Enabling servitization by affordance actualization: The role of digitalization capabilities.

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Abstract
Digital technologies enable servitization by providing opportunities for the manufacturer to understand the product usage and condition, in customer's operations. The present study seeks to validate the applicability of *affordance actualization theory* in order to help identify these opportunities. A systematic literature review of the extent servitization research is conducted to identify the key constructs of the theory and their role in enabling servitization using digital technology. The review identified common affordances across the servitization literature along with specific digitalization capabilities required to actualize these affordances. The study contributes further by proposing future research extended to affordance interdependence.

Keywords: Servitization, Affordances, Capabilities.

Introduction
Servitization and digital technology
Servitization as a differentiation strategy has gained substantial traction and become a global phenomenon. The cases from Xerox and Rolls-Royce exemplify successful transformation from manufacturing products to providing services (Baines and Lightfoot, 2013, Lightfoot and Baines, 2014). Original equipment manufacturers (OEMs) seek to add services to their product offerings and extend their utility.

Servitization implies that OEM's guarantee product availability and reliability (Lightfoot and Baines, 2014). Monitoring systems are developed that increase the visibility of the product in the field through digital technology, such as sensors, wireless technology and software (Yoo et al., 2010). Digital technology has not only been offering increased **opportunities** for client-manufacturer interaction and understanding customer needs but has also become one of the pillars for successful servitization (Coreynen et al., 2016, Baines and Lightfoot, 2013). Recent studies have shown that OEM's are contesting

for technological superiority by embedding more intelligence, data gathering and analysis among their products (Iansiti and Lakhani, 2014, Opresnik and Taisch, 2015).

Although OEM's continuously seek avenues to identify opportunities to enable servitization, the literature does not always provide the theoretical tools required. To guide managers, frameworks are required that can identify the opportunities, manage the required actions to operationalise the opportunities and indicate the capabilities to enable their operationalisation. To contribute to the development of such a framework, the research adopts the *affordances theory* in order to help the systematic analysis and conceptualisation of the role of digitalization in the servitization context. By validating the applicability of *affordances* theory and the relevance of its key constructs, the research helps to explain the integration of digital technology in physical products to enable servitization and provides opportunities for theoretically grounded future research in the area.

Theoretical Background

This section will first review the importance of affordances theory before examining the role of digitalization capabilities in actualizing affordances and the use of this theory to bridge the gap.

Theory of affordance actualization

Digitizing physical objects gives them properties that facilitate anticipated and unanticipated opportunities for products and service innovation (Barrett et al., 2015, Nambisan, 2013)(Yoo et al., 2012). (Re)Combination of a set of properties allows manufacturers to produce novel products and services (Barrett et al., 2015). This capacity of digital technology allowing diverse group of actors to utilize the opportunities in unanticipated ways, is problematized by affordance theory (Zittrain, 2008).

Affordances are defined as "the potential for behaviours associated with achieving an immediate concrete outcome and arising from the relationship between an **artefact** and a **goal-oriented actor** or actors"(Strong et al., 2014, 69). The **immediate concrete outcome** is a specific expected consequence of acting on the affordance that is useful for realizing organisational goals. According to affordance theory, the specific physical and digital properties of digitized industrial products (Yoo, 2013) are understood as providers of possibilities for an actor to achieve an immediate concrete outcome (Markus and Silver, 2008).

However, the affordance does not create an outcome without actualization. **Actualization**, is defined as **"the actions** taken by actors, as they take advantage of one or more affordances through their use of the technology to achieve immediate concrete outcome in support of organisational goals" (Strong et al., 2014, 70). It is a cascading process because the actualization actions generate outcomes which, in turn, give rise to new affordances. Actualizing affordances requires the actor to possess certain know-how and abilities.

Digitalization capabilities for affordance actualization

Within OEMs, certain capabilities are required to exploit these affordances. Since the affordances are realized due to the manufacturer's relationship with a digital technology, possessing digitalization capabilities enables manufacturers to actualize these affordances leading to immediate concrete outcomes. These outcomes lead towards realization of overarching goals such as providing higher reliability, greater efficiency, and optimization possibilities that improve the delivered service provision (Porter and Heppelmann, 2014).

Digitalization capabilities are defined as advanced abilities to use smart and connected products (Parida et al., 2015). They include the abilities to sense and capture information, connect products through wireless networks and analyse information to create insights and actionable directives (Lenka et al., 2017). To achieve technological supremacy, manufacturers are inclined towards enabling actualization of affordances that arise due to integration of digital technology in industrial products. The digitalization capabilities enable actualization of these affordances by establishing a platform for data gathering and remote functionalities. This actualization leads to affordance interdependency, the emergence of a series of affordances which cascade over time (Bloomfield et al., 2010 & Strong et al., 2014). In the context of servitization, an affordance such as *'monitoring product usage'* can be actualized by employing digitalization capabilities enabling data collection, storage and transmission. The availability of the recorded usage data, which will be the immediate concrete outcome of this actualization process, leading to realization of more affordances involving 'optimizing maintenance schedules' or 'issuing breakdown alerts'.

