Impact of IIoT Based Technologies on Characteristic Features and Related Options of Nonownership Business Models

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Abstract. Industrial internet of things (IIoT) can positively impact business from the process and the technical perspective. There is a limited understanding of the impact of IIoT on business models in general especially the novel nonownership business models (NOBMs). In this paper we analyze the literature, especially case study literature, to understand the impact of IIoT based technologies and related features on the NOBMs using a morphological box (developed by Lay et al. [4]) as a framework. We understood that IIoT- enabled technologies enables the implementation of a larger variety of NOBMs, such as, the pay-per-use, pay-per-output and pay-per-outcome business models, as well as a variety of options related to them. We also realized that there is a need to develop a morphological box for capital intensive manufacturing companies by developing new characteristic features and related options that can take IIoT enabled technologies.

Keywords: Industrial internet of things · Industry 4.0 · Business models · Nonownership business model · IIoT · IoT

1 Introduction

The academia and managers are currently having high expectations on the potential of the IIoT [1]. However, these benefits are not very apparent and easy to realize. While recognizing the uncertainties related to the realization of business benefits from IIoT, the novel types of Nonownership Business Models (NOBMs) enable collaborating companies to share both opportunities and downsides of IIoT for mutual benefit, thus creating novel networked value creation opportunities. Regarding such benefits, in general, IIoT has been demonstrated e.g. to enable decreases in transaction costs between companies in various manners [1], while increasing transparency in collaboration through increases in the quantity and quality of data and information (e.g. [2]).

Currently, there is a limited understanding in the academic literature about the value and benefits of IIoT to business and novel business models (see e.g. [3]). Therefore, the central novelty of this study is to understand the role of IIoT technologies in NOBMs

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(especially pay-per-use, pay-per-output and pay-per outcome) in the domain of industrial (business-to-business) capital-intensive manufacturing goods. The novelty is derived, in more detail, partly also from the use of a business model structuring framework [4], previously not used, to understand the role of IIoT technologies in the NOBMs. We will review the perspective of earlier studies that have addressed this topic in the next section.

We focus on companies that not only produce products for other companies, but more specifically, on companies the products (machines or machine components) of which are used as part of the other companies' manufacturing processes, and mostly are capital-intensive in nature, i.e. B2B companies. Thus, for instance, the risk aspect, associated to all NOBMs which transfer product ownership from customers to suppliers, is emphasized, while e.g. failures in products or product components can cause even significant interruptions in the whole production process, and thus, the supplier has significantly higher responsibility of such risks.

To address the above research gaps, our aim is to answer the following main research question: "*How do IIoT- based technologies impact the characteristic features and related business model enabled options of the nonownership types of advanced business models of business-to-business manufacturing companies*?"

The structure of this study is as follows: we first introduce the major concepts, primarily IIoT and NOBM business models, and related frameworks for this study. Second, we review existing research and the research gap in more detail. Third, we introduce the methodology of this paper. Fourth, we present the results, and discuss them, leading finally into the conclusions and managerial implications.

2 Theoretical Background

2.1 Industrial Internet of Things-Based Technologies

Smart Manufacturing (SM) improves the efficiency and responsiveness of a production system by integrating data with information technology and manufacturing. IoT employs sensors to communicate between the physical world and computers and was first used in 1999 [5]. IoT can record and measure parameters like temperature, pressure, and light with the help of affordable electronic sensors and wireless processors over the internet and considered as a technology that can revolutionize the future [6]. IIoT connects the factory machines with IoT [5]. IIoT consists of devices and sensors, communication technologies, gateways and switches, analytical and optimization programs, interconnected apps, and people (that use it) [5, 7]. Based on the literature, [1] four technologies are important for IIoT, (i) *Internet and communication protocols and middleware*, (ii) *Sensors*, (iii) *Actuators*, and (iv) *IT-driven services like AI and big data analytics*.

Evolution of digital technologies has transformed B2B companies [8]. Similarly, the information interoperability possible because of IIoT, has totally changed the relationships between the customers, manufacturers and the suppliers, and thus modifying the business models of the manufacturing companies [5, 6]. For example, now the electrical engineering and information and communication technology companies are looking for novel key partner networks and automotive suppliers use IIoT to increase their cost efficiency [3]. A systematic review study [9] has also shown that the scientific work has not looked at all the aspects of the business models, and these studies mainly focus on the key resources and activities of the companies, and utterly ignored the effect of IIoT adoption from the customer perspective. Therefore, although, the literature refers to the right business models as the force behind profitable use of IIoT, it lacks a comprehensive business model that caters towards the aspect of IIoT [5].

