The impact of the Internet of Things (IoT) on Servitisation: An exploration of changing supply relationships

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ABSTRACT

This research paper explores the emerging potential of IoT technology as an enabler for manufacturers seeking to exploit opportunities for new production, business and operating models. Following an analysis of extant literature and exploration of four in-depth cases, the paper presents four dominant pathways to servitising the business model through IoT implementation. This first finding is extended in the cross-case analysis, through a categorisation of cases into the four pathways, comparing different levels of supplier integration and information exchange. Using this data and categorisations, the paper arrives at certain theoretical propositions regarding the wider impact of IoT technology implementation on information exchange and relational rents through self-enforcing safeguards, risk and financial incentive sharing and lastly transaction cost economics. These propositions lead to the recommendation for suppliers to adopt a servitisation pathway of 'operational service' models, in order to reap maximum competitive benefit and return on specific investments. This suggests a dependence on the servitisation pathway chosen by the supplier, implying that there is no single solution to deal with buyer-supplier relationships in IoT servitisation environments.

KEYWORDS: Servitisation; IoT; buyer-supplier relationships; manufacturing, services

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1. Introduction

More and more devices are becoming interconnected, embedded with sensors and gaining the ability to communicate. While there is a plethora of terms used to describe this emerging technological shift (e.g., M2M, ubiquitous computing, smart objects), they are all characterised by the advent of *things* becoming equipped with computing logic, sensors and networking capabilities, forming the so-called *Internet of Things* (IoT hereafter) (Andreev et al., 2012). This ever-increasing interconnectedness and digitalisation of physical and virtual objects will be, and has already started to be, one of the most disruptive developments in contemporary times. In industrial applications, IoT and its value propositions of data analytics, machine monitoring and remote control, offer immense opportunities for manufactures wishing to extend their product portfolios with tailored services in analytics (Govindan et al., 2018) and remote/ predictive maintenance. The seamless flow of data between a network of ubiquitous things, enabling such services can be bundled into complex product-service solutions (Baines et al., 2009a; 2009b; Lightfoot et al., 2013), shifting manufacturers towards becoming service providers. While this transformation, also known as 'servitisation' (or 'servitization'), is not a new phenomenon, scholars are suggesting that the IoT may have a 'boosting' or accelerating effect on it (Baines et al., 2009; Coreynen et al., 2017). It entails a greater orientation around customer activities/operations and longer-term service contracts, making the analysis of changes in *systems integration* and *buyer-supplier relationships* (BSRs hereafter) the focus of this study.

This paper illustrates how traditional manufacturing businesses can transform their business models towards that of a service provider by utilising IoT technology. For suppliers and buyers alike, the findings in this paper can help managers on both sides of a servitisation contract to build new relationships, gauge the optimal level of IoT systems integration and overcome cognitive barriers.

While the influence of servitisation on systems integration (Davies, 2004) and BSRs (Saccani et al., 2014; Kraljic, 1983) and the "boosting" effect of digitalisation on servitisation (Coreynen et al., 2017) have been discussed in isolation, the analysis of these three concepts in combination, is important and rarely discussed.

<<Include Figure 1 about here>>

Further research is needed to understand how IoT technology may enhance opportunities for manufacturer service offerings, and to what extent the impact will complement or disrupt supply arrangements. Therefore, this study seeks to explore the following research question:

To what extent is the IoT enabling transformation of manufacturer services?

The foundation of the paper will be laid in Section 2, with a review of the most prominent literature, regarding the IoT, servitisation and BSRs. Section 3 presents the research methodology of this paper. The fourth section comprises a series of case studies, initially presented in isolation, but afterwards compared in a cross-case analysis, highlighting conformity, similarities and correlations across identified IoT servitisation pathways. Section 5 forms a discussion about potential propositions, derived from the case results. The paper concludes with theoretical and managerial implications, leading to a reflection on limitations as well as suggestions for further research.

2. Literature Review

2.1 The IoT and its impact on business models

The Internet of Things embodies the vision that every object in the physical world can become a part of the digital one (Vermesan, 2014). On a foundational level, the IoT can be defined as "a network of physical objects, or things, embedded with ubiquitous computing power, software, sensors and actuators that enable these objects to connect, collect, exchange and act on data they share" (Barkai 2016, p. 17). While the industrial internet of things is still at an early stage, comparable to that of the internet in the late 1990s (WEF, 2015), recent advancements and a continued reduction in sensor costs are accelerating its adaptation and creating a new wave of digitalisation. In the last decade alone, the number of sensors shipped has increased more than five times and is predicted to reach 20bn installed units as early as 2020 (WEF, 2015).

Within the Internet of Things, the digitalisation of physical objects is achieved through the complementation of multiple layers (see figure 2), forming an altered value-proposition (Vargo et al., 2008).

<<Include Figure 2 about here>>

The physical part in such a system (in figure 2 an aeroplane turbine), forms the first layer and provides the direct and tangible value to the customer, i.e. mobility (Fleisch et al., 2014). In the second layer, the turbine becomes equipped with ubiquitous computing power and a sensor, measuring the status, temperature, the need for maintenance and usage statistics. The third layer provides access to the internet for the previous two layers, enabling global control.

This connectivity and machine-to-machine communication (M2M) are forming the core of cyber-physical systems and the IoT (Atzori et al., 2010). Within the network of connected physical and digital elements they are automatically interacting with each other due to embedded computing capacity, sensors, and actuators in layer 1 and 2, thereby reducing complexity through decentralised coordination (Manyika et al., 2013). The fourth layer (analytics) collects, stores and classifies this data relying on emerging concepts such as cloud computing and data analytics, which is becoming more commonplace in the manufacturing context to improve quality, increase efficiency, and optimise operations (Rüßmann et al., 2015). The final stage of digital services is bundling all of these layers and the benefits they bring with them, amalgamating physical products and digital services into a hybrid bundle, which creates a long-term relationship between the supplier of the turbine and the customer.

Products are no longer "one-and-done" (Chen et al., 2014) and the way businesses create value, the core of their business model, is fundamentally changing in two principal ways:

a) Value creation through data analytics and information

The identifying, sensing, communicating and computing characteristics of IoT devices allow physical products to become platforms for data generation leading to invaluable analytics. This offers opportunities for more effective forecasting, process optimisation, customer behaviour pattern and market condition identification, enabling the creation of new service offerings (Rymaszewska et al., 2017; Lee and Lee, 2015; Shukla and Kiridena, 2018).

b) Value creation through monitoring and remote control

Secondly, over-the-air updates and the ability to monitor products in use makes it possible to respond to customer behaviour, identify operational patterns and determine potential improvements, leading to decreased cost and increased efficiency (Rymaszewska et al., 2017). Effective monitoring also optimises maintenance processes through the use of data-enabled preventive or predictive maintenance, reducing overall maintenance frequency and cost, while increasing operational reliability and availability (Gordon, 2017).