Research gap

In order to provide product availability guarantees, OEMs employ technological systems that provide a strong insight of the product usage in customer's operations. This requires augmentation of digital technology, such as sensors, wireless technology and software in physical products (Yoo et al., 2010). This augmentation is a critical enabler of servitization (Baines and Lightfoot, 2013).

Utilizing digital technology to enable servitization requires manufacturers to shift their focus from products to information. It implies a deliberate alignment of business and offerings with digital technology (Kryvinska et al., 2014). Aligning the business and offerings with technology constitutes a great challenge to manufacturers (Wall et al., 2005). In order to identify an appropriate application for digital technology in terms of a servitization opportunity, the underlying nature of the technology and their diverse business applications need to be understood in detail.

Affordances theory helps to effectively identify the opportunities for action that arise due to the relationship between the actor and the artefact, and the actions required to actualize the opportunities resulting in desired outcomes. This approach has shown significant evidence in identifying opportunities arising from digital technology in the information systems literature (Strong et al., 2014) (Volkoff and Strong, 2013) (Zammuto et al., 2007) (Majchrzak and Markus, 2012).

Methodology

The aim of this paper is to understand the applicability and relevance of the affordances theory in the context of servitization, and to identify the role of digitalization capabilities in the actualization process. To achieve this aim, the paper has set the following objectives: 1. Understanding the relevance of the key constructs from affordances theory in the servitization context. 2. Identifying the common affordances realized in the cases, and 3. Identifying the common digitalization capabilities required for the actualization of the realized affordances.

The research was conducted in the form of a qualitative systematic review of extant literature. The following steps were undertaken to achieve the review:

1. The review examined articles from English, *peer reviewed journals* published from the year 2004 onwards. 2004 was chosen as a cut-off date to include seminal articles (and their further development) on the intersection of servitization and remote diagnostic technologies (Davies, 2004)(Kuschel and Ljungberg, 2005)(Biehl et al., 2004).

2. The search for articles was based on the combination of keywords: *servitization, product service systems, digitalization, digitization, information and communication technology,* using the 'EBSCO' database which is widely used in servitization literature (Baines et al., 2009). The search resulted in a list of 225 articles.

3. For quality purposes only articles related to the field of business and management from the UK ABS list of 3, 4 and 4* ranked journals (ABS, 2015) and top conferences relevant to the context. The abstracts of the identified articles were examined to ensure their focus on servitization and the application of digital technology. To accommodate the affordance theory's need for extended contextual description only articles that drew evidence from qualitative basis were considered. The final search resulted in a reduced list of 12 articles which are shown in Table 1.

Table 1 List of reviewed articles

Reference	Reference Number	Case
(Rymaszewska et al., 2017)	1	Multi-case study approach on 3 organisations in B2B context.
(J. Cenamora, 2017)	2	Multi-case study on 4 multinational manufacturing organisations.
(Parida et al., 2015)	3	Multi-case study on 13 multinational manufacturing firms.
(Baines and Lightfoot, 2013)	4	Multi-case study of 4 manufacturing firms
(Lightfoot et al., 2011)	5	Multi-case study of 4 manufacturing firms
(Herterich et al., 2016)	6	Single case study
(Lerch and Gotsch, 2015)	7	Multi-case study of 3 manufacturing firms
(Coreynen et al., 2016)	8	Multi-case study of 4 manufacturing firms
(Huang et al., 2012)	9	Multi-case study
(Grubic et al., 2011)	10	Multi-case study
(Wilkinson et al., 2009)	11	Multi-case study of 2 firms
(Jonsson, 2006)	12	Multi-case study of 5 firms

Key Constructs

The analysis focused on the identification of the following key constructs (drawn from affordances theory and the literature of digitally enabled servitization):

- Affordance realization:
    1. *Organizational goal:* Affordance realization is dictated by the actor's goals. The analysis focused on identifying the organisational goal to understand the affordance realization.
    2. *Features of the technology:* The artefact plays an important role in affordance realization as the existence of an affordance is based on the relation between the artefact and the actor. The analysis focused on identifying the features of the digital technology as a key construct.
- Affordance Actualization**:**
    1. *Digitalization capabilities:* Seminal work on affordance actualization in the IS literature identified 'know-how' and skills of the actor which allowed the actor to take actions (Strong et al., 2014). The analysis focused on identifying digitalization capabilities as one of the key constructs.
    2. *Immediate concrete outcome*: Actualizing an affordance leads to a resulting outcome which is why immediate concrete outcome was identified as a key construct to describe affordance actualization.

