Behind the scenes of digital servitization: actualising IoT-enabled affordances

Abstract

Manufacturers are increasingly transforming through servitization, and the Internet of Things (IoT) is a crucial enabler of this transformation. Current literature describes the diverse outcomes from IoT that enable servitization but fails to explain the reasons behind the diversity and the processes manufacturers go through to create these outcomes. This study aims to identify these processes by drawing on affordance theory and its core principles of affordance perception (understanding an opportunity provided by technology) and affordance actualisation (taking advantage of an opportunity provided by technology). By using affordance theory to analyse the case scenarios of six manufacturing firms, the study develops a framework to explain the realisation of the opportunities the IoT provides to manufacturers' servitization efforts. The analysis identifies three types of affordances and actualisation processes that help manufacturers realise the opportunities of the IoT. This framework enables manufacturers to systematically manage the contributions from the IoT and the associated actualisation efforts required to advance servitization. The study adds to the understanding of the IoT's role in a manufacturing servitization context.

Keywords: Servitization, IoT, Affordance theory, Manufacturing

1. Introduction

Servitization, at its core, describes a business transformation where manufacturers shift their focus from selling products to offering a combination of products and services (Baines, Lightfoot, Smart, & Fletcher, 2013; Kastalli & Van Looy, 2013). One of the main enablers of servitization is the Internet of things (IoT) (Barrett, Davidson, Fayard, Vargo, & Yoo, 2012; Lerch & Gotsch, 2015; Lightfoot, Baines, & Smart, 2011); a system of uniquely identifiable and connected products ('things') creating an internet-like structure which enables the real-time flow of sensing, operation and location data (Ng & Wakenshaw, 2017). The contribution of the IoT to the servitization domain is emphasised by the dedicated IoT literature. This literature identifies the combination of products and services as an opportune business model to monetise the IoT investments (Ardolino, Saccani, Gaiardelli, & Rapaccini, 2016; Hsu, 2007; Rymaszewska, Helo, & Gunasekaran, 2017). In order to further advance servitization theory and practice, it is critical to understand the processes and mechanisms that underlie the varied opportunities the IoT offers.

The emerging research that specifically explores the intersection between the IoT and servitization domains is captured by the 'digital servitization' notion (Vendrell-Herrero, Bustinza, Parry, & Georgantzis, 2017). Corresponding studies investigate the varied contributions the IoT provides to the servitization context, for example, by examining how its sensing features help to remotely monitor product performance (Rymaszewska et al., 2017) which enables manufacturers to manage the risks inherent in servitization (Benedettini, Neely, & Swink, 2015; Hasselblatt, Huikkola, Kohtamäki, & Nickell, 2018). Other studies examine the IoT's ability to monitor product operations, which support manufacturers in their service design and effective delivery (Ardolino, Rapaccini, Saccani, Gaiardelli, Crespi, & Ruggeri, 2018; Grubic, 2014; Lee & Lee, 2015; Lee, 1998; Levrat, Iung, & Crespo Marquez, 2008).

As the understanding of the different IoT features and their varied contributions to the servitization context are being established (Ardolino, Saccani, & Perona, 2015; Herterich, Eck, & Uebernickel, 2016) a gap is becoming apparent in the understanding of the processes and mechanisms needed to identify and eventually realise these opportunities. A body of research that explores the diverse opportunities the IoT can provide without considering the processes and mechanisms that determine their realisation only allows a partial understanding of 'digital servitization'. To address this gap, the present study aims to expand the research focus from identifying *what* opportunities the IoT can provide to the servitization context to *how* manufacturers identify and realise these opportunities.

This study draws on *affordance theory* to develop a fine-grained understanding of the processes through which the opportunities provided by the IoT are identified and realised. Affordance theory specifically explores the range of opportunities a technology ‘affords’ to its user (Hutchby, 2001; Volkoff & Strong, 2018). However, instead of focusing on technologies’ features on their own to explain a technologies’ outcomes, affordance theory examines the interaction between the organisation’s goals and technology features as the drivers for opportunity creation. In its extension, the theory also explores the actions organisations take to realise the technologies’ various opportunities (Strong, Johnson, Tulu, Trudel, Volkoff, Pelletier et al., 2014; Volkoff & Strong, 2013). By examining the interactions between the manufacturers’ goals and the IoT features, the study develops a framework to explain how manufacturers identify the IoT’s opportunities to enable their servitization efforts and take actions to realise these opportunities.

To develop this framework, the study analysed the servitization of six manufacturers and the role the IoT plays in these. Through cross-case analysis, the study identified various specific affordances and actions that enabled the manufacturers to realise their servitization goals from the IoT technology. In addition, the study identified interactions between affordances (Strong et al., 2014) which explain the complex web of affordance dependencies that underlie the manufacturers’ digital servitization. The rest of the paper is structured as follows. First, the research background is presented to frame the research gap and formulate the research question. The next section outlines the methodology used for data collection and analysis, and this is followed by the presentation of the findings. The study concludes with a discussion outlining the proposed framework, contributions, limitations, and areas for future research.

2. Research background

2.1 IoT-enabled servitization

Servitization, the transformative process of manufacturers shifting their focus towards offering services coupled with their products (Lightfoot & Baines, 2014; Ziaee Bigdeli, Baines, Bustinza, & Guang Shi, 2017), has created substantial interest in practice and research. Manufacturers servitize in order to improve their profit margins, lockout competitors, create sustainable competitive advantage and address market demands (Bustinza, Bigdeli, Baines, & Elliot, 2015; Porter & Ketels, 2003; Raddats, Baines, Burton, Story, & Zolkiewski, 2016). These servitization efforts lead to service bundles that may typically include a warranty, spare parts, repair, maintenance, operator training, condition monitoring, in-field services, customer support agreements, and use or outcome-based contracts (Lightfoot & Baines, 2014).

As a subject of academic enquiry, servitization has been studied from the perspectives of industrial marketing (Kindström & Kowalkowski, 2014; Kohtamäki, Partanen, Parida, & Wincent, 2013; Ulaga & Loveland, 2014), service management (Kindstrom, 2010; Raddats, Burton, & Ashman, 2015) and operations management (Baines, Bigdeli, Shi, & Baldwin, 2016; Baines et al., 2013; Smith, Maull, & Ng, 2014). Over time, the research agenda has opened up from efforts targeted at conceptualising servitization and understanding its benefits (Oliva & Kallenberg, 2003; Wise & Baumgartner, 2000) and implementation challenges (Baines, Lightfoot, Benedettini, & Kay, 2009; Isaksson, Larsson, & Rönnbäck, 2009) to endeavours exploring how digital technologies, such as remote monitoring, information and communication technology, digital platforms, and big data analytics, support servitization (Ardolino et al., 2018; Frank, Mendes, Ayala, & Ghezzi, 2019; Lenka, Parida, & Wincent, 2017; Suppatvech, Godsell, & Day, 2019).

The IoT as a crucial enabler hereby represents a specific focal point when exploring digital technologies in the context of servitization (Ziaee Bigdeli et al., 2017). The IoT can be conceptualised along the dimensions of hardware, middleware, and presentation dimensions (Atzori, Iera, & Morabito, 2010; Gubbi, Buyya, Marusic, & Palaniswami, 2013). The hardware dimension includes identification, sensing and communication technologies, all of which enable remote monitoring (Grubic, 2014; Grubic & Jennions, 2018; Grubic & Peppard, 2016). The middleware dimension captures storage and computing tools for data analytics (Lee, Kao, & Yang, 2014; Opresnik, Hirsch, Zanetti, Taisch, & Isaja, 2014; Ren, Zhang, Liu, Sakao, Huisingh, & Almeida, 2019; Rizk, Bergvall-Kåreborn, & Elragal, 2017; Shukla, Tiwari, & Beydoun, 2019). The presentation dimension includes visualisation and interpretation tools that can be widely accessed and shared (Barrett, Davidson, Prabhu, & Vargo, 2015; Cenamor, Rönnberg Sjödina, & Parida, 2017; Gubbi et al., 2013). These tools and technologies have been recognised as key enabling IoT features in the servitization context (Lee & Lee, 2015; Rymaszewska et al., 2017).