This breakdown leads to the assumption that the core of the IoT potential lies within its ability to create services out of products. Therefore, on a very abstract level, these value propositions within the IoT can be visualised through the following formula based on a whitepaper by Fleisch et al. (2014), creating a composite that is greater than the sum of its parts.

<<Include Figure 3 about here>>

These new digital technologies are radically changing the way manufacturers are creating value for their customers and offering new opportunities for IoT services to form a more substantial part of the business model (Ostrom et al., 2010; Ardolino et al., 2017). In instances where manufacturers were potentially cautious about servitisation, IoT may serve to provide a clearer business case and evidence base to convince clients and supply chain partners of where to target future investments.

The trend of manufacturers adopting more services into their business model is not entirely new, and academics and business practitioners agree that technology has been a dominant driving force behind the progress of today’s service world, with some even calling the exploitation of information technology a foundation of service science (Rust and Huang, 2014; Chesbrough, 2011). Within many industries, the increasing intensity of competition, erosion of profitability, maturity of products and connected to this their commoditisation, is leading to a discussion about existing business models and the need for a new strategic direction into the service realm (Wise and Baumgartner 1999; Vandermerwe and Rada, 1988). Manufacturers in these industries are starting to leverage their business strategies on the capabilities enabled by technological innovation, to create profits further down the value stream and improve relationships with customers and suppliers through the implementation of services, in addition to product offerings (Wise and Baumgartner, 1999; Visnjic Kastalli and van Looy, 2013). The premise of the IoT to enhance existing or enable a whole new set of services could provide crucial opportunities for manufacturers in these increasingly competitive markets (Chae, 2015), so that it has been said that “the service revolution and the information revolution are two sides of the same coin” (Rust et al., 2014). Nonetheless, prominent academics such as Neely (2007) question the actual adoption rate of servitisation strategies and find that, thus far, it is mostly large, US businesses joining this “revolution”, with smaller firms lagging behind.

2.2 New business models and buyer supplier relationships

2.2.1 The Servitisation Paradigm

As established in the last sub-section, the emergence of IoT technologies is blurring the lines between producing industries and the service sector, a development that coincides with, enables and advances the phenomenon of *Servitisation*, a term first introduced by Vandermerwe and Rada in 1988, describing firms' transformation away from pure manufacturing firms to service providers by bundling services to the core product offering. Using these definitions, the authors of this paper understand servitisation to be a business model innovation, defined by the transformation of manufacturers competing on products towards competing on value propositions that integrate products and services.

<<Include Table 1 about here>>

To an extent, many researchers are in accord with four characteristics that distinguish services from tangible products, condensed to intangibility, heterogeneity, inseparability of consumption and production, and perishability, also known as the IHIP framework (Brax, 2013). However, this general classification has been criticised by many for not incorporating customer interaction, value co-creation and the nature of products, which ultimately enable service delivery (Spring and Araujo, 2009). Taking the shortcomings of the IHIP framework into consideration, for the scope of this paper, a service is understood to be a process that involves a set of activities between a customer and some form of service provider, with the aim of solving customer problems (Grönroos, 2007). Nonetheless, the paradigm of Servitisation is difficult to pinpoint on this spectrum as it goes beyond the clear definitions of products and services (Davies, 2004; Galbraith, 2002) and shows different characteristics depending on the observer's viewpoint (supplier vs buyer).

The emergence of new digital technologies such as the Internet of Things is now further advancing this servitisation trend, creating new business models in the process (Pettinen and Palmer, 2007; Ostrom et al., 2010; Ardolino et al., 2017; Rajput and Singh, 2018). This raises the question of how this transformation is taking place and where are the opportunities for manufacturers? To improve the mapping of IoT business models in the context of Servitisation, we focus on two lines of investigation (1) downstream technology integration, and (2) relational intensity.

2.2.2 Dimension 1: Downstream technology integration

As discussed in the previous section, IoT technology is not only directly supporting the product but also, and perhaps more importantly, the process that the product is designed to perform in the greater value stream. Suppliers integrating systems, or 'moving down the value stream', is not a new phenomenon, and can even be seen as an extension of industrial specialisation or the division of labour (Pavitt, 2003; Smith and McCulloch, 1838). Using their extensive product knowledge, numerous manufacturers have adopted logical extensions into 'support offerings' (Baines, 2006; Baines et al.,), a shift well accentuated in service, operations, and strategy research (Davies, 2004; Wise and Baumgartner, 1999; Vandermerwe and Rada, 1988; Benett and Gabriel, 2001). Working closely with their customers, these manufacturers are 'moving base' into their customers operations to overcome issues of interoperability, information exchange, cost structures, reliability and efficiency (Davies, 2004; Oliva and Kallenberg, 2003; Kapletia and Probert, 2010). The economics of systems integration can be observed from both a 'Smithian' perspective, of capital goods suppliers specialising in certain solutions to drive down unit prices, but also from a transaction cost perspective, dictating make or buy decisions (Dosi et al., 2003; Smith, 1838; Williamson, 1985; Domberger; 1998).

From a value stream perspective, a firms' value chain used to compete in a specific industry is embedded in a larger stream of activities (Davies, 2004; Porter, 1990), subdivided into four distinct stages beyond the manufacture and on the road to the final consumer (Davies, 2004; Wise and Baumgartner, 1999). Each stage adds value, from more tangible, technological developments upstream to intangible services like operating systems, customer care, branding and marketing, downstream, all accumulating to form the final offering. After the initial manufacturing stage, Davies (2004) lists further stages as being systems integration, operational services, service provision and ultimately the consumption by the final consumer. Nonetheless, it has to be noted that the value adding process is not following a linear pattern but rather a network of dynamic feedback loops, adding to the collaborative aspect of servitisation and system integration (Davies, 2004). As manufacturers (or capital goods suppliers) are moving further down this value stream, the boundaries between supplier and customer are becoming significantly blurred or even altered. According to Galbraith (1983), each firm possesses a 'centre of gravity' whose position in the value stream is dependent on its initial success in the industry which it grew up in. While this position is creating a degree of path dependency for a firm, it can learn to provide integrated solutions or support offerings and move its centre of gravity closer to the customer (Slywotzky and Morrison, 1998). This further pushes the traditional supplier-customer boundary downstream, as customers of such capital goods are shifting their focus onto the provision of services to the final consumer and outsourcing non-core activities (Davies, 2004).

This integration of solutions can be seen as a continuous spectrum from mere auxiliary support offerings to completely integrated service models. In full outsourcing scenarios, also called operator-models, ownership of capital goods, staff and responsibility is transferred to- or never leaves the supplier, no longer representing a fixed cost for the customer. Instead, a variable cost incurs on a regular basis for the duration of the service contract (Davies, 2004; Fleisch et al., 2014). Visnjic Kastalli and van Looy (2013) emphasise that such an offering will only be attractive to buyers if the service provider is able to create economies of scale in services, and economies of scope in products and services, providing them with a more cost-effective all-encompassing solution.