The articles were coded based on these constructs. A framework adopted from Strong et al. (2014) was used to organise, condense and synthesize the findings. Table 2 shows the references which share the affordances which are the focus of organising the findings and the products of the cases described in the reference articles. Together, the first two columns provide information about the cases analysed. Next, the table explains how the affordances are realized by describing the organisational goals of the case and the features of the technology employed in the case. Last two columns describe the digitalization capabilities which were required to actualize the affordances, and the immediate concrete outcomes which were a result of the actualization process.

Table 2 Literature analysis

Cases		**Affordance Realization**		**Affordance actualization**	
Ref no	*Product details*	*Organizational goals*	*Features of technology*	*Digitalization capabilities*	*Immediate concrete outcome*
Affordance: Product usage monitoring					
1, 2, 3, 10.	Precision sheet metal tools. Construction equipment. Network equipment and software. High capital-cost products (Manufacturing tools, automotive vehicles, aerospace components, mining equipment, medical.) Aerospace, defence, marine, oil and gas.	Changing market position to be closer to customer operations. Increasing customization and efficiency in providing services globally Offering service innovations on a global scale. Building closer relationships with customer.	Centralised cloud system to collect operational data and monitor key performance indicators. Telematics system collecting and sharing operational data IT platforms and integrated sensor technologies	Integration of computers and sensors on product line and connecting to centrally operated servers. Developing analytic tools and recruiting personnel. Analysing customer's daily operational data.	Providing remote support to customers and performance-based contracts. Provision of automated analysis of operational data, and repair warning signals. Better informed decisions about future service developments.
Affordance: Product condition monitoring					

1, 3, 4, 7, 10, 12.	Power transformers for electricity distribution. Trains, trucks and buses, excavation equipment, and office equipment. Cranes and motors. Aerospace, defence, marine, oil and gas.	Increasing life cycle of the product Offering service innovations on a global scale Expand portfolio of offerings using advanced services	Automated logging device connected through internet recording condition parameters Remote monitoring sensors and transducers. GPS technology	Real-time monitoring of the condition in operation. Transmitting captured data and fault alerts. Analyse stored data to generate insights.	Providing maintenance insights and avoiding operational faults. Better control of physical product. Increased reliability and productivity. Remote asset monitoring.
Affordance: Understanding customer needs					
2, 6, 8, 11.	Machines for tools manufacturing. Industrial trucks and warehouse equipment Hydraulic motors and industrial turbines.	Increasing customization and providing services globally Increase efficiency of existing service activities. Exploit core expertise to provide solutions.	Web-based IT platform supporting sensor based data collection through wireless networks. Analysis of usage data.	Analysing customer requirements and generating IT solutions. Analysis of operational data based on contextual information.	Provision of advisory regarding customers operations. Monitoring industrial products remotely. Better insight into customer's business processes.

Findings

Three shared affordances have been identified that are realized across a larger number of the cases identified in the literature. Despite the differences in organisational goals, the technology allowed for the realization of similar affordances such as *product condition monitoring* and *product use monitoring.* Actualization of the affordance, *product condition monitoring*, resulted in concrete outcomes such as providing maintenance insights, better control of the product, and remote asset monitoring. Product condition monitoring involves recording certain parameters that indicate the health, and wear & tear of the product while it is being used. The affordance was realized due to the integration of automated logging, sensors, transducers, and GPS devices in their products.

The actualization of the affordance *product use monitoring,* provided the manufacturer insights to make better decisions about the future service developments, and providing automated analysis of the operational information from the product use. *Product use monitoring* refers to recording of the product parameters to understand how it is used by the customer and gain insights in what role is played by the product in the customer's business process. The case manufacturers employed digitalization capabilities such as analysing the operational data for insights and connecting the products and sensors to central IT systems.

Understanding customer needs is found to be another shared affordance. The actualization of this affordance has helped manufacturers achieve a range of outcomes from understanding the business process and the application of their product in the customer's business, to higher machine uptime and providing advisory services regarding the customer's operations.

Other affordances found through this review are *better utilisation of business information* and *improving asset performance, reliability, and availability.* These affordances were case specific. They achieved the outcomes such as optimised inventory management, faster manufacturing processes, and remote asset monitoring. While the affordances and their immediate concrete outcomes may not be common to the 3 shared affordances discussed earlier, these affordances were realized based on similar features of technology compared to the earlier affordances, such as sensors, GPS and data acquisition servers.