Research has identified a wide range of specific outcomes enabling servitization that are provided by the IoT features (Opazo-Basáez, Vendrell-Herrero, & Bustinza, 2018). The IoT has been shown to provide continuous product-usage visibility, which helps manufacturers to assess operational risks and potential interventions in a servitization context (Ardolino et al., 2018; Vendrell-Herrero et al., 2017). The IoT has also been shown to help servitizing manufacturers develop fault awareness, improve maintenance, enhance equipment design to reduce existing faults, simplify maintenance activities, and inform operator behaviour (Ardolino et al., 2016; Lightfoot et al., 2011). In addition, the IoT has been highlighted for its ability to enable servitizing manufacturers to maintain closer customer relationships by sharing consolidated usage information (Coreynen, Matthyssens, & Van Bockhaven, 2017; Lenka et al., 2017) and educating customers about possible product usage improvements (Ardolino et al., 2018; Frank et al., 2019). With these IoT outcomes enabling a variety of product-service value propositions (Rymaszewska et al., 2017), different revenue models (e.g. pay-per-use, subscriptions) are opening up for manufacturers to capture some of the created value (Coreynen et al., 2017). Although the value-capture mechanisms represent an important part of servitization research, the present study specifically focuses on the IoT's role in enabling the value propositions underpinning servitization.

The IoT encompasses a bundle of features that may contribute to servitization through different outcomes (Bressanelli, Adrodegari, Perona, & Saccani, 2018; Cenamor, Sjödin, & Parida, 2018). As the ways in which the IoT can support servitization appear to be plentiful, considering the IoT on its own as a determinant of these outcomes risks ignoring the impact of the manufacturers' diverse goals and actions when using the IoT. There seems to be a substantial gap in our understanding of how manufacturers perceive different opportunities to use the IoT and how these opportunities are acted upon to create the outcomes to enable servitization. Without understanding the perception and realisation of these opportunities, manufacturers face barriers in making systematic decisions on the effective use of the IoT (Peillon, Dubruc, & Mansour, 2018). In order to address this gap, the present research is focused on answering the pertinent question: *How can manufacturers realise the opportunities from the IoT to enable servitization?*

2.2 Affordance theory

Affordance theory helps to frame the identified research gap and provides a structure to investigate the link between the IoT and its diverse outcomes. According to the theory, an affordance captures an opportunity for action, from technology, which arises from the relation between the technological artefact's features and a goal-oriented actor (Zammuto, Griffith, Majchrzak, Dougherty, & Faraj, 2007). It is based on the notion that an actor can see different opportunities to use an artefact irrespective of what it is designed for. An example of this might be: a chair is designed for sitting on but it could also be used to stand on to reach an overhead object (Strong et al., 2014). The difference in these opportunities is a result of the difference in the actor's goal for using the artefact. Affordance theory emphasises the importance of this difference through *affordance perception* (Volkoff & Strong, 2013), which is the perception of an affordance based on the interaction between an actor's goal and the artefact's features (Markus & Silver, 2008), and *affordance actualisation*, which is the actions required to realise the perceived affordances (Strong et al., 2014).

Along with *affordance perception* and *affordance actualisation* as its two core pillars the theory operates on three main principles (Bernhard, Recker, & Burton-Jones, 2013).

- Artefacts only create affordances when in relation to a goal-oriented actor (Volkoff & Strong, 2018). It is not the technology on its own that determines opportunities for action. Thus, artefact and actor are inseparable when discussing affordance perception (Davis & Chouinard, 2017).
- Although an affordance is a prerequisite for an action, it does not imply that the specific action will or has occurred (Hutchby, 2001). Affordances need to be actualised by a goal-oriented actor in order to achieve an outcome (Volkoff & Strong, 2013).
- Affordances are often cascading. Hence, the perception or actualisation of some affordances depends on the perception or actualisation of other affordances (Bloomfield, Latham, & Vurdubakis, 2010; Strong et al., 2014).

Strong et al., (2014) drew on affordance theory to examine a hospital's digital transformation towards an electronic health record (EHR) system. In order to identify the range of affordances the system could offer and their actualisation, the authors examined the features of the EHR system (artefact) together with the hospital stakeholders' (actors') goals. The authors identified affordances such as *capturing and archiving digital data about the patients* and examined the required actions taken by individual employees to actualise these affordances (for example, *recording all appropriate data and coordinators accessing* *and communicating through the EHR system*). The study not only showed how, through affordance perception and actualisation, the hospital was able to create concrete outcomes (for example, reduce costs, provide high-quality and safe patient care) but also identified affordance dependencies where one affordance was required to perceive or actualise another.

Other studies have used affordance theory, for example, to explain IT-associated organisational change (Markus & Silver, 2008; Strong et al., 2014; Volkoff & Strong, 2013; Zammuto et al., 2007) or IT use (Orlikowski, 2007; Orlikowski & Scott, 2008). The theory has helped researchers to explore IT artefacts as diverse as visualisation software (Van Osch & Mendelson, 2011), simulation software (Leonardi, 2013), electronic health records system (Volkoff & Strong, 2013) or general business systems (Savoli & Barki, 2013; Sebastian, Bui, & Shidler, 2012; Seidel, Recker, & vom Brocke, 2013). In these studies, affordance theory is not only used as a guiding framework to understand technology-based opportunity identification and realisation but also as an analytical tool to structure the actual analysis. Inspired by Strong et al (2014), the theory has been used to guide researchers' coding efforts in different organisational contexts (Dremel, Herterich, Wulf, & Vom Brocke, 2019; Du, Pan, Leidner, & Ying, 2019; Lehrig, Krancher, & Dibbern, 2017; Mallampalli, Safadi, & Faraj, 2018). Affordance theory with its specific constructs has been used as a template to systematically analyse technology-associated organisational change (Volkoff & Strong, 2018).

Affordance theory provides an opportunity to address the current gaps in the digital servitization research by providing a frame to conceptualise the opportunities to use IoT and a template to analyse IoT-enabled servitization scenarios. The application of affordance theory to the digital servitization context expands the research focus from explorations of technology features and a description of outcomes from their use, specifically the IoT as a technology, to investigations of the actor's role in interacting with technological features. Affordance theory provides a theoretical and analytical basis to investigate ***how*** *manufacturers realise the opportunities from the IoT to enable servitization.* In order to answer the research question, the study first seeks to identify the different affordances the IoT provides to the servitizing manufacturers and then to develop a framework to explain the actualisation of these affordances to enable servitization.

3. Methodology

3.1 Data collection

A multiple-case study methodology was chosen to address the above research question and objectives. Multiple case studies allow researchers to explore new theory (Beverland & Lindgreen, 2010), investigate a theory's boundaries and relationships with a phenomenon of interest (here: the IoT contribution) and context (here: servitization) (Yin, 2009) and add breadth and depth to the collected data (Kindstrom, 2010).