More recently, with regard to the continued digitalisation of businesses, these integrated solutions have developed into so-called 'smart services', going beyond mere support services like maintenance. Fundamentally, these smart-services are pre-emptive, based on real-time intelligence using internet connectivity, rather than reactive or even proactive approaches that characterised services in the past (Allmendinger and Lombreglia, 2005). With the emergence of another digital revolution, i.e. the IoT developments described in section 2.1, this smart services paradigm can be further extended through ubiquitous computing power and remote control.

With respect to the IoT, manufacturers are therefore continuing to move along this dimension, providing all-encompassing services, which are simultaneously increasing the need for closer buyer-supplier relationships, as explored in the next sub-section (Bastl et al., 2012; Kowalkowski, 2005).

2.2.3 Dimension 2: Buyer-supplier relationships within the servitisation environment

In the servitised economy, the close customer focus, is transforming the way business partners trade and interact. Depending on the degree of servitisation, the level of co-creation, customisation and mutual benefits may vary. In recent years, scholars have reported examples of dialogue-based buyer relationships replacing unidirectional, short-term and transactional relations. Servitisation therefore requires manufacturers to start building long-term partnerships rather than the short-term transactional relationships that has typified their approach in the past (Davies, 2004; Tukker, 2004; Oliva and Kallenberg, 2003; Kraljic, 1983). While the research on servitisation to date has been mostly focused on the rationales behind it (Baines et al. 2007; Vandermerwe and Rada, 1988), as well as the financial benefits of adopting a servitisation strategy (Wise and Baumgartner 1999; Neely, 2008), there is a lack of research understanding of the impact IoT enabled servitisation has on BSRs.

Building on the relational view of competitive advantage through servitisation (Dyer and Singh, 1988; Tangpong et al., 2015), BSRs play an incremental role in the development of integrated solutions (Bastl et al., 2012; Windahl and Lakemond, 2006). These integrated solutions are best utilised through relational exchange instead of transactional interactions, creating a link to TCE theory, and servitisations' promise to reduce such costs (Zajac and Olsen, 1993; Oliva and Kallenberg, 2003). Furthermore, the advent of performance- and outcome-based contracts may foster long-term relationships, effectively locking in participating companies (Bastl et al., 2012). BSRs can therefore be classified as being either transactional or relational (Cannon and Perreault, 1999), with the trend of servitisation moving the relationships towards the relational side of the spectrum (Eloranta and Turunen, 2015). In these symbiotic exchanges, communication between the parties is imperative, making information exchange and dialogue a frequent occurrence, which is, in turn, reducing conflict (Eggert and Helm, 2003).

To closer analyse BSRs in a servitised context, Cannon and Perreault's (1999) framework of relationship "connectors" will be used in this paper to compare classical and servitised relationships. These will also be used as the case study analysis variables (see methodology section). This framework is particularly effective as it incorporates multiple theoretical lenses, including transaction cost economics (TCE; Williamson, 1985), the resource-based view and extensions towards the relational view (Barney, 1991; Dwyer and Singh, 1998), social exchange theory (SET; Dwyer et al., 1987) and lastly resource dependence theory (RDT; Pfeffer and Salancik, 1978). This combination of different theories is what makes this framework so unique and adequate to form an all-encompassing analysis on commercial exchange.

<<Include Table 2 about here>>

While certain aspects of relationships are not explicitly included as a “connector” (e.g. trust, commitment and degree of long-term orientation), Bastl et al. (2012) noted that these omissions are still directly related to the connectors selected by Cannon and Perreault, for instance, trust can be seen as a direct currency of information sharing (Lee and Whang, 2001).

In the context of IoT enabled servitisation, the introduction of interconnected components may therefore have substantial impacts on all connectors presented by Cannon and Perreault, which will form the principal unit of analysis for the following case study.

3. Methodology

3.1 Research Strategy

To tackle the novel nature of the IoT, this paper takes an exploratory approach, seeking to contribute to the understanding of the IoT in a servitised context by identifying factors, concepts and relationships between the two research realms. Following this research strategy, a multiple case study design was chosen to investigate IoT technology in practice, as it promises to be most suitable in dealing with the IoT novelty (Yin, 2009). For this case study, the main unit of analysis was the supplier’s relationship with buyers of such servitised offerings. To build theory from case study observations, this research followed the seminal paper of Eisenhardt (1989), using a clear 8-step structure *(1. Getting Started, 2. Selecting Cases, Crafting instruments and Protocols, 3. Crafting Instruments and Protocols, 4. Entering the field, 5. Analysing data, 6. Shaping hypotheses, 7. Enfolding literature, 8. Finding closure).* Starting with case selection in step 1-2, Eisenhardt’s structure supported the methodology throughout all of the literature review, results, data analysis and discussion.

3.2 Case Selection

For this research, companies were selected on conceptual grounds. Working along the two previously discussed (section 2.2.2 and 2.2.3) dimensions of downstream technology integration and BSRs, the cases were selected to show a balanced variety of service models within the ‘IoT Servitisation’ field. The unit of analysis was set out to be supplier focused, i.e. their changing relationships with buyers pre- and post-IoT service implementation was the key factor in this purposive case selection and analysis. . To emphasize the far-reaching impact of the IoT, the selected companies operate in different industries and deliver a range of distinct services. Following Siggelkow (2007), targeting particular organisations can be very beneficial as it allows the researcher to gain certain insights that cannot be found elsewhere, especially if the organisation acts as a pioneer in its field. However, additional consideration was given to then create conclusions about these ‘special’ organisations and draw inferences about normal organisations (Siggelkow, 2007). The resulting case sample can still be considered a ‘convenience sample’ (Etikan et al., 2016) due to the limiting factors of IoT novelty, research originality and time resources of the researcher. Nonetheless, when compared to the prominent literature on recent developments in the servitisation field, the sample size of 4 is acceptable (Bastl et al., 2012 *n=1*; Coreynen et al., 2017, *n=4;* Saccani et al., 2014, *n=4*). Beyond external validity, special emphasis was given to internal and construct validity (Gibbert et al., 2008) during the formation of methodology and the shaping of resulting hypotheses.

3.3 Data Sources

As the third step, Eisenhardt's approach starts with crafting the instruments and protocols used for the case study. This entailed a rigid document analysis, ranging from company and consulting reports to the dominant academic literature, and resulted in the literature review in section 2, which highlighted the impact of the IoT on business models, the drivers behind servitisation and the theory of BSRs.

This is directly linked to the fourth step of entering the field, as it informed the case research. To collect further data, previous case studies, company press releases, consulting reports and more practice-oriented journals (e.g. MIT Sloan Management Review or HBR) were analysed to inform cases and get detailed information about the changing business models. Most useful were executive interviews in these practice-oriented journals and consulting reports (Winig, 2016; Siegele et al. 2016; Knapp et al. 2015; Watson, 2016).