The digitalization capabilities employed to actualize the realized affordances by the case firms are also found to be shared. The most common digitalization capabilities for actualization of affordances are found to be *integration of sensors and digital technology in products*, *monitoring operational data,* and *analysing data to generate meaningful insights*. These capabilities are essential to achieve the immediate concrete outcomes such as failure alerts, scheduling maintenance, remote monitoring and improving reliability of the products. These capabilities are complimentary to each other. In the review, case firms have first employed the capability to *integrate sensors and digital technology into their products*. This enabled them to measure the operational performance and condition of their products, which was carried out by employing the capability of *monitoring the operational data*. Finally, the firms developed insights from this data by *analysing the operational data*. The firms invested significant resources to develop these capabilities which include acquiring necessary technology, recruiting personnel, and developing analytic tools.

It is clear from the review that servitization can be enabled by digital technologies, specifically technologies such as remote monitoring sensors. All the cases show evidence of integrating sensors and remote monitoring technology in their physical products. Along with the sensors, manufacturers have adopted centralised data collection and storage technologies which can be cloud based or physical server based. GPS technology has also been adopted in the reviewed cases to enable remote asset monitoring. However, it is a noteworthy observation that all the products in the reviewed cases have an inherent high capital-cost and a long life-cycle. Such a nature of these products makes it suitable for the manufacturers to make investments in integration of sensors, and facilitating data storage and analysis.

Discussion

The review shows the relevance and existence of the important constructs from affordances theory, discussed in the earlier section of the article. This means that the servitization literature focused on implementation of digital technology describes the cases with implicit references to the affordances theory, thus validating its relevance to the field of servitization. Since the theory provides a meaningful frame to structure the investigation, explicit application of the theory to understand the integration of digital technology to enable servitization can be the next step. To further apply this theory in the context of servitization, the extension of the theory, 'affordance interdependency', should be considered.

The identification of digital affordances provides an opportunity to explore the notion of affordance interdependency (Strong et al., 2014). Affordance interdependency means that

many more affordances can be realized once a basic affordance has been actualized (Strong et al., 2014). The immediate concrete outcome resulting from the actualization of a basic affordance creates conditions which lead to realization of more affordances (Volkoff and Strong, 2013). The findings of this review show three shared affordances which were realized due to the relationship between the actor and features of the digital technology. These affordances could be basic to realizing many more affordances.

To actualize the affordances, the article has found crucial digitalization capabilities required to achieve the immediate concrete outcomes. The findings are synonymous with existing literature on the importance of digitalization capabilities (Lenka et al., 2017). The digitalization capabilities identified in this review focus on connecting physical products to a common network using sensors, sensing and capturing operational data, and analysis of data to generate predictive insights about the condition of the product. The review reiterates the importance of digitalization capabilities and the technological superiority attained by manufacturers by embedding remote sensing and intelligence functionalities (Parida et al., 2015). Findings show clear indication that data gathering and analysis are the primary capabilities required to help manufacturing firms achieve maximum value (Opresnik and Taisch, 2015). The review also emphasises the fact that digital technology plays a crucial part in enabling servitization of manufacturing (Baines and Lightfoot, 2013).

Herterich et al. (2016) recommend extending the understanding of affordances in servitization by adopting the affordance interdependency view which will help scholars to explain digitally driven servitization, and how to develop or acquire digitalization capabilities required to achieve it (Herterich et al., 2016). Literature recommends extending the theory of affordances in field beyond traditional IS literature as it will contribute to understanding how the relations between, digital technology, its design, organisations, and its artefacts matters in digitally-enabled organisational change, thus leading to better outcomes and successful transformations.

Conclusion

Through the review of servitization literature focussed on implementation of digital technology to enable servitization, we have validated the relevance of the theory of affordances in explaining how digital technology can enable servitization. We also show that, to actualize the realized affordances, manufacturers have employed digitalization capabilities which have enabled them to achieve desired outcomes. The most common affordances identified through this review are 1. *Product condition Monitoring,* 2. *Product use Monitoring,* and 3. *Understanding customer needs.* These affordances were realized due to the relationships between the case organisations and the technologies available or owned by them, which were commonly sensor based remote monitoring technologies and GPS technology based on a centrally connected digital architecture. To actualize these affordances, manufacturers have employed a common set of digitalization capabilities which include connecting physical products to centralised wireless networks and sensors, and analysing the collected operational data to generate predictive maintenance and repair insights.

Through this review, we express the relevance of affordance actualization theory in the field of digitally enabled servitization. We provide evidence on applicability of the theory to explain how digital technology can enable servitization. By highlighting common affordances, the review suggests the existence of basic affordances which can unfold over time through actualization, thus showing possibility of affordance interdependency in the context of digitally enabled servitization. To actualize the

affordances, the article has found crucial digitalization capabilities required to achieve the immediate concrete outcomes.

The research contributes to solving managerial problems concerned with digitally enabled servitization by providing a theoretically grounded approach to explaining integration of digital technology to enable servitization. While extending the boundaries of affordances theory and applying it to an unexplored context, the research also provides a future research agenda for a more comprehensive understanding and theory application through the path of affordance interdependency.

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