2.2 Nonownership Business Models

Nonownership model can be defined as a *"service in which customers acquire some property rights to an asset and are offered a certain degree of freedom in using this asset for a specified period of time while the burdens of ownership remain with the owner"* [10].

The above definition describes the concept of nonownership in a clear manner from the customers point of view, as it talks about how a customer can use the asset but not own it, by keeping the ownership with the manufacturer. To take the manufacturer's point of view into consideration, the earning logic of nonownership business models must be described. This can be done by dividing the nonownership model into pay-per-use, pay-per-output and pay-per-outcome models. Pay-per-use type nonownership model implies that the customer pays for the use of the machine and every other aspect related to the machine, i.e. ownership, installation, maintenance, upgrade and recycling is taken care of by the manufacturer. Pay-per-output type nonownership model focuses on the result of the machine use, which is usually quantified in monetary terms. Pay-per-outcome type nonownership model focuses on the value derived by the customer after using the machine provided by the manufacturer.

Literature has covered the nonownership models from various different sectors; such as, software industry [11], B2C product manufacturers such as washing machine manufacturers [12], manufactured products such as the copier and printer [2]. The above-mentioned product ranges are easy to scale because the economies of scale work very well for software products, B2C products and use intensive copiers and printers. B2B manufacturers that make equipment or machines that are critical in customers process, such as the air-compressors or jet engines (critical components for an airplane manufacturer) have a very different risk profile when it comes to these nonownership models when compared to the above-mentioned products. There are some authors that discuss the risk profile for these kind of manufacturing companies [13]. Some of the authors [2, 13, 14], discuss the impact of IIoT on the business models of the manufacturing companies using the business model framework. They do not discuss the impact of IIoT on specific nonownership business models, such as the pay-per-use, pay-per-output and the pay-per-outcome models in a manner that the companies can define the value proposition for every individual model. Hence, we take the morphological box designed by [4] and understand the impact of IIoT on each and every characteristic feature as well as related options of the morphological box for manufacturing companies.

2.3 Morphological Box - Framework for Nonownership Business Models

Advanced business models that enable manufacturing companies to transition from sales-based revenue to a more continuous, service-based revenue generation are very appealing for a myriad of reasons, including closer customer relations, lock-in, more control of complex assets, and access to the system's operational data for the manufacturer. There are several tools and frameworks available that aim at supporting manufacturing companies during the early phases of this complicated transition. In this paper, we specifically focus on the strategic perspective of the business model development. One established framework is Lay et al.'s [4] morphological box that allows to describe service/based business models in a structured way. Table 1 illustrates the basic structure of Lay et al.'s morphological box. This framework is intended to allow manufacturing companies with limited experience in nonownership business models to envision their own, unique set-up.

Table 1. Morphological box framework for nonownership business concepts [4]

Characteristic Features		Options			
Ownership	During the phase of use	Equipment producer	Leasing bank	Operating joint venture	Customer
	After the phase of use	Equipment producer	Leasing bank	Operating joint venture	Customer
Personnel	Manufacturing	Equipment producer	Operating joint venture	Customer	
	Maintenance	Equipment producer	Operating joint venture	Customer	
Location of operation		Equipment producer's establishment	Establishment "fence to fence" to the customer	Customer's establishment	
Single/multiple customer operation		In parallel operation for multiple customers	Operation for a single customer		
Payment model		Pay per unit	Pay for availability	Fixed rate	Pay for equipment

Lay et al.'s morphological box depicts five different characteristic features, ownership, personnel, location of operation, single/multiple customer operation, and payment model. By "characteristic features", we mean the central features of novel manufacturing business-to-business product- related business models, which are typical, as well as centrally differentiate the different types of novel business models from each other, and thus can be used for identifying the variety of options in the case of novel business models.

The first two, ownership and personnel are split in two sub-sets of characteristic features, during*/after the phase of use*, and *manufacturing/maintenance* respectively. For each of the characteristic features, different options are provided, reflecting the different possible set-ups for nonownership business models in manufacturing companies.

2.4 Impact of IIoT Enabled Technologies on NOBMs

While there is still a relatively small amount of academic studies discussing IIoT technologies' various roles in novel business models, and furthermore, especially aiming to understand these roles from the perspective of investment- and capital intensive business-to-business products, some studies [1, 2, 14–16] have addressed the topic. This literature that focuses on software products cannot be directly applied for understanding NOBMs in manufacturing capital intensive products. This is since software products can be scaled up as well as delivered and installed to customers' machines and manufacturing lines in a very different manner than large and expensive manufactured products. Second, due to such scalability and delivery challenges, risks related to suppliers' earnings being significantly linked to manufacturing customer e.g. not using the equipment in their production, bring significant risks to NOBM use in manufacturing context, limiting the adoption of experiences received from earlier literature derived from software NOBMs or consumer product NOBMs (see e.g. [15]).

