The Internet of Things in a Business Context: Implications with Respect to Value Creation, Value Drivers, and Value Capturing

Victor Wolf, Jutta Stumpf-Wollersheim, and Lukas Schott

Abstract The Internet of Things (IoT) is a network that connects devices and everyday objects to exchange data. IoT solutions consist of two elements, namely, the "thing" itself and its digital addition. Thus, these solutions deliver value based on a physical "thing"-based function and on a digital, connected IT-based function. Due to this hybrid nature of the IoT construct, firms have to rethink how to create and capture value. However, we still know very little about the influence of the IoT on value creation, value drivers, and value capturing in a business context. We conceptually analyzed the potential impacts of the IoT on value creation, value drivers, and value capturing. With regard to value creation, we suggest that the characteristics of IoT solutions (the independence of the information stream and its accessibility) result in new possible ways of creating value and in specific drivers of value creation in IoT environments, namely, efficiency, network effects; customization, servitization and value co-creation, shared value drivers, and novelty. With regard to value capturing, we suggest that the hybrid value construct enables the value stream of digital information to be independently marketed, thereby allowing for completely new ways of capturing value in the IoT context.

Keywords Internet of Things · Hybrid structure · Value creation · Value drivers · Value capturing

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1 Introduction

Investigating how the Internet of Things (IoT) (i.e., the interconnection of physical and virtual "things" based on existing and evolving interoperable information and communication technologies, ITU 2012, p. 1) influences value creation, value drivers, and value capturing in a business context is important for the following reasons. First, in a traditional business environment, value creation was (and still is) directly related to the product itself. By contrast, the IoT adds value by enabling additional services based on digitalization. For example, firms that traditionally sold printers might offer smart printers that reorder printing cartridges themselves. Thereby, the firms do not solely offer the printer (physical value) but also offer a service, namely, the service of delivering printing cartridges at the appropriate moment (digital value). Due to such differences between traditional and IoT business environments, investigating potential changes concerning value creation, value drivers, and value capturing is of utmost importance. Second and relatedly, the IoT connects different industries and thus represents the basis for new business models based on value co-creation and value networks. Spanning the borders of firms and industries will presumably increase competition, which will, in turn, force firms to rethink their established business models and market assessments (Turber et al. 2014). Accordingly, changes with respect to value creation, value drivers, and value capturing appear to be very likely in IoT business environments. Third, a Gartner study forecasts that the number of connected "things" will increase from 8.3 billion in 2016 to over 20 billion by just 2020 and projects the corresponding endpoint spending related to these units to then reach nearly 3 trillion US dollars (Gartner 2017). Given that the IoT offers a significant potential for businesses to create and capture value (Openshaw et al. 2014), such forecasts underline the importance of gaining a better understanding of firms' value drivers and of how firms create and capture value.

Previous research on the IoT has primarily focused on the technological aspects of the IoT (Del Giudice 2016). For example, prior research has looked at how the IoT can be used to integrate intelligent interfaces in the information network (Atzori et al. 2010; Berman and Kesterson-Townes 2012), how the IoT can improve efficiency in the use of resources (Palacios-Marqués et al. 2015), or how the IoT can optimize production systems, services, and decision-making processes (Iglesias et al. 2013; Del Giudice and Straub 2011). Additionally, there are few contributions that identify the drivers of value creation in IoT solutions (e.g., Fleisch et al. 2017; Mejtoft 2011). However, the "IoT is not well presented in management literature" (Whitmore et al. 2015, pp. 269–270), and we still know very little about the influence of the IoT on value creation, value drivers, and value capturing in a business context (Westerlund et al. 2014).

We seek to address this noticeable research gap by conceptually analyzing the potential impacts of the IoT on value creation, value drivers, and value capturing in a business context. Based on theoretical considerations concerning the IoT and value creation, value drivers, and value capturing in traditional business environments, we suggest potential influences of the IoT in a business context. We end by discussing our suggestions, implications for theory and practice, and suggestions for future research.