In order to explore how manufacturers use the IoT to enable servitization, the study followed Seawright and Gerring's (2008) case selection objectives for exploratory multiple-case research. Their case selection objectives focus on the need to 1) capture a representative sample with regards to the core area of interest to be able to generalize the findings, and the need to 2) vary the dimensions of interest to add critical richness to the data (Silverman, 2015).

To identify a representative sample for the study, our case selection focused on identifying (a) multinational manufacturers that (b) produce IoT-enabled products which (c) are offered in form of product-service bundles (d) to industrial customers. Criteria (b) and (c) were motivated by the particular nature of the research question (i.e. 'establishing the opportunities from the IoT to enable servitization'). Criteria (a) and (d) were established to account for the observation that the bulk of servitization research focuses on multinational companies and industrial customer relationships (Baines et al., 2010; Baines et al., 2014; Rymaszewska et al., 2017), providing an opportunity for our findings to contribute to an emerging cumulative research tradition. Within this scope, we sought to select companies from different industry sectors to ensure the contributions are relevant and useful for the wide range of industries that are currently engaged with servitization (Mastrogiacomo et al., 2019).

In order to identify candidate cases based on these criteria, we reviewed a wide range of secondary data sources, such as websites, brochures, news articles, and videos (Baines et al., 2013; Ziaee Bigdeli et al., 2017). The details gathered from these sources helped to obtain insights into the nature of the manufacturer's IoT-enabled product, the specificities of the product-service bundle offered and its geographical spread of operations (to confirm its status as a multinational company). To gather interest in participation and verify eligibility, managing directors (or equivalent) were approached through emails and/or phone calls. As a result, six candidate cases agreed to participate in this study. Table 1 describes the range of manufacturers that were eventually used for data collection and highlights the multinational context (i.e. operations in more than one country) and a diverse range of industries of the identified manufacturers. The within-case analysis provides details on the manufacturer's core products and the specific IoT-enabled product-service bundles being offered.

Table 1 Case description

Case	Manufacturer			Interviewee		Additional data
	Product	**HQ**	**Staff**	**Position**	**Years in org.**	
Alpha	Healthcare technology	Sweden	4000	VP Global Services IoT program director	14 13	a, b, c, d, e
Bravo	Life sciences technology	Sweden	10,000	Director Connected Solutions	10	a, b, c, e
Charlie	Food processing technology	Germany	19,000	Head of Global Service Operations	13	a b, d
Delta	Infrastructure technology	USA	4000	Director Business Development	18	a, b
Echo	Material-handling technology	USA	10,000	Director of Global Service Solutions	10	a, d
Foxtrot	Banking and retail hardware	USA	23,000	VP Global Services	19	a, b, c
a=official websites, b=brochures c=news articles, d=videos, e=internal reports						

The data collection focused on interviews to obtain rich insights into the ways manufacturers use the IoT to enable their servitization. This specific research focus on the IoT/servitization intersection required access to interview participants that have insights and exposure to both perspectives. Due to this specific focus, the data collection took place in the form of expert interviews (Bogner & Menz, 2009). Expert interviewing describes a data collection strategy that focuses on individuals that stand out for their knowledge, designation, education, practice or experience on a particularly complex topic. It is considered an apt strategy to explore complex phenomena that can only be explained by individuals that have the encompassing insights required to shed light on the issue of interest (Meuser & Nagel, 2009).

To provide the necessary insights, representatives with a detailed understanding of the manufacturer's servitization as well as its IoT artefacts were required (Rymaszewska et al., 2017; Coreynen et al., 2017). Across the manufacturers, only a select number of representatives met these criteria. Therefore, only one or two interview partners were identified as interviewees, which is in line with other studies drawing on expert interviews (Herterich et al., 2016; Long, Blok, & Coninx, 2016; Matthyssens & Vandenbempt, 2008). All interviewees had an engineering background and several years of experience in leading the development and delivery of servitized offerings. They also had responsibilities for overseeing interactions with the IoT development teams and providing them with senior-level guidance on the service-based requirements. Table 1 captures the position and experience of the interviewees.

The data collection was informed by the guiding principles and key constructs of affordance theory (see Section 2.2), which were adapted to cater to the specific context of the study (Yin, 2013). The data collection was carried out in the form of semi-structured interviews with questions focusing on: (1) the firm's current product, services and servitization motivations; (2) the role and details of the IoT within these services; (3) the actions taken to integrate the IoT, and (4) the outcome of the integration. Two researchers were responsible for conducting the interviews, which allowed the researchers to maintain clarity and consistency in the interview process, as well as ensure the dependability of the research (Guba & Lincoln, 1994). The interviews lasted between 45 to 60 minutes for each respondent, and were recorded and subsequently transcribed.

In addition, secondary sources of data in form of publicly available information material (e.g. website) internal company material (e.g. internal reports, brochures) were collected providing important insights on the manufacturer's service offering and detailed descriptions of their service delivery (Table 1). The researchers used the secondary sources to corroborate the interview data by confirming stated details on the manufacturer's servitization objectives and technology use (data triangulation; Yin, 2009). The secondary data sources were also used to supplement the interview data with additional details on the service offerings, hereby expanding the scope and depth of data available for analysis. All primary and secondary data were used for further analysis and formed the basis for the identification of the IoT affordances.

3.2 Data analysis

The data analysis was conducted by two researchers and based on thematic analysis (Aronson, 1995; Vaismoradi, Turunen, & Bondas, 2013). A deductive coding process was used based on theory-derived categories to focus the analysis on aspects of data directly addressing the research question and to accommodate the adopted theoretical framework (Braun & Clarke, 2006; Braun, Clarke, & Terry, 2019; Joffe, 2012). Thematic analysis has been successfully used in previous servitization studies (Cenamor et al., 2017; Lightfoot et al., 2011; Raddats et al., 2016; Story, Raddats, Burton, Zolkiewski, & Baines, 2016; Zhang & Banerji, 2017).

The coding was formalised through the use of a codebook containing the information on the codes, how to identify them, and data examples (Boyatzis, 1998; Braun et al., 2019). The codebook developed for this study included the key constructs of affordance theory (Table 2). The *features of IoT* captured the wider IoT technology that plays a role in the servitization effort, including remote sensors and communication modules that are integrated into the manufacturers' products. The *manufacturer's goal* captured the manufacturers' specific organisational goal that they want to achieve through servitization. The *affordances* captured the particular opportunities perceived by the manufacturers to use the IoT within the context of the organisational goal. The *actions* captured the specific actions taken by the manufacturers to actualise the perceived affordances leading to servitization-enabling outcomes, identified as *outcomes.* The researchers also used the secondary sources of data to verify the interviewee responses, specifically in terms of the *IoT features* (official websites and product/service brochures), and the *manufacturers' goals* (news articles and videos). This also aided the interpretation of the interviewee responses with respect to the key constructs of affordance theory.

The codebook and its categories were first used by two of the researchers independently to analyse part of the data. The researchers then compared and subsequently refined the codes until there was an agreement on their application. The researchers then replicated the agreed coding technique for the rest of the data (Braun et al., 2019).

Next, the researchers used the coded data to identify themes - meaning-based observations derived from the codes (Braun & Clarke, 2006) which are presented in a coherent and compelling form. An iterative 'define and refine' process (Braun & Clarke, 2006) was used to verify the identified themes and consolidate their different interpretations (for example, integrating 'knowing what the product does', 'how does the customer use our product? what does our product do for the customer?' into the theme 'understanding product usage'). The theme-identification sought to ensure internal coherence, consistency but also distinctiveness among the themes (Braun & Clarke, 2006). Table 2 presents theme-identification examples using affordance theory as the underlying analytical framework.

