1342.

Chesbrough, H. (2007), "Business model innovation: it's not just about technology anymore", *Strategy & Leadership*, Vol. 35, No. 6, pp. 12-17.

Chesbrough, H. (2010), "Business model innovation: opportunities and barriers", *Long range planning*, Vol. 43, No. 2, pp. 354-363.

Christensen, C. (2013), *The innovator's dilemma: when new technologies cause great firms to fail,* Harvard Business Review Press.

Dillow, C. (2017), "The inflexible economy", Vol. London.

Eisenhardt, K. M. (1989), "Building Theories from Case Study Research", *Academy of Management Review*, Vol. 14, No. 4, pp. 532-550.

Eisenhardt, K. M. and Graebner, M. E. (2007), "Theory Building from Cases: Opportunities and Challenges", *Academy of Management Journal*, Vol. 50, No. 1, pp. 25-32.

Firestone, W. A. (1993), "Alternative arguments for generalizing from data as applied to qualitative research", *Educational Research*, Vol. 22, No. 4, pp. 16-23.

Gassmann, O., Frankenberger, K. and Csik, M. (2013), *Geschäftsmodelle entwickeln*, Hanser.

Hermann, M., Pentek, T. and Otto, B., (2016). "Design Principles for Industrie 4.0 Scenarios", paper presented at *49th Hawaii International Conference on System Sciences (HICSS)*, 5-8 Jan. 2016.

Jansen, J. J. P., Van Den Bosch, F. A. J. and Volberda, H. W. (2005), "Exploratory innovation, exploitative innovation, and ambidexterity: the impact of environmental and organizational antecedents", *Schmalenbach Business Review (SBR)*, Vol. 57, No. 4, pp. 351-363.

Lichtenthaler, E. (2005), "Corporate diversification: identifying new businesses systematically in the diversified firm", *Technovation*, Vol. 25, No. 7, pp. 697-709.

Lusch, R. F., Vargo, S. L. and Tanniru, M. (2010), "Service, value networks and learning", *Journal of the Academy of Marketing Science*, Vol. 38, No. 1, pp. 19-31.

Markides, C. (2006), "Disruptive innovation: In need of better theory", *Journal of product innovation management*, Vol. 23, No. 1, pp. 19-25.

Miles, M. B. and Huberman, M. A. (1994), *Qualitative data analysis*, Sage, Thousand Oaks, CA.

Porter, M. E. and Heppelmann, J. E. (2014), "How smart, connected products are transforming competition", *Harvard Business Review*, Vol. November, pp. 34-60.

Posada, J., Toro, C., Barandiaran, I., Oyarzun, D., Stricker, D., de Amicis, R., Pinto, E. B., Eisert, P., Döllner, J. and Vallarino, I. (2015), "Visual computing as a key enabling technology for industrie 4.0 and industrial internet", *IEEE computer graphics and applications*, Vol. 35, No. 2, pp. 26-40.

Schneider, S. and Spieth, P. (2013), "Business model innovation: Towards an integrated future research agenda", *International Journal of Innovation Management*, Vol. 17, No. 01, pp. 1340001.

Spieth, P., Schneckenberg, D. and Matzler, K. (2016), "Exploring the linkage between business model (&) innovation and the strategy of the firm", *R&D Management*, Vol. 46, No. 3, pp. 403-413.

Strauss, A. and Corbin, J. (1990), *Basics of Qualitative Reserach: Grounded Theory Procedures and Techniques*, Sage Publications, Newbury Park, CA.

Stuart, I., McCutcheon, D., Handfield, R., McLachlin, R. and Samson, D. (2002), "Effective case research in operations management: a process perspective", *Journal of Operations Management*, Vol. 20, No. 5, pp. 419-433.

Teece, D. J., Pisano, G. P. and Shuen, A. (1997), "Dynamic Capabilities and Strategic Management", *Strategic Management Journal*, Vol. 18, No. 7, pp. 509-533.

Vendrell-Herrero, F., Bustinza, O. F., Parry, G. and Georgantzis, N. (2017), "Servitization, digitization and supply chain interdependency", *Industrial Marketing Management*, Vol. 60, pp. 69-81.

Wang, L. and Wang, G. (2016), "Big Data in Cyber-Physical Systems, Digital Manufacturing and Industry 4.0", *IJEM-International Journal of Engineering and Manufacturing (IJEM)*, Vol. 6, No. 4, pp. 1.

Westerman, G., Bonnet, D. and McAfee, A. (2014), *Leading Digital: Turning Technology into Business Transformation*, Harvard Business Press.

Whitmore, A., Agarwal, A. and Da Xu, L. (2015), "The Internet of Things—A survey of topics and trends", *Information Systems Frontiers*, Vol. 17, No. 2, pp. 261-274.

Zott, C., Amit, R. and Massa, L. (2011), "The Business Model: Recent Developments and Future Research", *Journal of Management*, Vol. 37, No. 4, pp. 1019-1042.