2 Theoretical Background

2.1 The Internet of Things

In recent years, the IoT has grown in relevance and became a leading theme in academic, professional, and popular discussions (Fleisch 2010). The term "IoT" is often used very broadly to refer to the network of things itself, the underlying technologies (e.g., sensors, actuators, network infrastructure), and the applications built atop that technology (Miorandi et al. 2012). The main principle behind the IoT is the notion that, based on new sensor and networking technology, the integration of digital elements enables physical objects to gain additional characteristics of digital technology (Yoo et al. 2012). These characteristics include the capability to be uniquely and individually addressable, interoperable, programmable, and communicable based on standard communication protocols (Chan 2015; Glova et al. 2014). Thus, the IoT bridges the gap between the physical world and its representation in information systems (Haller et al. 2009). Conceptually, the IoT architecture can be described based on the prevalent four-layer modular architecture of digital technology (ITU 2012) (see Fig. 1).

In the first layer, the *device layer* (often referred to as the sensing layer), sensors and actuators measure physical real-world events, transform them into digital

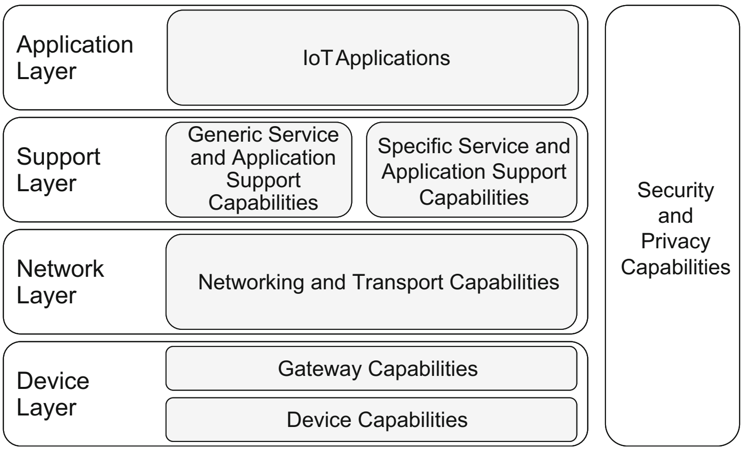

Fig. 1 Layer architecture of the IoT. Based on the "IoT reference model" (ITU 2012, p. 7)

information, and process this information in real time (Ju et al. 2016). The quantity and quality of sensors have a major impact on the ability to acquire the required data in the required granularity (Fleisch 2010). The cost of deploying and maintaining the required sensing infrastructure is therefore one of the key factors influencing the feasibility and economic usability of IoT technology. The second layer, the *networking layer,* fulfills the function of providing a robust network structure that meets the high-performance requirements for low latency, high bandwidth, security, and a high number of concurrent users to transmit information (ITU 2012). The third layer, the *support layer*, handles the main functions related to data processing. This layer provides data analytics for both aggregated data and real-time streaming data, depending on the intended use case (ITU 2012). The fourth layer, the *application layer*, provides the user interface with specific applications. This layer is one representation of the so-called future Internet, which is the basis for a web-based service economy, consisting of service platforms and services that are offered on that platform. The types of services can range from high-level business services to low-level sensor services (e.g., aggregated services or the read-out of a certain sensor state) (Haller et al. 2009).

Such a layered architecture is advantageous for several reasons. First, it enables design decisions for the components of each layer to be made individually and with minimal consideration of other layers, while standardized communication protocols assure the compatibility between layers (Yoo et al. 2010). Second and relatedly, the modularity resulting from the decoupling of the layers and their components in the architecture allows multiple stakeholders in the network (i.e., the focal firm, suppliers, customers) to contribute across all layers (Turber et al. 2014). The layered modular architecture enables the possibility of serving as a platform on one layer while serving as a component or product on another (Yoo et al. 2010). Therefore, each layer can itself be seen as a source of value creation (Turber et al. 2014).

From a management perspective, however, a less detailed consideration of the IoT concept appears more favorable. Fleisch et al. (2017) suggest considering the IoT as a hybrid construct that consists of two elements, namely, the "thing" itself and its digital addition. The value of the IoT solution that is delivered to the customer thus comprises a physical "*thing*"*-based function* and a digital, connected *IT-based function*, i.e., a digital service (see Fig. 2).