4. Results

4.1 GE Predix

A prime example of an industrial manufacturer changing its product offering towards that of a service offering is General Electric (GE) and its IoT software platform *Predix*. Faced by weakening revenues in its heavy machinery sectors, GE decided to digitally transform itself from a manufacturer to a quasi-software company in 2015, starting with a $1 billion investment to equip its jet engines, gas turbines and generators with ubiquitous sensors, enabling cloud analytics and increasing machine productivity as well as reliability (GE Digital, 2018). GE was predicting a data volume of 50 million variables from over 10 million sensors, creating the need for a software solution capable of handling and integrating such vast amounts of information (Winig, 2016). The newly founded business division GE Digital came up with a cloud-based software platform called *Predix*, which allows customers of GE's products to gather real-time information about the state of their entire production facility, improve machine efficiency and reduce downtime through predictive maintenance. The machine centric platform supports data acquisition, storage, management, analytics and provides an interface for machine, data and people interaction through custom 'apps' and 'digital twins' (a virtual copy of the machine) tailored to the customer's needs (GE Digital, 2018). The nature of the open platform also encourages users to write applications themselves to support their individual needs. In this case the IoT therefore acts as an intermediator and interaction facilitator through the reduction of time taken, removing distortion and correcting asymmetry in communication. While the IoT initially was an unknown field for GE to venture into, it now sees its manufacturing background and expertise as a competitive advantage against small IT start-ups that try to adapt their software to a heavy-industrial operations technology environment (Winig, 2016). Especially in capital-intensive sectors such as oil and gas, GE saw huge opportunities to customise service offerings and improve asset productivity, following predictions of the IoT platform market to reach $ 225 billion by 2020 in the industrial segment alone (LaWell, 2015).

By promising to improve both asset and operations productivity, Predix is thus creating new value propositions and bringing GE closer to its buyers. An example of buyer cooperation is GE's work with RasGas, the largest LNG producer in Qatar (Winig, 2016). GE data analysts and gas turbine specialists were working closely with operations experts at RasGas to install Predix throughout the entire production plant, even on non-GE components. This move is creating immense value for buyers such as RasGas, who seek a holistic image of their plant, consisting of only 20% GE machinery, while the rest is made up of less capital-intensive, supporting equipment from competitors. The reduction in sensor costs and the advent of platform software like Predix is therefore creating an all-encompassing monitoring network across the whole plant by looking at it as an ecosystem instead of a collection of individual components. In an interview with the MIT Sloan Management Review, GE's key account executive Jeff Monk talked about the initial problems in implementing Predix in oil and gas companies who were unwilling to share such a high degree of operational information (Winig, 2016). Nonetheless, after initial data security concerns with the cloud system architecture, customers with operations across the globe embraced the ability *"to have a central repository that local operators can share vital, problem-solving data with*", explains executive director for the Industrial Internet, Dan Brennan, in the same interview (Winig, 2016).

Traditionally, GE's business model has been characterised by a very product-centric, transactional sales process for its fixed-price machines, parts and maintenance contracts (Iansiti and Lakhani, 2015). Now, with the advent of Predix, GE salespeople are engaging in more strategic conversations about complete solutions rather than product features. It forced GE to retrain their industry experts, add solution architects to the sales teams and inject service and software selling expertise across the entire organisation (Iansiti and Lakhani, 2015). This specific move was also caused by a change in buyer participants, with the Chief Information Officer now becoming more involved in the purchase process, requiring more detailed software knowledge to be shown by GE's sales teams, says Kate Johnson, chief commercial officer of GE Digital (Winig, 2016). When successful, the customer then agrees to a 10-15 yearlong contractual service agreement, allowing GE to connect to and monitor the product, provide analytics and recommendations as well as performing predictive maintenance. Both parties agree on certain thresholds, which, when exceeded, grant GE a bonus payment. This evolves the pricing model from a mere capital expenditure, bundling products with services and software, to an operational expense model that is wrapped up in a service contract. This outcome-based pricing requires GE to stay committed to the relationship while also "*putting more risk on the table"* through a high level of customisation and customer specific adaptations, says GE executive Jeff Monk (Winig, 2016). Beyond performance thresholds, the service contract also clarifies to what extent GE is taking control of the customer's operations, regarding access to data and scheduled downtime to allow for maintenance across all assets. This even applies to non-GE components, according to Jeremiah Stone, general manager for GE Digital's Industrial Data Intelligence business. Because of the novelty and complexity of the IoT, many customers initially struggle to see the added value in such a service contract, or as GE Vice Chair Beth Comstock puts it, "*we're trying to sell them something they don't know they need"* (Iansiti and Lakhani, 2014). GE combats these reservations by offering many customers to run a tailored pilot at their plant, for them to see Predix in operation. This usually includes a 4-week exercise where GE designers cooperate closely with the customer's operations engineers to develop a software solution for a specific problem. This not only allows GE to "*get a foot in the door*" but also gives the buyer a clear picture of the IoT value proposition in its unique context, providing initial trust in a relationship with GE, potentially leading to conversations about future engagements (Winig, 2016).

4.2 Siemens MindSphere

With comparable revenue numbers and a nearly 70% overlap in markets (Siegele et al., 2016), GE's main competitor in the race for dominance within the industrial IoT is the similarly diversified industrial conglomerate Siemens. However, instead of completely reinventing itself like GE, Siemens is taking a much more deliberate approach and is relying on its roots in product design and factory automation. Staying away from operator models like GE's, it is starting to offer highly tailored software solutions aimed at improving its buyer's operational processes. It realised that in the industrial B2B world, cloud services and platforms don't scale well, because of the specific requirements of each buyer (Siegele et al., 2016). Further reasons for this more tailored, customer-centric approach stem from Siemens' strong foothold in the German manufacturing market, making it dependent on machine-tool makers that only want to use components from Siemens without having to lose their own relationships with industrial customers by being forced to interact through a software platform from Siemens. It therefore adapted its business model to that of a service-oriented one, with its introduction of *MindSphere,* a cloud-based IoT operating system connecting a multitude of sensors equipped on Siemens components and enabling analytical services around them (Siemens.com, 2018). Because of the specific requirements of each buyer, a strong relationship is built over the platform ecosystem.

An example of a successful buyer relationship after Siemens' digital transformation can be found within the rail industry, where it is retro-fitting the locomotive fleet it had previously sold to Deutsche Bahn, with telemetric systems enabling condition-based and predictive maintenance (Siemens, 2017).

Using such data analytics, locomotive faults and disturbances can be identified early, resulting in higher train availability and fewer delays. "*The long-term partnership with Deutsche Bahn is strategically important for us. By linking data analytics and vehicle-specific know-how, we are supporting Deutsche Bahn with its digitalisation efforts and attaining its goal of hundred-percent availability,*" said Johannes Emmelheinz, CEO of Siemens' rail service business, after signing a 6-year software contract with Deutsche Bahn (Siemens, 2017). The distinct changes in all buyer-supplier relationships are summarised through the lens of Cannon and Perrault's (1999) relationship connectors framework in Table 3.