We have studied literature reviews on IoT impacts to business models, literature reviews on NOBMs (e.g. [15]), and their references through forward and backward references of these reviews. No studies were found directly addressing our research question from the selected perspectives of capital-intensive manufacturing companies and from the perspective of NOBMs and the related changes in ownership of machines. We review the literature which is most closely associated with our research aim, context and research question.

Recently, [1, 2, 14, 16] have studied the role of IoT technologies in NOBMs. However, their studies do not address the topic from the perspective of capital-intensive manufacturing products. Metallo et al. [16] studied IoT technologies in three cases (Intel, Apio and Solair), making use of BM framework of [17], the so-called business model canvas, related to BM building blocks, but of which none are about capital intensive manufacturing products. Bock & Weiner [14] aim to study IIoT technologies' roles in NOBM's, their case study is focusing on capital-intensive manufacturing products, and they make use of [18] well-known BM framework. However, their perspective is focused on how these technologies can help to manage the uncertainties and risks (upsides and downsides of IIoT technologies) associated with NOBMs. Ehret & Wirth [1] focused on the role of IIoT technologies on NOBMs' BM components (Osterwalder's (see e.g. [17] well known BM framework), making use of economic theories (transaction cost theory and entrepreneurship theory) to understand the roles in more detail. However, their study is conceptual, and not concentrating on manufacturing capital-intensive products. They do neither, however, address directly the topics and issues of changing ownership in machines, related to NOBMs.

There are also some relatively recent systematic literature reviews on links of IoT and BMs [3, 15]. However, [15] discussed IoT's impact to software business models, which, for the above reasons, cannot be applied reasonably into manufacturing companies' product-oriented business models in the case of NOBMs. Arnold et al. [3] focus on generic business model impacts of IIoT into individual business model components of Osterwalder's business model canvas framework. They do not, however, discuss directly the implications to changes in ownership of investment products or NOBMs as such, but overall benefits to BM components, or on the changes in customer relationships.

3 Research Methodology

In this research we take a literature-based approach to investigate the impact of IIoT on the morphological box for NOBMs [4]. Lay et al.'s [4] framework was published in

2002, and since then, the digital transformation within the Industry 4.0 paradigm has had a significant impact on the feasibility and design of advanced NOBMs.

After identifying the relevant papers in a literature review, in a next step we map the reported case studies to the morphological box. More specifically, we analyze first, whether a certain characteristic feature is addressed in the case studies and second, if and how IIoT had an impact on said characteristic feature. Similarly, we proceed about the different options presented in the morphological box and apply the same methodology. After identifying the impact of IIoT on the individual characteristics features and associated options, we discuss the overall impact and the validity of the morphological box given the changes in the technological landscape. Furthermore, we analyze whether there are additional aspects that are reported as relevant in the recent case studies that are not represented in the morphological box at present. These missing aspects are discussed and put into context to build the foundation for future work aiming at creating an updated framework, taking advanced digital technologies and their requirements and opportunities into consideration.

4 Results and Findings

In this section we present the findings related to the impact of IIoT based technologies on the morphological box (shown in Table 1) in two parts. Table 2 shows the impact of IIoT based technologies on the characteristic features, whereas, Table 3, shows the impact of IIoT based technologies on the options related to the characteristic features (shown in Table 2).

IIoT technologies influence the tracking of the ownership using the sensors and the actuators as well as impact the prediction of the wear and tear to estimate the recycle time of the machine after the phase of use [1]. Lay et al. [4] did not separately considered the ownership of data component (under ownership) in the morphological box. After embedding IIoT based technologies with the machines and the equipment, it is possible to collect data of processes and the condition of the machine. This collected data on further analysis can enable process optimization, wear and tear prediction and new product design with better optimization for the manufacturer. Hence, it becomes imperative to consider the ownership of data associated with the process of manufacturing and condition of the machine [2, 14]. As per Lay et al. [4], operating "personnel" characteristic feature describes the allocation of the workforce in a business concept. IIoT based technologies have a big impact on the way personnel carry out the work in a manufacturing process. IIoT technologies create a connected environment for the machines via cloud, which enables the machine operator to remotely control the machine from another location. Thus, the customer worries only about the output of the machine. For example, Kaeser Compressors while adopting the IIoT enabled nonownership model, agreed with the customer that Kaeser will be the owner of the equipment and will also manage the operation of the compressors on customers' behalf [19–21].