Table 2 Codebook example

Code	Definition	Example (Case Delta)	Themes
Manufacturer's goal	The reason behind the manufacturers' decision to servitize (Raddats et al., 2016).	'Well, we say we provide them with data that allowed them to manage their business better, so, and their field better, so it's really	Improve customers' product utilisation

		about providing data and the data we give them is utilisation data.'	
IoT features	A distinctive attribute, aspect, or ability of the IoT (Strong et al., 2014).	'Information about the location of the machine. So, where it's located. It's not through GPS, but through cell phone triangulation which means it's not just very, it's perfectly accurate.'	Location monitoring
Affordance	An opportunity for action arising from the relation between a manufacturers' goal and features of IoT (adapted from Strong et al., 2014).	'A lot of our customers have multiple sites, they move the machines, especially contract cleaners, move machines around a lot because they move from one contract to another or they swap machines between sites.'	Ensure authorised machine movement
Actions	The actions taken by the manufacturer to take advantage of the affordances through its use of IoT (adapted from Strong et al., 2014).	'So, keeping track of their machines is critical for them.'	Monitor and record data of machine movement across customer sites
Outcomes	A specific expected outcome from actualisation that is viewed as useful for realising the overarching motivation to servitize (adapted from Strong et al., 2014).	'So, through the system, they can locate the machines and, when they move, they get an alert that the machine is being moved, moved away, outside the zone, so the triggers an action too.'	Customer notifications when a machine changes sites or is lost

Table 3 Codebook example

Once the themes were identified, the researchers used these to analyse each individual case in the form of a within-case analysis (see Table 3). The themes were arranged in a tabular form based on the structure provided by affordance theory. This allowed the researchers to become familiar with each case and let the unique patterns emerge on an individual-case level before they were generalised across all the cases (Eisenhardt, 1989; Voss, 2010).

The subsequent cross-case analysis focused on considering the structured tables of the within-case analysis and comparing the patterns observed. This led to a cumulative list of themes, and the identification of commonalities and relationships between the themes that were relevant to the research question (see Tables 4 and 5). Finally, a pattern-matching logic was used to verify the congruence between the observed relationships in this study and the theoretical relationships as stated in the affordance theory, such as affordance perception, actualisation, and dependency (Sinkovics, 2018). The pattern-matching exercise allowed researchers to address the research question satisfactorily, as well as to ensure the rigour and relevance of their findings by maintaining consistent alignment with the key principles of affordance theory. The analysis explicitly sought to draw on established concepts of affordance theory (Strong et al., 2014; Zammuto et al., 2007) to ensure theoretical rigour in the analysis, and to provide contributions to the context of IoT-enabled servitization for the wider development of affordance theory.

4. Findings

4.1 Within-case analysis

This section provides a brief overview of the individual servitization cases and the within-case analysis findings of the identified instances of affordance perception (interactions between manufacturers' goals and the IoT features) and affordance actualisation (actions that lead to desired outcomes). The full range of the affordance perception and affordance actualisation instances identified are presented in Table 3. The individual case descriptions provide examples to illustrate the manufacturers' affordance perceptions and actualisations.

The case company Alpha is an established international manufacturer of high-value healthcare technology. Its organisational goal was *to improve service efficiency*. Alpha's initial perception of the IoT affordances (i.e. its recognition of the opportunity for action the IoT represents) focused on the IoT's ability to support its goal through its opportunity to detect problems remotely. Alpha took the action of establishing remote connections with its products. The actualisation of this affordance provided live usage data as an outcome which gave rise to further opportunities:

> *Our old mentality was if we can collect as much data as we possibly can from the machine, at some point in the future we can mine that data and do something with it. Actually, what happened is we collected and discarded billions and billions of rows of data on a weekly basis and we never did anything with it.*
>
> (VP, Global Services, Alpha)

Alpha's further range of affordance perception and actualisation instances are presented in Table 3.

Bravo is an international manufacturer of high-tech healthcare and life science technologies. Its goal was *to improve its reactive services (maintenance and repair)*. Table 3 shows how, considering the IoT technology, Bravo perceived the evaluation of its products' conditions as a desirable IoT affordance which was actualised by analysing the product data via remote connections, resulting in condition reports. Through these condition reports, Bravo could analyse and identify trends of wear and tear and was able to develop effective maintenance scheduling.

Charlie is a manufacturer for process technology in the food industry. The goal was *to enhance the performance of its products.* Within its considerations of the opportunities the IoT technology offered (Table 3), decision-makers perceived an affordance to support customers with their efforts to self-maintain their products and actualised this affordance by developing and sharing insights on efficient maintenance and product service using the live monitoring data. The actualised IoT affordance was used to strengthen the customers' dependence on Charlie.

Delta is an international infrastructure technology manufacturer, serving various industries. The organisational goal of Delta's servitization was *to improve its customers' product utilisation*. Table 3 shows that in the context of this goal, Delta perceived the IoT to provide an opportunity to understand product usage through its remote monitoring features, which resulted in product usage reports after it actualised the affordance by connecting to its product. Further data analysis provided opportunities to ensure product uptime and identify quick-fix solutions.

> *Well, we say we provide them with data that allows them to manage their business better… so it's really about providing data and the data that we give them is utilisation data, so that allows them to see whether the equipment is consistently being utilised or over utilised or underutilised.*
>
> (Director, Business Development, Delta)

Echo is a manufacturer of heavy lifting and material-handling equipment. Its goal was *to expand its service portfolio*. Among the range of IoT opportunities that the decision-makers at Echo perceived was that IoT technology provides an opportunity to reduce maintenance costs and product damage and optimise parts replacement. Through the actualisation of these affordances, Echo was able to create outcomes such as improved engineer deployment (avoiding multiple visits to customer sites), better customer education to reduce faults, accidents, product damage, and part replacement needs.

Foxtrot is a manufacturer of banking and retail hardware. Its goal was *to increase product availability and customer satisfaction*. Table 3 shows how its consideration of the IoT technology helped the company to see an opportunity to improve its maintenance schedules. They actualised this affordance by analysing product usage logs in order to identify future maintenance requirements and enabling the company to prioritise its engineer deployment.

Table 3 Summary of within-case analysis

Case	Perception			Actualisation	
	Manufacturer's goal	**IoT features**	**Affordances**	**Actions**	**Outcomes**
Alpha	Improving service efficiency	Remote monitoring	**Remotely detect problems**	Establish remote connections and collect usage data	**Access to live usage data and connectivity**
		Live usage data	**Understand product usage**	Contract third party for data analytics	**Data analytics used to identify patterns of anomalies**
		Data analytics	**Identify common faults**	Analyse data for alarm scenarios using experienced engineers	**A portfolio of alarm scenarios is generated**
		DA and alarms	**Reduce fault occurrence**	Analyse data to identify the cause of common faults	**Improved product design and reduced faults**
		Data analytics	**Reduce shutdowns due to maintenance**	Analyse data to predict maintenance of machines	**Customers notified and maintenance scheduled advance**
		Data analytics	**Improve customers' business process**	Analyse usage and commercial data to advise customers	**A new stream of revenue based on performance advisory services**
Bravo	Improving reactive services	Remote monitoring	**Understand product usage**	Establish remote connections from a pilot project	**Access to live usage data and connectivity**
		Live usage data	**Evaluate product condition**	Collect product usage data to evaluate the product	**Generation of detailed condition reports**
		Condition reports	**Identify operational faults**	Analyse data to develop fault alerts	**Customers informed about live condition and faults**
		DA and condition reports	**Improve maintenance efficiency**	Analyse data to identify trends of wear and tear	**Effective scheduling of maintenance visits and resource allocation**
		Data analytics	**Ensure uninterrupted operations**	Collect and monitor data to evaluate the quality of incoming utilities	**Customers alerted about impure utilities to protect the product**
		Condition reports	**Identify the causes of faults**	Analyse condition reports to identify causes of faults	**Able to educate customers to avoid poor usage**
		Data analytics	**Manage customers' consumables stock**	Analyse data to identify the consumables levels	**Able to offer customers stock management**
Charlie		RMT and DA	**Estimate product status**	Collect data and find a partner to co-analyse with	**New analytics and live monitoring tool**