4.3 Trumpf TruServices

Trumpf is a leading German high-tech enterprise producing machine tools as well as industrial laser cutters used in the manufacture of cars, electronics and machinery. It has 11.000 employees and € 3.1 billion in revenue (Trumpf.com, 2017), and is well-known as an exemplar of a German industrial manufacturer adopting an IoT business model focused on services. While service has always played a role in Trumpf's interaction as a supplier for car manufacturers, like GE (case 1), it chose business model innovation to overcome issues in its traditional product-centred model (Knapp et al., 2015). Noticing that their service offering had to go beyond mere maintenance provision, Trumpf started educating their buyers on the benefits the IoT can bring to their operations, and transformed its offering into a hybrid product, part service and part product (PSS). This led to the implementation of *TruServices*, starting with the creation of a telepresence portal, allowing direct information exchange between the machine installed on the buyer's plant and Trumpf's in-house service team, offering immediate support and remote machine maintenance to its buyers (Knapp et al., 2015). Further, every industrial laser cutter Trumpf sells now comes with advanced sensors and analytical capabilities, constantly comparing performance against a trial benchmark in the cloud. These capabilities allow Trumpf machines to be fully integrated into buyer's ERP and automation systems, aimed at creating a 'smart factory' ecosystem for its buyers. Unlike GE (case 1), Trumpf decided to refrain from complete operator models, as it recognised the ability of its buyers to organise production processes around Trumpf machines "more efficiently than Trumpf ever could in an operator solution", admits Till Küppers, Trumpf's Chief of Services, in an interview (Knapp et al., 2015). Instead it found a high demand in its installed base for offers around customised condition monitoring services, big data analytics and consulting services as a "bundle with its products to improve the buyer's asset and operational productivity", declares Vice President Kammüller (Knapp et al., 2015).

4.4 MAN Telematics fleet management

A last example can be found at MAN with its efforts to optimise the long-haul truck business in a highly fragmented market characterised by competition rather than collaboration (Schroeder, 2016). Faced with a shortage of drivers and very low margins in the industry in general, MAN saw a gap in the market to sell its trucks as a service instead of a product (Schroeder, 2016). Technology and the IoT played a significant role in this transformation as it enabled MAN to remotely monitor its trucks on driver behaviours, route management and vehicle performance. Initially MAN started by capitalising on this technology through a product-service bundle (PSS), combing their trucks with remote monitoring and maintenance contracts, but soon realised the potential for a pay-per-use model (Lyden, 2016). In this model, the truck's ownership remains with MAN, which can use its IoT *Telematics* software to monitor, evaluate and manage the risk and maintenance of the truck (man.com, 2018). While such operator models are not completely new, the IoT age is driving new value propositions and increases buyer-supplier cooperation, says Andreas Schroeder, of the Advanced Services Group at Aston Business School in an interview (Schroeder, 2016). To further advance this relationship, MAN is proactively offering an 'uptime guarantee', reimbursing the buyer/operator for any revenue losses caused by a broken-down truck. On the software side, MAN is building out its IoT platform capabilities to stratify individual driver behaviours, providing its buyers with analytics, and drivers with recommendations about potential driving style improvements (Lyden, 2016). This benefits both sides of the BSR. While MAN is able to lock in a long-term relationship and recurring revenue, while the operator doesn't have to worry about asset utilisation or maintenance and gains data analytics that help drive down its most unpredictable cost – fuel (Schroeder, 2016).

<<Include Table 3 about here>>

4.5 Cross-case analysis

Building on the two dimensions explored in the literature review (section 2.3.1), this study adapts Oliva and Kallenberg's (2003) seminal matrix of business models within the IB service space, to categorise each case based on their unique service models. Suppliers are showing a transition from firstly, transaction- to relationship-based customer interactions (vertical axis of Table 4) and secondly, from a focus on product efficacy – whether the product works – to the product's efficiency and effectiveness within the end-user's process (horizontal axis of Table 4), as the principal value proposition (Oliva and Kallenberg, 2003; Koof et al., 2016). In combination stronger ties between products and services are formed which is fundamentally changing the way the service is monetised.

<<Include Table 4 about here>>

Plotting cases along this 2x2 matrix allowed us to test IoT cases against Oliva and Kallenberg's research, as well as analyse cross case patterns and within group similarities (Eisenhardt, 1989).

I. Basic installed base services

Basic installed base service models carry the lowest degree of integration, individuality and intangibility in their offerings (Mathieu, 2001; Tukker, 2004; Koof et al., 2016). This can also be observed in case 3, with 'traditional' after-sales services such as maintenance at Trumpf. Even after implementing IoT based services, these cases show the highest degree of transactional relations, and information exchange appears to be very limited, lacking the contractual obligations of *maintenance* or *operational service* models in cases 1 and 4. Legal contracts remain basic but strict in this category, specifying maintenance intervals or delivery guarantees.

II. Professional services

This category acts as the second stage in the service transformation process, where product and services are not necessarily tied, such as software solutions (Neuendorf, 2018). Case 2 (Siemens) and to an extent case 1 (GE), very much align themselves with this orientation through the provision of a common IoT operating platform. This platform is facilitating information exchange and allows the supplier to provide detailed performance data and analytics to improve operational efficiency. Through a high degree of integration into the buyer's operations, this software is creating significant operational linkages, especially when compared to product-oriented models. To protect their data, buyers adopt legal bonds, acting as a threat but also a sign of the long-term commitment of both parties.

III. Maintenance services

Moving further along the horizontal axis, the product becomes part of the offering as opposed to being the center of the value proposition. This hybrid orientation of *Maintenance services* very much sits in between *professional services* and *operational services* and is characterised by the bundling of tangible products and intangible services so that they jointly are capable of fulfilling specific customer needs (Oschmann, 2010). As observed in the case company Trumpf, software (in this case a telepresence system) is significantly increasing buyer touchpoints and operational integration. In combination with physical maintenance services, these are then all wrapped up in a product-service-system contract moving away from a markup for labor and parts every time a service is provided, to a fixed price covering all services over an agreed period (Tukker, 2004, Oliva and Kallenberg, 2003). This legal bond also acts as assurance for the supplier, as for the first time in the service transformation path, ownership is not transferred to the buyer, thus leaving Trumpf or MAN with significant risks through their specific investments.

IV. Operational services

Operational services present significant opportunities for IoT adoption and closer collaboration between manufacturers and customers, yet it carries the highest level of responsibility and thus risk for service providers. As seen in case 1 and 4, they are typically complex and highly customised to respond to very specific business needs and improve operational efficiency. Being the supplier of highly integrated 'operator model' services, like MAN and GE, requires a high degree of knowledge about the buyers' operations, individual end users and the general industry environment. Information exchange is therefore essential in operator models and can be observed to be most intense in cases 1 and 4. Data extracted from IoT sensors on turbines or trucks respectively, is used to determine supplier compensation, capacity demand and maintenance windows. Conversations about potential improvements arise, based on analytical findings, and lead to the supplier and buyer now co-creating value.