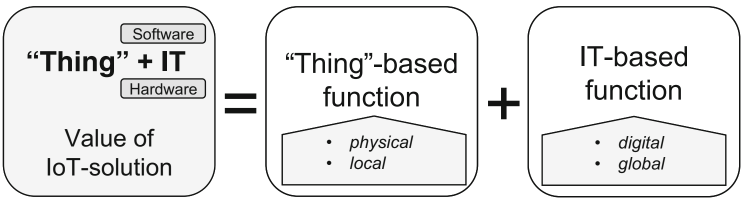

Fig. 2 The hybrid value of IoT solutions, adapted from (Fleisch et al. 2017, p. 8)

2.2 *Value Creation, Value Drivers, and Value Capturing in Traditional Business Environments*

Value creation is the heart of any business model and involves activities that increase the value of offerings either by encouraging the customer's willingness to pay for the offerings or by decreasing the opportunity costs of suppliers and partners (Hui 2014; Zott and Amit 2007). Value creation characterizes the form in which the firm's products and services are bundled to create value for a certain customer segment, i.e., creating the firm's product or services' preferability over a similar offering. The business model concept emphasizes the understanding of value creation as the total value generated for all business model stakeholders (i.e., investors, employees, suppliers, and customers). Therefore, the analysis of value creation must encompass not only the value added by a single firm but also the value bundle created by networks. Typically, value is created through a transaction, which can be described by three components: a transaction object (i.e., a physical product or service), an information stream, and a money stream. In traditional business models, the money stream is exclusively dependent on the prices of the product stream (Bucherer and Uckelmann 2011). Traditionally, the costs and prices of information are integrated into the product itself and do not create value independently.

Value drivers in a traditional business model context refer to the sources of value and the factors that enhance the overall value that a firm creates (Amit and Zott 2001). Amit and Zott (2001) introduced four key drivers for value creation in e-business: novelty, efficiency, complementarities, and lock-in. In an e-business context, novelty means that value is created by, for example, innovating the transaction structures and connecting previously unconnected parties. Efficiency is connected to transactions, in such a way that when the transaction efficiency increases, the costs per transaction decrease, and hence, more value is created. Complementarities mean that value increases by offering bundles of complementary products/services to customers, thereby increasing revenue. Lock-in means preventing the migration of customers/partners to competitors through, for example, digital bonus points, which creates value through the repetition of transactions (Amit and Zott 2001).

Value capturing describes the activities helping the monetization and revenue generation of the created customer value. While value creation focuses on increasing value, value capturing is about how the firm will appropriate some portion of that value for itself (Osterwalder and Pigneur 2005). Traditionally, in selling physical products, firms have focused on capturing value by transferring ownership through a sales transaction of perpetual ownership (Osterwalder and Pigneur 2005). For example, a classic revenue model for many product-oriented companies has been to research, develop, and produce a product that is then marketed in the form of a relatively fixed value proposition for a certain price to the appropriate customer segment. The one-time price paid by the customer for the product is practically the only source of revenue for the company, resulting in a so-called unit-based revenue scheme.

3 Value Creation, Value Drivers, and Value Capturing in an IoT Context

3.1 Potential Impacts of the IoT on Value Creation

The hybrid nature of the IoT construct plays a key role in how value is created in IoT environments. A valuable IoT solution is not just the sum of a physical "thing"-based function and a digital, connected IT-based function but also receives its value from an effective integration of each aspect. Although the "thing"-based function is an integral part of the overall value offering, it does not offer an increased value proposition compared to a "non-IoT thing" (without the addition of the IT-based function) (Fleisch et al. 2017). Therefore, the IT-based function of the hybrid construct appears to be the main value driver for value creation based on an IoT solution. Compared to traditional business models, the IoT helps to separate the IT-based function, and therefore the information stream, from the product and to shape it to become a value and revenue stream on its own. The separation of the information stream enables both the removal of geographical and physical constraints and the commercialization of the information in a virtual market. As a consequence, information represents a value in itself and its accessibility in an information marketplace represents one of the most important characteristics in the value creation process (Bohli et al. 2009; Höller and Karnouskos 2014).