	Enhancing product performance	Data analytics	**Identify potential faults**	Analyse data using experiential knowledge	**Insights on potential faults that trigger maintenance requirements**
		Data analytics	**Reduce fault occurrence**	Analyse data to detect and predict faults	**Preventive response to predicted faults**
		Automated DA	**Respond to faults more quickly**	Analyse data automatically	**Automatic fault detection and alerts**
		Data analytics	**Reduce breakdowns**	Analyse data to predict faults	**Customers informed about predicted faults**
		Data analytics	**Help self-serve customers**	Develop insights about product maintenance and repair for self-serve customers	**Self-serving customers locked in**
		Data sharing	**Share insights with customers**	Develop insights to be shared through a central access portal	**Centralised access to insights for the company and customers**
Delta	Improving customer's product utilisation	Remote monitoring	**Understand product usage**	Connect to product and collect usage data	**Established connections and generation of product usage reports**
		Data analytics	**Ensure product uptime**	Analyse data to diagnose and fox problems ASAP	**Prompt problem-solving to ensure uptime**
		Data analytics	**Fix faults immediately**	Analyse data to identify faults that can be fixed by the customers	**Quick solutions for faults solved without engineers**
		Location monitoring	**Ensure authorised machine movement**	Monitor and record data of machine movement across customer sites	**Customer notification when machines change sites or are lost**
		Remote monitoring	**Ensure product condition and availability**	Analyse remote data to identify faulty operations	**Customer education about faulty operational practices**
		Data analytics	**Help customers make the right product choices**	Analyse data to identify under and over utilised products	**Customer trust and reduced customer proximity because of performance advisory**
		Data analytics	**Improve customers' business process**	Analyse data across customers to advise on improving business performance	**Better utilisation of the product across the portfolio of customers**
		Data analytics	**Reduce customer costs**	Analyse data to provide insights in reducing operational costs	**Improved business performance due to performance advisory**
Echo	Expanding service portfolio	Remote monitoring	**Understand product usage**	Establish connections to products onsite and collect data	**Live usage data ready to be analysed**

		DA and live usage logs	**Reduce repair costs**	Analyse data to identify areas of possible faults or maintenance	**Identification of possible faults and maintenance requirements**
		Data analytics	**Reduce maintenance costs**	Analyse data to detect faults accurately and associate error codes	**Effective engineer deployment avoiding multiple visits**
		Remote monitoring	**Reduce product damage**	Monitor data to identify faulty operations	**Customer education to reduce faults, accidents and product damage**
		Data analytics	**Collect replacement pre-orders**	Analyse data to identify parts requiring replacement	**Customer education on the need to replace parts**
Foxtrot	Increasing product availability and customer satisfaction	Remote monitoring	**Understand product usage**	Establish remote connections and collect usage data	**Remote connections, usage logs and fault history**
		DA and usage logs	**Improve maintenance schedules**	Analyse usage logs to identify maintenance requirements	**Engineer deployment based on the priority of required maintenance**
		Automated DA	**Ensure product uptime**	Automatically analyse data to predict maintenance	**Timely maintenance conducted, avoiding breakdowns**
		RMT and DA	**Increase product usage in customer business**	Collect and analyse data from product-environment to develop actionable insights	**Advisory services for customers and increased proximity**
		RMT and DA	**Provide transparent data access**	Develop and share insights on a central platform	**A central platform to access insights and machine information**
					Legend: RMT- Remote monitoring, DA- Data analysis

Table 3 presents the range of IoT affordance perception and actualisation instances identified within each of the cases. It is of particular interest to recognize the diversity of affordances that contribute to the manufacturer's goal and the different ways in which they contribute. For example, several of the manufacturer's goals identified entailed implications for the product maintenance process: In this context, the study identified customer-facing affordances that reduce unplanned downtime ('reduce shutdowns due to maintenance') but also minimize the extent of the downtime ('improve maintenance efficiency'); yet, in the same context, affordances were also identified that provide direct opportunities for the manufacturer itself to reduce its maintenance effort ('reduce maintenance costs') and support its workforce planning ('improve maintenance schedule'). Although these affordances all contribute to the manufacturer's goals, they highlight distinct opportunities which require distinct actions for their realisation.

4.2 Cross-case analysis

The within-case analysis provided a wide range of affordances (opportunities for action) that are perceived based on the manufacturer's goals. The cross-case analysis explores the mechanism explaining the actualisation of these affordances, and also identifies their cascading dependence, which is critical for understanding the way IoT enables servitization.

4.2.1 Affordance actualisation mechanism

In congruence with the core principles of affordance theory (Strong et al., 2014), the identified affordance instances are based on interactions between the manufacturer's goal and the IoT features (illustrated in Figure 1).

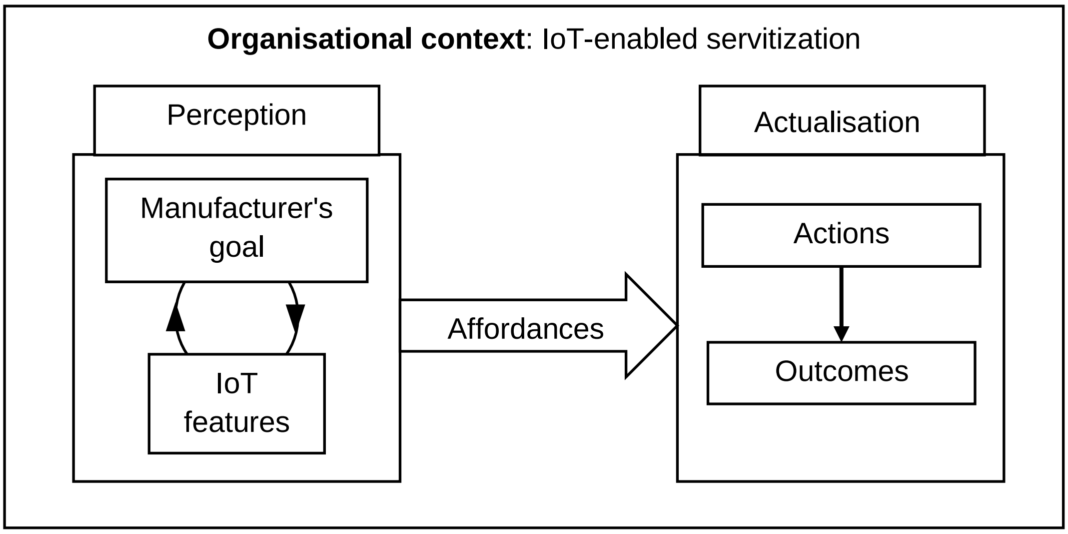

Figure 1 Affordance actualisation mechanism

The cross-case analysis identified a limited number of key IoT features (i.e. remote monitoring, data analytics, data sharing), which in interaction with the diverse manufacturers' goals created 28 of the 37 different affordances across the cases. The emergence of affordance diversity highlights the important role of manufacturers' goals in the affordance perception process.