Perhaps the most significant pattern emerging from the analysis of operational service models is the way legal contracts are used to enforce the BSR. For both MAN and GE, outcome-based contracts are linking the buyers' revenue to their own, which means legal bonds are becoming an incentive mechanism rather than threat. As information exchange and the characteristics of the business model are mutually reinforcing, stronger cooperative norms are also naturally formed. Through the knowledge-intensive and customised nature of such models, the supplier covers the largest part of the risk across cases and has the highest specific investment into the relationship. Across cases, it can therefore be observed that along the servitisation path, supplier engagement and integration in the design and delivery of buyer solutions, is the key variable distinguishing BSR intensity.

5. Discussion

5.1 IoT as a servitisation enabler

This paper was set out to confirm the enabling factor of IoT technology implementation for the service transformation of manufacturers. As established in the literature review, the IoT is providing users with a boundless flow of data, through a stack of value-creation layers added to tangible assets (Coreynen et al., 2017; Rymaszewska et al., 2017; Lee and Lee, 2015; Fleisch et al, 2014). This can enable value-added services through data-analytics, monitoring and remote control as hypothesised by Fleisch et al. (2014).

Case study data of pioneering firms in this transformation process (GE, Siemens, Trumpf & MAN) clearly confirmed this link and aligned itself with the enfolding literature. The cases each had different characteristics and pathways to servitisation but showed conformity with the categorisation applied in the cross-case analysis using Oliva and Kallenberg's (2003) service space matrix. While this alignment may be primarily attributed to the conceptual case selection, it may be generalisable as servitisation pathway choices, according to Koof et al. (2016) (i.e. fairly equal spread of firms adopting basic installed base-, professional-, maintenance- or operational services).

Across all cases, the implementation of IoT technology is bringing buyers and suppliers closer together, as products are not 'one and done' anymore and opportunities for value creation and customer integration are increasing. Especially for firms like GE, Siemens and Trumpf, it moved their business model away from planning for obsolescence in their product to keep revenues recurring, to the 'as-a-service' model, offering predictive or remote maintenance, which is binding the two parties in a perennial relationship.

Nonetheless, the analysis of GE and its IoT Predix platform also produced findings regarding the limited willingness of new buyers to adopt complex projects involving novel IoT technology. While GE is combatting these cognitive barriers through its 'pilot' sales process, giving buyers insights into the potential benefits through a test phase, the findings still suggest that already existing trust in the supplier also drives trust in the suppliers IoT implementation credibility and perceived usefulness of the technology itself. This is in line with Falkenreck and Wagner (2017) and their analysis of IoT implementation reservations.

5.2 IoT impact on buyer-supplier relationships

While the enabling factor of IoT technology for service transformation has been hypothesized before (Coreynen et al. 2017; Fleisch et al., 2014) the truly novel findings of this paper were made in its analysis of changing IoT BSRs. The relational view presented in the literature review, offering a rationale for the service transformation phenomenon, was found to be most applicable to explain the BSR changes within IoT enabled Servitisation. Dyer and Singh's visionary paper on the relational view from 1998, can therefore be applied to this modern context and extended by certain propositions presented hereafter. These may act as guidance for future quantitative research.

The IoT's transformative effect on business models is significantly altering BSRs, as firms are moving closer together and dialogue-based buyer relationships are replacing unidirectional, short-term and transactional relations. The following proposition thus acts as a ground for further elaborations in Proposition 1 *a*, *b*, *c*, d and *e* respectively.

Proposition 1: The IoT is enabling a 'marriage' between buyer and supplier through a range of factors (a, b, c, d, e).

Being the supplier of highly integrated 'operator model' services, MAN and GE are using the data extracted from IoT sensors on turbines or trucks respectively, to leverage information about the buyers' operations, individual end users and the general industry environment. The buyer uses this data to improve operational efficiency and enable new pricing models (pay-per-use etc.), greatly increasing information exchange in both directions.

Proposition 1a: The IoT amplifies information exchange in the relationship.

As established by Dyer and Singh (1998) and revised by Tangpong et al. (2015), the extent to which partners in a relationship can generate relational rents is influenced by two key sub-processes: the length of the relationship and governance arrangements preventing opportunism. With long-term service contracts, such as those enabled by the IoT value proposition, determining length (years), operational control and data access, both sub-processes see positive increases compared to pre-IoT implementation, across all cases studied in section 4.

This paper proposes that the open platform, bi-directional information exchange and monitoring capabilities of IoT sensors add another sub-process to this established theory of Dyer and Singh (1998), as higher transparency increases the ability of partners to invest in relation-specific assets.

Proposition 1b: The IoT acts a safeguard against opportunism in the buyer supplier relationship, increasing the potential for relational rents from relation-specific assets.

While these safeguards are mostly driven by legal contracts, the case analysis showed that the increase in information exchange, collaboration and co-creation gave rise to self-enforcing safeguards. On one side, formal self-enforcing safeguards were created through the high level of specific investments of suppliers like GE and MAN, into their tailored IoT service offering. Previous papers have hypothesised that trust in the relationship is increasing because these investments are likely to decrease in value if opportunistic behaviour is shown or cooperation is lacking, effectively making these investments a "hostage" (Pisano, 1989). As information exchange and the characteristics of the IoT business model are mutually reinforcing, stronger cooperative norms are also naturally formed, further increasing trust, the most important informal self-enforcing safeguard.

Proposition 1c: The IoT is creating formal and informal self-enforcing safeguards of economic hostages and trust.

Directly linked to this is the way risk and financial incentives are shared in these IoT service contracts. With the increase in trust and new IoT pricing models, contracts are becoming incentive mechanisms instead of threats, enforcing the BSR. For both MAN and GE, outcome-based contracts are linking the buyers' revenue to their own, aligning incentives and encouraging transparency, while discouraging free riding behaviour. Similarly, the risk of the investment is now shared, as ownership is not transferred to the buyer. While previous scholars have found equity arrangements to be most effective in aligning incentives (Mowery et al., 1996; Lavie, 2006), the cases in this paper showed that the IoT and the outcome-based contracts it enables, provide a promising alternative.

Proposition 1d: IoT Services are aligning incentives of partners through risk and financial incentive sharing

The last factor enabling a 'marriage' between the buyer and supplier, is the IoT's impact on transaction costs. In its reasoning for a service transformation, transaction cost economics theory posits that competitive advantage can be achieved through long-term service agreements, removing the cost of searching, adaptation, monitoring and control connected with every transaction (Gulbrandsen et al., 2017; David and Han, 2004). The long-term service models studied in this paper very much confirm these findings as the increase in trust of both relationship partners leads to lower transaction costs. Furthermore, beyond the positive but more indirect impact on trust, the IoT also has a direct effect on transaction costs as the business model itself is built around an open platform encouraging information exchange and real-time monitoring, lowering marginal costs (contracting, monitoring), irrespective of contract length.

Proposition 1e: IoT Services are reducing transaction costs through reduced bargaining and monitoring costs.