Kaeser made use IIoT based technologies to enable operational efficiencies resulting from big data analytics and predictive maintenance. Real-time or near real-time condition monitoring of the machine's operation makes the "location of operation" decision making simpler for the manufacturer to remotely control the process and maintenance of the

Table 2. Impact of IIoT based technologies on characteristic features of advanced business models

Characteristic Features			Impact of IIoT based technologies	References
A	Ownership	During the phase of use	Ownership of Data associated with the process of manufacturing and condition of the machine	[2, 14, 19, 20, 22]
		After the phase of use		
B	Personnel	Manufacturing	Adaptive control using predictive analytics of the machine impacts the Personnel activities. Predictive maintenance impacts overall maintenance activities.	[1, 19, 21, 24, 25]
		Maintenance		
C	Location of operation		Condition monitoring gives more freedom when it comes to selecting the location of operation	[2, 23, 24, 26]
D	Single/multiple customer operation		Real-time or near-real time monitoring allows multiple customer operations with ease.	[14, 19]
E	Payment model		IIoT based technologies enable flexible and smart contracts	[27]

machine. adaptive control allows the manufacturer to let the customer make the decision on the location of the machine [2, 22, 23]. The characteristic feature that deals with the exclusivity of use of the machinery (Lay et al. [4]) focuses on "single/multiple customer operation" aspect. IIoT technologies enable real time or near real time monitoring of the machine use. This allows the manufacturer to create a system where multiple customers in the same location can use the machine as per a dedicated timeslot.

For example, if Kaeser has five customers in the same industrial area then it can set up a compressor system in a manner that all the five customers can use the same compressor system without purchasing any compressor [14, 19]. Kaeser can monitor the usage and the wear and tear of the compressor system and control the operation using IIoT based technologies.

Finally, IIoT based technologies in combination with Blockchain technology can lean-up the payment model for the manufacturer. Manufacturers can use smart contracts [27] to create more dynamic contracts with the customers. They can customize the smart contracts in a manner that it can cater to the pay-per-use model in the beginning but as the usage intensifies the contract automatically advances to pay-per-output and then to pay-per-outcome, giving maximum benefits to the customer and increasing the profit margin for the manufacturer. Blockchain in combination with the machine's real time operational data and related analytics enables the manufacturer and customer to agree on the dynamic nature of the contract [27].

Table 3 assesses the impact of IIOT based technologies and the enabled improved process capabilities (such as condition monitoring, predictive maintenance, etc.) on the options under the characteristic features (A to E from Table 2). Table 3 enables decision making, especially for the manufacturer. IIoT based technologies allow the manufacturer

Table 3. Impact of IIoT based technologies on the options related to characteristic features of advanced business models

<table>
<tr><th>C.F.*</th><th colspan="4">Options</th><th>Impact of IIoT based technologies</th></tr>
<tr><td rowspan="2">A</td><td>Equip-ment producer</td><td>Leasing bank</td><td>Operating joint ven-ture</td><td>Customer</td><td rowspan="2">Condition Monitoring and Predictive Mainte-nance enables the equipment producer to take more risk in own-ership</td></tr>
<tr><td>Equip-ment producer</td><td>Leasing bank</td><td>Operating joint ven-ture</td><td>Customer</td></tr>
<tr><td rowspan="2">B</td><td>Equipment pro-ducer</td><td>Operating joint venture</td><td colspan="2">Customer</td><td rowspan="2">Adaptive control allows the equipment producer to take control of the manufacturing process and maintenance</td></tr>
<tr><td>Equipment pro-ducer</td><td>Operating joint venture</td><td colspan="2">Customer</td></tr>
<tr><td>C</td><td>Equipment pro-ducer’s estab-lishment</td><td>Establishment “fence to fence” to the customer</td><td colspan="2">Customer’s establishment</td><td>Optimization, predic-tion and geo-localization allows the equipment producer to operate the machine at any location</td></tr>
<tr><td>D</td><td colspan="2">In parallel operation for multiple customers</td><td colspan="2">Operation for a single customer</td><td>Usage monitoring, intensity assessment and condition monitor-ing allows the equip-ment producer to serve multiple customers with the same machine.</td></tr>
<tr><td>E</td><td>Pay per unit</td><td>Pay for availability</td><td>Fixed rate</td><td>Pay for equipment</td><td>Smart contracts based on all the IIoT based capabilities allows flexibility in payment contracts.</td></tr>
<tr><td colspan="6">* C.F. – Characteristic Features as in Table 2</td></tr>
</table>

to select options which give them more control over the machine’s operation and usage by minimizing the risks. For instance, in case of the “ownership” characteristic feature (A), the manufacturer or equipment producer can take control of the ownership related to the equipment as well as maintenance by using condition monitoring and predictive maintenance [2, 19, 20].