Against this background, in an IoT context, it is important to understand the resource characteristics of information and information services that contribute to value creation. The value of information is nonexhaustive, increases with use, higher resolution (volume, accuracy, number of sources), and higher aggregation, and depends on the timeliness and personalization (Bohli et al. 2009; Bucherer and Uckelmann 2011). Accordingly, the value of information is highly dependent on a personalized actionable aggregation for a specific use case. Therefore, customization is a critical requirement for value creation (and value capturing) based on the information stream. Additionally, the importance of making information accessible and sharing it between information providers in a network becomes apparent (Bucherer and Uckelmann 2011).

The value of IoT applications is dependent on an effective integration of its features. Information is one of the enabling factors in this set. Fleisch (2010), Lee and Lee (2015), and Porter and Heppelmann (2014) identified key functions of IoT applications, driving value creation for customers. These functions can be grouped into three categories: trigger functions, security and validation functions, and customer feedback functions that influence the following capabilities: monitoring, control, optimization, and collaboration. The four capabilities must be considered cumulative. Each capability builds on the underlying functions and results of the preceding one. This ascending building of capabilities results in three modes of value creation facilitated by IoT: manufacturing, supporting, and value co-creation (Mejtoft 2011). The *manufacturing* mode adds value mainly by leveraging efficiency gains of connected things in the production and supply chain. The *supporting* mode is characterized by an increasing sensor density and therefore data density across a multitude of different industries and on different levels of the value network. A co-creative system between manufacturer and customer can be established. *Co-creatio*n represents the highest-level mode of IoT value creation. Whereas in a supporting mode, the IoT simply enabled co-creation between manufacturer and customer, in a co-creation mode, the IoT can now think for itself. Embedded intelligence enables the IoT itself to be the co-creation partner.

3.2 Potential Impacts of the IoT on Value Drivers

The four key drivers for value creation in e-business (Amit and Zott 2001) serve as a basis for identifying value drivers in an IoT context. To categorize value drivers in the IoT context, we rely on the factors of the independent information stream and value networks: customization and value co-creation. As a result, the following six categories for analysis are derived.

First, e*fficiency* represents a value driver in an IoT context, because efficiency comes along with reduced transaction costs that result from the reorganization of activities (Zott and Amit 2010). Given that the IoT can connect a huge number of different parties and span borders of firms and industries (Zott and Amit 2010), the amount of transaction costs plays a crucial role in the question whether activities have the potential to create value. The more efficient the activities are, the more likely they can contribute to firms' value creation.

Second, *network effects* represent a value driver in an IoT context (Bohli et al. 2009; Mejtoft 2011). Network effects are present when the value of a product, service, or technology depends on the number of its users. That is, the value of the entire network increases with the number of users in it (e.g., phones, Internet, social networks). However, to benefit from network effects, a critical mass of users is necessary; and a specific degree of the product or service's value is essential to ensure that other participants join and/or existing participants stay. Therefore, it is important to develop value offerings based on the IoT alongside the IT-based and thing-based functions (Mejtoft 2011). The mutual influence of both elements will be essential for reaching a critical mass and enabling investment in the platforms.

Third, *customization* represents a value driver in an IoT context. Customization offers a method for better differentiating value propositions directly by value, instead of prebundling a value proposition to cater to a market segment. In an IoT context, customizability often persists beyond the time of purchase, resulting in a prolonged value proposition, which can be developed further through IT-based upgrades (Hui 2014; Whitmore et al. 2015).

Fourth, many firms integrate services in their value propositions, a development called "*servitization*" (Kindström 2010). The reason for this integration is that product-based value offerings often come under pressure when commoditization of the market occurs due to increased competition and lower sales margins. The servitization of industries often requires firms to redesign their business models with a service orientation to create additional value. The topic of this so-called servitization and its effect on value creation is of particular interest in an IoT context because the hybrid nature of IoT value leads to always having a service part in the value chain because of the IT-based function, which is based on digital information (Fleisch et al. 2017). Service-based business models come along with a redefinition of the roles of the customer and other partners toward the roles of the co-creator and co-producers in the value creation process (Kindström 2010; Turber et al. 2014). Value for the customer is therefore created by having the ability to be integrated more closely with and earlier into the process of designing a customized value proposition. A problem of basing a large portion of the value proposition in service elements is that customers find it more difficult to appreciate the value of intangible services (Kindström 2010).