The propositions produced in this section so far are all leading to a certain inference. Following the two dominant service transformation dimensions, produced in the literature review (2.2.2) and cross-case analysis (4.5), the predominant service models *(I. basic installed base services, II. professional services, III. maintenance services, IV. operational services)* were assessed and compared to each other. However, when looking at the potential impact of the IoT on BSRs and the propositions produced so far, they all presuppose a high supplier integration, financial incentive and risk sharing. These conditions are only met in operational services (IV.), through outcome-based contracts, and maintenance service models (III.), as seen with Trumpf and its PSS offering. Therefore, from a relational view, only these two models are encouraging information exchange, financial risk and incentive sharing to a sufficient degree to create relationalism and allow for relational rents.

Proposition 2: To optimally capitalize from the IoT service transformation, firms need to adopt operational services models to generate relational rents from their high specific investments.

5.3 Rationalising constraints

Propositions 1a-e and 2 came with certain limitations however. While the increase in risk for the supplier can be regarded positively, i.e. as risk sharing *(proposition 1d)*, an issue which emerged from the case study was the threat of overexposure to risk. Despite executives of companies analysed in the case study having a mostly positive outlook on servitising their offerings, the comment made by GE Vice Chair Beth Comstock (case 1), "*we're trying to sell them something they don't know they need*" (Iansiti and Lakhani, 2014), still shines a light on certain reservations for buyers to invest into IoT technology. This may result in a lack of commitment from the buyer, hindering relationalism and exposing suppliers to the threat of becoming a captive supplier, a relationship type characterised by low relationalism, with the buyer having high power leverage over the supplier (see section 2.3.2). This unequal power distribution stems from the supplier's disproportional investment into relation-specific assets, making it highly dependent on buyers' goodwill. To combat this threat the supplier has to thrive for relationalism to benefit from the aforementioned safeguards.

Proposition 3: When committing significant resources into IoT assets, suppliers have to actively seek relationalism with the buyer, to prevent captive-supplier scenarios.

Consolidating these two propositions (2, 3), the findings suggest that along the supplier integration spectrum, specific investments (by the supplier) are directly correlated to risk exposure and show diminishing returns after a certain point, reinforcing proposition 2.

5.4 Reflections: IoT business models a sustainable path for the future?

The central argument of this paper thus far is that a pair of firms, connected through IoT service agreements, can generate more value than single firms. With so much praise for IoT business models and the myriad of positive relationship effects presented, reflections and considerations need to be made for the possibility of this phenomenon only being a 'hype' and of a short-term nature. An argument for the longevity of this phenomenon are the high start-up costs of capital intensive service offerings like GE Predix, which excludes smaller companies and potentially makes this exclusive tie-up amidst large companies the norm.

In contrast, there are exceptions disproving this norm, with case company 1 (GE) recently losing an IoT service contract with French energy supplier Engie to a small Silicon-Valley start-up *C3 IOT* (Crooks, 2017), raising the notion that small, nimble start-ups may be superior in customising their offering. Either way, it demonstrates that for industrial manufacturers, like those studied in the case study, "dominance in hardware will not necessarily translate into software" (Crooks, 2017).

Further, the decision to let an IoT service supplier analyse their data and run their operations raises a fundamental question for all businesses: what value are they adding? The conflict between these critical reflections and the positive propositions made in this discussion section so far, may lead to the conclusion that the IoT service transformation is only of a cyclical nature, meaning the industry will go back to its original phase after having explored long term, IoT enhanced relationships. This relates to Charles Fine's visionary book on *clock speed* (1998) introducing the idea that every industry goes from one phase to another phase but always comes back to its original phase, making the only difference between them the speed (clock speed) at which this transition takes place. Fine referred to such "fast-clockspeed" industries as "fruit flies" due to their short lifespan and emphasised the importance of studying such industries. Time will tell if this IoT enabled service transformation is merely a short-term trend or the pre-cursor for business model innovation, but the analysis of such emerging phenomena and their underlying industry dynamics can have far reaching managerial implications, as it facilitates business decisions in the value chain, and gives insights into how an industry may develop in the future. Much of the past research has reported on the impact of IoT in capital intensive high-value assets such as aircraft, trains and defence systems, yet the ever-reducing costs of IoT devices and processes may pave the way for commodity manufacturers to also explore servitisation business models. Following the same principle, service providers with no manufacturing capability may also consider a strategy of *productization*, embedding IoT and the ability to customise such devices into their operations.

6. Conclusion

6.1 Theoretical implications

Combining the reach of the internet with industrial capabilities to monitor, control and coordinate machines is creating entirely new business models and value propositions (Ng & Wakenshaw, 2017). With the emergence of the IoT, and its core functions of data analytics, machine monitoring and remote control, the industrial world may see a renewed wave of manufacturers becoming service providers. This service transformation entails the extension of product portfolios through advanced services, customised to buyers' needs, with the ultimate aim of increasing customer touchpoints and forming long-lasting relationships (Baines et al., 2009a; 2009b). Bridging the seminal papers of Bastl et al. (2012), Saccani et al. (2014) and Coreynen et al. (2017), this paper presented how the IoT technology is enabling manufacturers to transform business models and enhance buyer-supplier relationships. Based on a multiple-case study, examining four pioneering suppliers in the manufacturing sector, this paper considers the following contributions.

Firstly, this paper adds insights regarding the interrelation of servitisation, BSR and IoT literature through the analysis of links in between these paradigms. Secondly, this paper extended Oliva and Kallenberg's matrix to include IoT cases and explored servitisation pathways and dynamics. It was noted that supplier offerings may adopt the characteristics of more than one pathway. Thirdly, based on the literature and cases, several propositions were constructed to assist future research. Our results illustrate the impact of the IoT on BSR aspects such as information exchange, self-enforcing safeguards, trust and transaction cost economics. In summary, the IoT therefore supports servitisation pathway theory to the extent that it enables a stronger link between buyers and suppliers, through the increase in trust, safeguards and risk- and financial incentive sharing.

6.2 Managerial implications

With its practical orientation, this study has significant relevance for managers on both the supplier and buyer side. For suppliers, the findings in this paper illustrate concrete strategic pathways to servitise their offering using IoT technology. Suppliers can leverage IoT through one or more of the business model strategies shown in Table 4 and build on the experiences of the 4 pioneering manufacturers shown in the case study. Although manufacturers may be tempted to push for higher value channel controlling operational service models (IV.) in *proposition 2*, our research urges managers to actively seek and promote relationalism with their suppliers in *proposition 3.* This links to the notion that IoT implementation will not automatically lead to competitive advantage (Barney, 1991), which the paper addresses in its findings about the importance of BSR, giving insight to managers about what relationship connectors to prioritise.

Similarly, buyers can extract the findings about IoT enforced relationships to make decisions between individual supplier's offerings and evaluate them based on their capability to provide sufficient resources for relationship specific investments and their inclination to develop trust and commitment to the relationship. Further, presenting the multitude of benefits shown in the case study to buyers, may help overcome cognitive barriers they might carry in relation to new technology.