Similarly, adaptive control allows the manufacturer’s personnel to control the operation and maintenance remotely or limiting the visits to the customers facility [2, 19]. Hence, the manufacturer can have their own “personnel” for both manufacturing and maintenance. When it comes to the “location of operation”, the manufacturer can provide any of the option, equipment producer’s establishment, establishment “fence to fence” to the customer, customer’s establishment, because manufacturer can control the operation using optimization, prediction and geo-localization. IIoT enabled technologies allow usage monitoring, intensity assessment and condition monitoring letting the manufacturer to serve multiple customers using the same equipment system [14, 19]. Finally, when it comes to the options for payment model, smart contracts [27], give dynamic capability and freedom to the manufacturer to offer any nonownership contract, pay-per-use, pay-per-output or pay-per-outcome.

5 Discussion and Conclusions

In our paper, the objective of the morphological box (originally by [4]) was to demonstrate the larger variety of possible different types of NOBMs, making use of the characteristic features and related options (as shown in Table 1). According to the results demonstrated above, IIoT- enabled technologies and facilitated process capabilities impact the above-mentioned characteristic features and related options in a way that this enables the implementation of a larger variety of NOBMs, such as, the pay-per-use, pay-per-output and pay-per-outcome business models, as well as a variety of options related to them.

The characteristic features and related options described by [4] in Table 1 were found relevant to the NOBMs. We found it possible to implement any type of NOBM using the characteristic features and the related options in different combination as demonstrated by [4]. IIoT based technologies on the other hand, were found to impact the characteristic features and related options in a manner that manufacturers can implement the variety of NOBMs. As shown in Table 2, "ownership" changes the way NOBMs are implemented because of IIoT enabled technologies. At the business model level, IIoT based technologies were found to impact the "ownership" characteristic feature in a manner that manufacturers interested in NOBMs can take better control of the ownership. This, in turn, may impact the "personnel" provided by the manufacturer to operate and maintain the machine, impacting the "location of operation" to be at the customer's site and finally impacting the way "payment model" is designed. Bock et al. [19] discuss how Kaeser changed the way they did business by employing the NOBM (pay-per-output model). With the IIOT based technologies, Kaeser took over the "ownership" of the compressor system and provided compressed air to the customer at customer's location using Kaeser's personnel to operate the compressor system and maintain them. In return, Kaeser was able to deploy the pay-per-output model for their customers to make payments for the compressed air they received [19].

NOBMs can be implemented without IIOT technologies as well. But, IIOT technologies were found to allow the manufacturing companies to implement a large variety of NOBMs. This variety can be seen using a morphological box, which constitutes of various characteristic features and options [4]. It is the options in the morphological box, that enable the variety in the NOBMs. IIoT based technologies enable the tapping into every detailed data point in a machine, providing big data and good quality data in real time or near real time. This access to data makes all the options (as in Table 3) that can contribute the variety of NOBMs i.e. pay-per-use, pay-per-output and pay-per-outcome feasible. Manufacturer can take control of the ownership, personnel that can operate the machine and do the maintenance, location of the machine as well as whether the machine system can be used by one or multiple customers. Finally, it is using the morphological box manufacturers can recognize and design novel business model -related experiments with their customers, and thus understand better the potential of various types of NOBMs and their feasibility.

After the analyses of results making use of the morphological box by [4], originally designed for various types of novel manufacturing business models, and the related IIOT enabled technological impacts analyzed from the literature making use of the morphological box, we realize that there is a need to create a facilitated new morphological box for manufacturing companies to take better into consideration these specific types of novel business models, NOBMs (such as pay-per-use, pay-per-output and pay-per-outcome). For instance, there is a need to design new characteristic features that, for example, can take the overall changes in asset ownership into account. This means, in addition to the machine ownership, that for instance data ownership, software ownership etc. are considered in the model. These changes and additions will allow the manufacturing companies to better design the advanced NOBMs such as the pay-per-use, pay-per-output and pay-per-outcome business models.

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