Fifth, *shared value drivers* are important in an IoT context. A distinctive feature of the IoT network is the interlinked and coherent nature of firm boundary spanning value delivery. This distinctive feature makes the individual motivations of a focal firm relevant to the entire network and thus creates shared motivations (Westerlund et al. 2014). Because all stakeholders in a network have incentives to increase the value of the platform, every stakeholder has an incentive to support shared value drivers, which are constituted throughout the entire value chain. That is, the value is heavily dependent on the compliance of all stakeholders in reaching a specified value characteristic.

Sixth, the *novelty* of business model elements itself represents an important value driver (Amit and Zott 2001; Zott and Amit 2010). Novelty acts as an amplifying and complementing force in combination with other value drivers. The value of novelty can be leveraged through the aspects of adopting new activities into the value proposition, finding new ways of linking these activities, or innovating the participants and their propositions in the value chain.

3.3 Value Capturing in the IoT

The IT-based function of the IoT also plays a key role for firms regarding value capturing. To identify how the IoT changes the ways of capturing value in this context, the focus lays on the revenue streams. Products become IoT-capable through sensors and connectivity and therefore enable manufacturers to generate additional value for the customer through IT-based functions (i.e., the independent information stream) via, for example, apps for remote control products such as heaters.

Given the independence of the information stream from the physical product, the IoT enables an additional value stream of information to be marketed and monetized independently from other value streams, resulting in completely new but also highly complex possibilities for value capturing. This monetized information stream results in new revenue streams even after the product is sold because software updates and fixes can refresh the value proposition, enable new features, or leverage functionalities for new use cases. This way of capturing value through an information stream is not possible in traditional business models and can extend the use case of a specific product, thus opening up the possibilities for prolonged and increased revenue streams.

At the same time, products of other manufacturers can profit from the generated information: for example, an electronic car maker will profit from data generated by a smart powermeter, which, in turn, profits from smart home data. The influence of a multisided market can result in new configurations of pricing schemes through, for example, ad-supported revenue streams or in exchange for usage data.

Furthermore, pricing schemes need to consider the distinct pricing mechanisms of the physical IoT product on the one hand and the information stream on the other hand, as well as a possible combination of the two. Pricing mechanisms, i.e., the determination of prices for the offered value, can be differentiated into two main groups: *fixed menu pricing* sets predefined prices based on static variables, while *dynamic pricing* sets prices based on market conditions (Osterwalder and Pigneur 2010). Features of IoT solutions enable new possibilities in both categories.

The increased capabilities for customization and co-creation make a virtually boundless variance of value proposition bundles possible. Pricing mechanisms can integrate "versioning" and "add-on" features, which are based, for example, on the resolution or timeliness of data streams (Bohli et al. 2009). Such versioning can also be applied dynamically to allow for a high degree of flexibility and therefore increased value for the customer. For instance, the customer can pay for the weekly aggregation of data but has the flexibility to request a higher granularity (e.g., daily aggregation) for an additional fee.

The addition of an independent value stream based on digital information leads to the possibility of basing revenue mechanisms on parameters other than those that were previously possible in traditional business models, namely, enabling an easier move from unit-based revenue schemes to value-based revenue schemes that are based directly on the value of service and information (Huber and Kaiser 2015; Kindström 2010). As an example, the traditional unit-based sale of cars can move toward selling the value of mobility in the form of revenue schemes based on runtime, distance traveled, or battery charging cycles and, in doing so, attract new customer segments. Another example is the move from per-unit sale of machines and bundled maintenance contracts in manufacturing toward value-based contracts based on, for example, uptime, output, or error rate.

Important factors in realizing such revenue schemes are the technical feasibility of measuring the value parameter and a transparent and clear proposition of the underlying value to the customer. Supplier and customer need to be in agreement on how value parameters are measured and used to determine the pricing (Kindström 2010). This necessity represents a challenge at a current point in time. While usage-based pricing would best leverage the value of information, often a subscription-based model is easier to implement and control by the supplier, because there is no need for metering the usage (Bohli et al. 2009; Bucherer and Uckelmann 2011). The predictable stream of recurring payments reduces revenue and cost volatilities for customers and suppliers alike, making suppliers reluctant to introduce new pricing schemes. The introduction of new pricing schemes is especially relevant because some possible models, such as product-as-a-service, significantly increase the buyer's power, as the buyers can switch between products much more easily in these models than they can with perpetual ownership (Porter and Heppelmann 2014). One possibility for mitigating this problem is to leverage value drivers such as customization and network effects.