The cross-case analysis also recognised a limited range of common actions (i.e. connect to the product, monitor product, collect data, analyse data, and develop insights) that are central for the actualisation of the 37 identified affordances. However, certain actions, such as *collaborating with a third party* and *find a partner to co-analyse* also point to unique efforts that some manufacturers make to actualise their affordances.

4.2.2 Affordances and their outcomes

The cross-case analysis also provided insights into the type of opportunities that the identified affordances provide to the manufacturers and the specific outcomes they create when actualised. As part of the analysis, we categorised the affordances based on their contributions into first-, second-, and third-order affordances. The outcomes from their actualisation were categorised as basic, internal, and external outcomes.

The analysis identified those affordances where the manufacturer uses the IoT features to establish basic remote connectivity and to collect operational data as **first-order affordances** (table 4). These affordances include examples such as *remotely detect problems* (Alpha) and *evaluate product condition* (Bravo). Alpha actualised their perceived affordances by taking the action of '*establishing remote connections'* which created '*access to live usage data'* as an outcome. Bravo actualised their perceived affordance by taking the action to '*Collect product usage data to evaluate the product'* which created '*Generation of detailed condition reports*' as an outcome. To distinguish these first-order affordance outcomes from the outcomes of higher value affordances, we label them as **basic outcomes.**

Interestingly, the analysis shows that the basic outcomes serve as IoT features for the perception of more affordances. The case of Bravo is used to illustrate the nature of the step-wise affordance actualisation and outcome creation. For Bravo, which seeks to improve its reactive service provision (manufacturer's goal), the IoT with its 'live usage data' (IoT feature) provides an important prospect as it offers the opportunity to remotely evaluate the condition of its product (affordance). However, in the interview, the company representative explains a range of activities required by Bravo to capture this opportunity (actualisation).

Capturing this critical opportunity required Bravo to actively ‘collect product usage data to evaluate the product’ in order to get an initial understanding of product behaviour and to calibrate the interpretation of its data. The actualisation of this affordance provides Bravo with ‘generation of detailed condition reports’ as its immediate outcome. Similar instances for other case studies are summarised in Table 3.

Table 4 First-order affordances and outcomes

1^{st}-order affordances	Basic outcomes
Remotely detect problems	Access to live usage data and connectivity
Understand product usage	Access to live usage data and connectivity
Evaluate product condition	Generation of detailed condition reports
Estimate product status	New analytics and live monitoring tool
Understand product usage	Established connections and generation of product usage reports
Understand product usage	Live usage data ready to be analysed
Understand product usage	Remote connections, usage logs and fault history

Those affordances that allow manufacturers to improve their business performance, thus achieving higher-value outcomes, were grouped as **second-order affordances** (see Table 5). The analysis showed that manufacturers use initially created basic outcomes, such as *usage data* to perceive high-value second-order affordances, such as *improve maintenance efficiency* (Bravo) or *reduce fault occurrence* (Charlie). By actualising the affordance: improve maintenance efficiency, Bravo created the outcome *effective scheduling of maintenance visits and resource allocation.* Similarly, by actualising the affordance: *reduce fault occurrence*, Charlie created the outcome: *Preventive response to predicted faults.* These outcomes demonstrate how second-order affordances allow manufacturers to improve their business performance. Because the impact of these outcomes directly contributed to the manufacturers’ internal businesses, we labelled the outcomes of the second-order affordances as **internal outcomes**. The improved internal business performance allowed the manufacturers to guarantee the performance of their products in the customers’ businesses, further unlocking new opportunities to support their customers’ businesses.

Table 5 Second-order affordances and outcomes

2^{nd}-order affordances	Internal outcomes
Identify common faults	A portfolio of alarm scenarios is generated
Reduce fault occurrence	Improved product design and reduced faults
Reduce shutdowns due to maintenance	Customers notified and maintenance scheduled in advance
Identify operational faults	Customers informed about live condition and faults
Improve maintenance efficiency	Effective scheduling of maintenance visits and resource allocation

Ensure uninterrupted operations	Customers alerted about impure utilities to protect the product
Identify fault causes	Able to educate customers to avoid poor usage
Identify potential faults	Insights on potential faults triggering maintenance requirements
Reduce fault occurrence	Preventive response to predicted faults
Respond to faults more quickly	Automatic fault detection and alerts
Reduce breakdowns	Customers informed about predicted faults
Ensure product uptime	Prompt problem-solving to ensure uptime
Fix faults immediately	Quick solutions for faults solved without engineers
Ensure authorised machine movement	Customer notification when machines change sites or are lost
Ensure product condition and availability	Customer education about faulty operational practices
Reduce repair costs	Identification of possible faults and maintenance requirements
Reduce maintenance costs	Effective engineer deployment avoiding multiple visits
Reduce product damage	Customer education to reduce faults, accidents and product damage
Improve maintenance schedules	Engineer deployment based on a priority of required maintenance
Ensure product uptime	Timely maintenance conducted, avoiding breakdowns
Increase product usage in customer business	Advisory services for customers and increased proximity

Those affordances that allow manufacturers to support their customers' businesses, thus achieving even higher-value outcomes were termed as **third-order affordances** (see Table 6). These include affordances, such as *reduce customer costs* (Delta) and *help self-serve customers* (Charlie). By actualising the affordance: *improve the customers' businesses*, Delta was able to create the outcome: *better utilisation of the product across the customer's portfolio*. Charlie was able to create the outcome: *lock-in new customers* by actualising the affordance: *help self-serving customers*. Actualising third-order affordances led to outcomes that have an impact on the customers' businesses – therefore, being external to the manufacturer. Hence, we termed these as **external outcomes**.

Table 6 Third-order affordances and outcomes

3rd-order affordances	External outcomes
Improve customers' business processes	A new stream of revenue based on performance advisory services
Manage customers' consumables stock	Able to offer customer stock management
Help self-serve customers	Self-serving customers locked in
Share insights with customers	Centralised access to insights for the company and customers
Help customers make the right product choices	Customer trust and proximity from performance advisory
Improve customers' business process	Better utilisation of the product across the portfolio of customers
Reduce customer costs	Improved business performance due to performance advisory
Collect replacement pre-orders	Customer education on the need to replace parts
Provide transparent data access	A central platform to access insights and machine information

4.2.3 Affordance dependency

While the identification of different affordances provided important insights, the dependence among these affordances emerged as a crucial finding to explain IoT-enabled servitization. The analysis identified the three types of affordances to be connected in a sequentially progressive manner linking the outcome of the first-order affordances (basic outcomes) to the perception of second-order affordances, with its outcome (internal outcome) contributing to the perception of the third-order affordances (see Figure 2). Hence, the actualisation of the third-order affordances is, in effect, dependent on the actualisation of the second-order affordances, which in turn are dependent on the actualisation of the first-order affordances. The recognition of these affordance dependencies is critical for explaining the IoT contributions for servitization.