It is important to emphasize that value can only be created and captured if the necessary data to build higher-level services are accessible. In turn, a higher value usually necessitates the input, storage, and analysis of more sensitive and higher resolution data (e.g., location and usage data). Accordingly, data providers demand increased compensation for higher value data. It will therefore become essential to transparently and explicitly show data providers how their data are used and what value they, in turn, receive and to incentivize them to continue providing these data (Porter and Heppelmann 2014). Firms need to gauge what data type and in what granularity and time sensitivity is required to deliver a certain value. In the next step, the question regards the degree to which the customer values these parameters and thus the degree to which the customer is willing to pay for the offering based on these parameters (Bohli et al. 2009; Leminen et al. 2015).

4 Discussion

This book chapter explores how the IoT can change the way value is created and captured and how value drivers are impacted by the IoT. Merging knowledge regarding the general characteristics of the IoT with insights on value creation, value drivers, and value capturing in traditional business environments, we demonstrate that the IoT is very likely to change value creation, value drivers, and value capturing in firms.

With regard to value creation, we suggest that the characteristics of IoT solutions (i.e., the independence of the information stream and its accessibility) result in new ways of creating value by commercializing the information stream in a virtual information network. The characteristics of IoT solutions also result in specific drivers for value creation in IoT environments: efficiency, network effects, customization, servitization and value co-creation, shared value drivers, and novelty. With regard to value capturing, we suggest that the new, independently marketed value stream of digital information allows for completely new ways of value capturing in the IoT context by creating new revenue streams for firms by switching from a unit-based revenue scheme to a value-based revenue scheme. This switch of the revenue scheme results in value capturing for the firm even after the physical product is sold.

Against this background, it appears to be obvious that the IoT leads to new business models. These new business models are based on a network-centric view of value creation and the independence of the information stream. That is, the importance of partner networks and creating value by integrating multiple products increases significantly. For the end customer, the value of an offering through the

IoT mainly depends on the degree to which it can be customized and integrated with an already diverse mix of products. Additionally, as customization requires the increased involvement of the customer as a co-creating entity, service orientation and intensified customer relationships gain major importance.

Our findings provide various theoretical and practical implications. From a theoretical perspective, we primarily contribute to the IoT research by focusing on the connected processes of value creation, value drivers, and value capturing. In this context, it is particularly noteworthy that we provide a better understanding of how value creation and value capturing are linked with regard to the specifics of IoT-based environments. For practitioners, first, our work might be valuable because we suggest that firms should assess their value propositions from a network-centric point of view. Instead of using an inside-out perspective and regarding other value offerings as competitors, firms should try to find common ground for generating value inside a network. Second, we suggest that firms should orientate their offerings toward the customization of products and the integration with already existing products owned by the customer. Again, this recommendation is in line with acknowledging the synergetic and complementary value of different solutions instead of following a closed-down, firm-centric bundle of offerings.

As with all research, our work suffers from some limitations. First, we relied on a conceptual approach to investigate value creation, value drivers, and value capturing in an IoT environment. Second, we did not focus on a specific business model framework as a unit of analysis. To address these limitations and to enlarge the interesting and important research field concerning value creation, value drivers, and value capturing in IoT contexts, we encourage future research to narrow down the scope of analysis to a specific industry or to focus on a specific part of the IoT architecture with the help of a specific business model framework (such as on the business model canvas) to gain more detailed findings. Simultaneously, we encourage researchers to conduct empirical research in the future. For example, researchers could perform case studies focusing on specific layers of the IoT or compare firms belonging to different industries in the IoT context.

In conclusion, IoT-specific characteristics shape the way in which value creation and value capturing can be achieved. We hope that this chapter encourages practitioners and researchers alike to consider the IoT from a management, strategy, and/or organizational perspective rather than solely focusing on the technical aspects of this important technology.

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