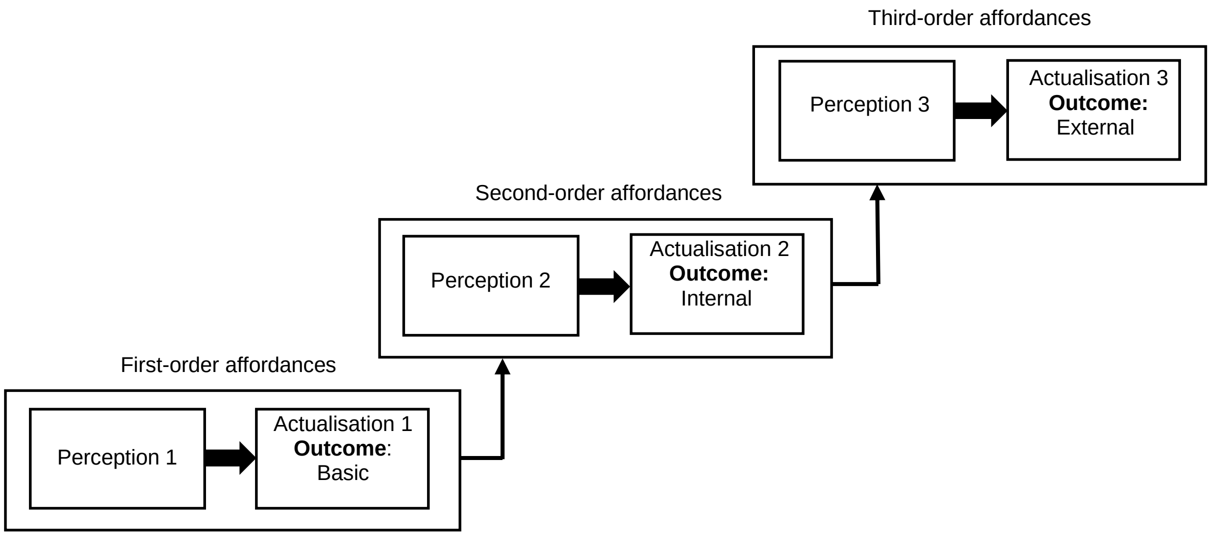

Figure 2 IoT-enabled affordance framework

These dependencies became apparent through Table 3 by applying the categorisation of affordances and their outcomes to individual cases. For example, consider the case Alpha. To develop a *new stream of revenue based on performance advisory services* as a high-value service offering to its customers, Alpha had to perceive and actualize the third-order affordance: *improve customer's business process*. Before attempting to support the customer's business through these third-order affordances, the manufacturer had to ensure that their business process and the product perform optimally. This was achieved through the internal outcomes - *customer notification and maintenance scheduling* and *improved product design and reduced faults* create. These internal outcomes were created by actualising the second-order affordances - *reduce shutdowns due to maintenance* and *reduce fault recurrence*. In order to perceive these second-order affordances, which allow the manufacturer to analyse data to improve its product's performance, the manufacturer required established remote connections and collected data. These requirements were provided by the basic outcomes that were created by actualising the first-order affordances: *identify common faults*, *understand product usage* and *remotely detect problems*.

Similar affordance dependency can be observed in the other cases outlined in table 3, such as Bravo, where the first-order affordance - *manage customers' consumables stock* is dependent on the actualisation of the second-order affordances - *identify operational faults*, *identify fault causes*, *improve maintenance efficiency* and *ensure uninterrupted operations*. These second-order affordances, in turn, are dependent on the actualisation of first-order affordances - *understand product usage* and *evaluate product condition*. Recognising the dependence among these affordances is critical to explain the contribution the IoT provides to servitization.

5. Discussion

5.1 Emergent features

The study set out to show '*how manufacturers realise opportunities from IoT to enable servitization'.* The question was motivated by the need to explain the diversity of outcomes created using the IoT. This required us to move away from the assumption that the IoT creates enabling outcomes on its own through a direct link between the IoT and the outcome. We adopted affordance theory, which suggests outcomes from technology are a result of an actor's actions on opportunities that are perceived from the relationship between the technological features and the actor's goal (Strong et al., 2014).

On the one hand, this study confirmed many of the IoT features that are already established in the extant literature. We identified *remote monitoring* (Grubic & Jennions, 2018; Grubic & Peppard, 2016), *data analytics* (Opresnik & Taisch, 2015; Shukla et al., 2019) and *data sharing* (Barrett et al., 2015; Cenamor et al., 2017) as the key features of the IoT in the context of servitization (Lee & Lee, 2015).

On the other hand, the study showed that the features of the IoT emerge with use; for example, *collection of usage data* is also a crucial feature of the IoT, although it was found to emerge as a result of using the IoT for monitoring product usage. This finding supports Orlikowski's (2007) notion that the features and usefulness of digital technology evolve with its contextual use.

The IoT appears to be a technology that has emergent features, which develop based on the way the IoT is used. Hence, the affordance theory is a fitting theoretical lens to investigate IoT usage as it focuses on the organisational context in which the IoT is used, and does not limit the research to technology.

5.2 Affordances and their dependency

Our study has identified a step-by-step mechanism through which the IoT creates organisational outcomes (Figure 1), while most other studies tend to conceptualise a direct link between the IoT and its contributions. Porter and Heppelmann (2014), for example, map out a large variety of contributions that the IoT can provide to manufacturers and their products, but do not specifically explain how these contributions are created.

Our study emphasises the perception of affordances (opportunities can only be perceived in the specific context of a manufacturer's goal) and the distinction between perception and actualisation (as perception does not indicate the achievement of an outcome) (Hutchby, 2001). Hence, we identified and disentangled the affordances perceived by manufacturers, which allowed us to examine them individually. This meant it was possible to look at the different steps required to perceive and actualise the affordances. The study identified three types of affordances (opportunities) arising from the use of the IoT to enable servitization, namely first-order, second-order, and third-order affordances. Additionally, the affordances were found to be dependent on each other. The study shows how the use of the IoT in a servitization context creates a complex web of dependent opportunities to create outcomes instead of the direct outcomes suggested when looking at the IoT as a technology. This allows us to explain the realisation of the opportunities the IoT offers and encourage us to be aware of the factors that could impede this realisation processes.

The identification of these dependencies within IoT-enabled servitization adds to other studies that specifically focus on the bundling of different technologies to enable servitization, (Ardolino et al. 2015) or the bundling of different service offerings (Smith et al. ,2012; Baines et al., 2014). However, our study establishes the IoT-based affordance dependency as a key framework that describes IoT-enabled servitization. This perspective integrates the interaction among manufacturers' goals, features of IoT, and the manufacturers' actions making the affordance dependency framework (see Figure 2) a crucial cumulative finding of the study that addresses the research question.

5.3 Actions and outcomes

The literature has previously discussed various outcomes from the IoT that enable servitization (Ardolino et al., 2018; Kinnunen & Turunen, 2012; Parida, Sjödin, Wincent, & Kohtamäki, 2014; Zancul, Takey, Barquet, Kuwabara, Cauchick Miguel, & Rozenfeld, 2016). The study not only confirms these outcomes but also adds to the list along with a clear categorisation based on the impact of the outcomes. More importantly, the study also explains the diversity of these outcomes through consideration of the manufacturers' role behind their creation.

The study identifies manufacturers' specific actions that realise the affordances, such as *connect to the product, monitor product, collect data, analyse data* and *develop insights.* These actions further our understanding of the IoT's ability to enable servitization by indicating that the IoT can create diverse outcomes that enable servitization but requires the manufacturers to take specific actions. This is highlighted by affordance theory and its emphasis on the potential for action. This perspective will be useful in future research to explain the impact created from IoT usage. Following these actions, the outcomes identified in this study were explained as *basic outcomes, internal outcomes,* and *external outcomes.* Basic outcomes relate to the collection of information about the product and providing clear visibility of the product usage, which have been known to be important outcomes from using the IoT (Vendrell-Herrero et al., 2017). Internal outcomes relate to the optimisation of manufacturers' internal service design or delivery, such as maintenance and repair activities, which are also found to be a crucial IoT contribution to enable servitization (Ardolino et al., 2016; Lightfoot et al., 2011). External outcomes that allow manufacturers to support and help improve their customers' businesses were found to enable closer customer relationships, which are crucial to servitization (Ardolino et al., 2018; Coreynen et al., 2017; Frank et al., 2019). Although the study has found outcomes similar to the extant literature, it indicates that the outcomes are hierarchically dependent, which is apparent in the discussion on the identified affordances.

6. Conclusion

6.1 Theoretical contribution

The study has introduced affordance theory as an explanatory and analytical framework for servitization research. It has introduced the key principles of affordance theory and used the established framework to systematically investigate the role of the IoT in servitization. This study also contributes to the affordance theory by helping to extend the theory to an organisational level of analysis (Herterich et al., 2016; Strong et al., 2014). Previous studies have discussed affordances on an individual level (Bernhard et al., 2013; Goh, Gao, & Agarwal, 2011; Leonardi, 2012; Strong et al., 2014; Volkoff & Strong, 2013), leading to theoretical extensions of actualisation and dependency. We address specific calls to expand affordance theory to an organisational level (Wang, Wang, & Tang, 2018), and to extend the affordance actualisation lens to address organisational change and transformation (Volkoff & Strong, 2018). The study has also demonstrated the suitability of affordance theory to explain how manufacturers make decisions regarding the use of the IoT to enable servitization.

The study has also put the IoT into a theoretical context for servitization, highlighting the notion that the IoT does not necessarily have an intrinsic purpose, but should rather be considered as a platform for creating opportunities in specific contexts. This study demonstrates this notion by investigating the opportunities that the IoT provides for the context of servitization. Although the literature has already recognised the IoT as an important enabler of servitization (Ardolino et al., 2016; Rymaszewska et al., 2017), we add to this discussion by highlighting the specific range of opportunities that the IoT offers and categorising them based on their role in enabling servitization.

In addition, with the adoption of affordance theory, our study provides a clear framework to analyse and distinguish these opportunities and processes beyond their perception and realisation. In this way, we highlight the role of the manufacturers in achieving the outcomes expected from the opportunities. These insights add to prior studies that only explore the outcomes from the IoT with a focus on technology (Ardolino et al., 2018; Frank et al., 2019; Grubic & Peppard, 2016; Lenka et al., 2017; Lightfoot et al., 2011). The introduction of the concept of affordance dependency helps to shift this focus to a relationship between manufacturers and the IoT. We also explain the dependency between the outcomes from the opportunities provided by the IoT, indicating a cascading effect (Strong et al., 2014) of IoT-enabled affordances in servitization.

6.2 Managerial contribution

The study and its findings allow managers to understand the creativity behind IoT-enabled servitization. While it is widely accepted that the IoT represents a critical component for servitization, the processes responsible for the diversity of outcomes have not yet been recognised. The study explains these processes by identifying the opportunities perceived when using the IoT, acting on which helps create three types of enabling outcomes. Academic and practitioner-based studies have acknowledged diverse outcomes from the IoT, but often seem to imply that the IoT can provide them by itself. This study, however, argues that manufacturers play a crucial role in making unique contextual use of the IoT which explains the diversity in outcomes.

The study also helps decision-makers to see the dependencies between different stages of use of the IoT. One stage becomes the basis for another. It is important, therefore, for manufacturers to identify and use this understanding of the dependencies to manage their strategy of integrating the IoT in their organisations. Manufacturers that seek to achieve servitization enabling outcomes to need to develop long-term action plans to help manage and realise opportunities they perceive by using the IoT.

The identification of key IoT features in the context of IoT enabled servitization allows IoT vendors to drive their offerings and revenue models based on the affordances that can be enabled by their products. This research also suggests possibilities for vendors to offer upgrades and add-on features for their installed base to enable affordances that their customers want to perceive and actualise. Internally, for manufacturing firms, the study provides a framework for the IT departments to drive their IoT-integration projects based on the outcomes they want to achieve.

6.3 Limitations and future research

As with all research, this study has its limitations. First, the selected method itself has intrinsic limitations. Our use of multiple case research drawing on expert interview data was justified by the need to find individuals that can provide research-specific and informed responses (Bogner & Menz, 2009). However, while this approach provided opportunities to gain expert knowledge, it also created limitations in terms of internal validity owing to the smaller number of expert interviewees we could draw upon. In order to address these limitations, we used secondary sources of data such as websites, brochures, news articles, and videos to validate the responses (Jack & Raturi, 2006; Yin, 2009).

Also, the selected multiple case research method itself has limitations. Our focus on multinational manufacturers that have already established advanced services offerings for industrial customers naturally limits the generalisability of our findings and resultant framework. To further expand the scope of the affordance framework future research should explore the role of IoT-enabled affordances among manufacturers that are in the early exploratory phase of their servitization effort (Dmitrijeva et al., 2019), where the servitization objectives may not yet be clarified with manufacturers engaging in extensive experimentation. Further, it would be promising to explore how industry sectors and product categories impact the underlying nature of the IoT-enabled affordances. The present study has drawn on data from manufacturers of large capital investment products for industrial customers. With growing interest in the opportunities, servitization provides for manufacturers of consumer-products (Vendrell-Herrero et al., 2017); it would be of interest to explore how the requirements of these industries impact on their ability to utilise the IoT to enable servitization.

Further, the thematic analysis method relies on the expertise and experience of the researchers to define and refine the themes (Braun & Clarke, 2006). Hence, although the theme-identification drew on several researchers to minimize biases we cannot exclude that other researchers might not emphasise on different aspects. In addition, the study's construct validity was ensured by the use of established affordance theory framework to structure the interviews and analysis (Yin, 2013).

Second, the study does not measure the successful accomplishment of the manufacturers' goal. While we clearly highlight the outcomes that are achieved through the successful actualisation of the diverse affordances, we do not take into account the overall level of economic or strategic benefits that these outcomes create for manufacturers. As research is starting to explore measures to assess a manufacturer's overall servitization development and success (Ziaee Bigdeli, Baines, Schroeder, Brown, Musson, Guang Shi et al., 2018), future studies should adopt a similar perspective to assess the success and level of contribution that are created by individual affordance outcomes. Approaches for quantifying the success of servitization are required to further advance servitization research and practice.

Third, the study provides retrospective accounts of the different IoT-related developments. While the use of retrospective accounts is common practice in case research, accounts may suffer from historic distortions and misinterpretations (Thomas, 2011). With the widespread adoption of the IoT and servitization taking place, there is a valuable future opportunity to conduct longitudinal case research that explicitly explores the individual decision-making that forms part of the servitization approach.

Fourth, the affordance dependency identified in the present study is based on manufacturers providing themselves with the range of processes that underlie their service offering. However, with the emergence of dedicated analytics provider (Wang et al 2019) scenarios may emerge where manufacturers may not themselves need to actualize the first-order (e.g. evaluate product condition) or second-order affordances (e.g. identify potential faults) in order to realize their third-order affordances (e.g. improve customers' business process). It would be important for future research to explore how the cascading dependency can be organized and also, how manufacturers will be able to ensure they can protect their interests within these business networks (Schroeder et al, 2019). With the network perspective on servitization creating increasing attention (Martin, Schroeder, & Bigdeli, 2019; Ziaee Bigdeli, Bustinza, Vendrell-Herrero, & Baines, 2018), a focus on affordance dependency would provide an important avenue to add further insights to these network dependencies.

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