Lastly, the findings presented in section 5 can help managers on both sides of the relationship identify how to build new relationships and which relationship connectors (Table 3) to particularly emphasise, depending on the servitisation path chosen. For example, as *proposition 1c* showed, legal bonds may not be as effective in value-creation oriented models, compelling managers to supplement legal bonds with informal, self-enforcing safeguards such as trust and relationalism.

6.3 Limitations and suggestions for future research

Firstly, for theory-building purposes, an exploratory case study method was chosen, making the case selection conceptual and purposeful in nature. This meant that the propositions derived in the discussion section were based on a carefully selected yet somewhat limited number of case companies. This covered B2B firms in the heavy manufacturing industry, which were analysed from a supplier to buyer perspective, neglecting potential relationships outside of a dyadic partnership. Therefore, the generalisability of the propositions requires further testing. Future research should expand its focus on the myriad of other industries impacted by the IoT or expand the unit of analysis across the entire supply chain and firm ecosystems.

Furthermore, this paper adopted Cannon and Perreault's (1999) seminal 'relationship connector' framework as a lens to analyse cases. Such lenses carry inherent limitations, as the distillation down to 5 'relationship connectors' may not do justice to the incredibly complex integrated systems and relationships studied. Future research may adopt the revised BSR typology of Tangpong et al. (2015) to get a more holistic picture of collaboration in the BSR.

Looking forward, we expect the propositions constructed in section 5, to act as the basis of hypotheses generation, enabling future quantitative assessment through survey methods with manufacturing companies. This may lead to the definition of a generic operations strategy, for suppliers aiming to leverage IoT relationships with buyers of their servitised offerings.

Lastly, another interesting research opportunity can be found in the notion of "trustless trust" introduced by Werbach (2017), stating that modern information technology permits "trust in the outputs of a system without trusting any actor within it", potentially disrupting the intrinsic trust architecture of buyer-supplier relationships.

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Table 1: Popular definitions of Servitisation	
Author	**Definition of servitisation**
Vandermerwe and Rada (1988)	"Market packages or 'bundles' of customer-focused combinations of goods, services, support, self-service and knowledge."
Baines et al. (2007)	"Servitisation is the innovation of an organisations capabilities and processes to better create mutual value through a shift from selling products to selling PSS."
Ren and Gregory (2007)	"A change process wherein manufacturing companies embrace service orientation and/ or develop better services, with the aim to satisfy customer's needs, achieve competitive advantages and enhance firm performance."

Table 2: Relationship connectors (Cannon and Perrault, 1999)	
Relationship connector	**Description**
Information exchange	Information exchange is an expectation of an open sharing of information that might be useful for both parties.
Operational linkages	Operational linkages capture the degree to which systems, procedures and routines of both parties (for example customer and supplier) have been linked to facilitate operations.
Legal bonds	Legal bonds are detailed and binding contractual agreements that specify the obligations and roles of both parties in the relationship.
Cooperative norms	Cooperative norms reflect expectations the two exchanging parties have about working together to achieve mutual and individual goals jointly.
Buyer and supplier adaptation	Relationship-specific adaptations are investments in adaptations to process, product or procedures specific to the needs or capabilities of an exchange partner.

Table 3: Summary of the relationship connectors (Cannon and Perreault, 1999) between the supplier and its buyers pre and post IoT implementation

Relationship	Information exchange	Operational linkages	Legal bonds	Specific adaptations	Cooperative Norms
GE-Buyer **pre** *Predix*	Information exchange is limited after the initial purchase agreement. Supplier provides only limited data after repair services (duration, parts used etc.)	Fixed interval maintenance is the only touchpoint/linkage of supplier and buyer.	Big-ticket and transactional sales process. Contract sets obligations and fixes price for the supplier (GE). No long term bonding or tie up.	Product is customised to buyer's needs. Certain buyers adapt manufacturing plant to GE's product.	Deals are made on a transactional basis, creating no desire for relational benefits.
GE-Buyer **post** *Predix*	GE provides detailed performance data and analytics to be used by the buyer to pay the supplier and forecast production outages. The buyer and supplier exchange ideas about how to improve the performance using advanced analytics insights.	GE is fully integrated into the buyers operations and takes over certain activities. Complete integration of Predix into the buyers ERP and scheduling systems to improve data transfer and allow for maintenance downtime.	10-15 yearlong outcome-based contract sets out obligations for GE about: (i) performance targets; (ii)service pricing; (iii) degree of operational influence; (iv) data access; (v) data security and confidentiality. The buyer in turn is expected to cooperate with GE data specialists and provide plant access.	GE covers a larger part of the risk and has a high specific investment into the relationship, through customisation, and adaptations of Predix to integrate it into the buyers ERP system. Ownership of assets is never transferred to the buyer.	Relationship is kick-started by a 'pilot' sales process and further cooperative norms are built through the information exchange between GE analysts and buyer's engineers. Greater commitment to the relationship is shown by the supplier (GE).
Siemens - Buyer **pre** *MindSphere*	Products are sold on a transactional basis, removing any interaction after the sale.	No touchpoint/linkage of supplier and buyer after the sales process.	Transactional sales process. No long term bonding after the component was sold.	Buyers customise plant operations to Siemens' component.	Components are sold on a transactional basis, creating no desire for relational benefits.
Siemens– Buyer **post** *MindSphere*	Siemens is providing real-time information about train condition and maintenance widows over the *MindSphere* platform.	Siemen's *MindSphere* software is fully integrated into the buyer's assets to increase availability and operational efficiency. High number of touchpoints through condition monitoring, predictive maintenance and cloud platform *MindSphere*.	6-year term contract setting out obligations for Siemens about: (i) software pricing; (ii) data access; (iii) maintenance schedules. The buyer in turn is expected to cooperate with Siemens and provide sufficient data.	Siemens fully customises *MindSphere* to the buyer's needs. Customisation creates a significant specific investment into the relationship. The buyer adapts its maintenance scheduling to Siemens' software recommendations and is transferred ownership of the component.	Relationship is fuelled by close interaction through the predictive maintenance software, requiring high cooperation on both sides. Fewer breakdowns and higher availability in for example trains, is benefiting the buyer, potentially leading to reciprocal action into the relationship.
Trumpf - Buyer **pre** *TruService*	Information exchange is limited after the initial purchase agreement. Supplier provides only limited data after repair.	Fixed interval maintenance is the only touchpoint/linkage of supplier and buyer.	Transactional sales process. No long term bonding after the machine was sold.	Buyers customise plant operations to Trumpf's machine.	Deals are made on a transactional basis, creating no desire for relational benefits.
Trumpf – Buyer **post** *TruService*	Trumpf is staying in close contact to the buyer all over the globe through its telepresence portal, enabling a secure audio-video information exchange and remote maintenance.	Trumpf's *TruService* software is fully integrated into the buyer's ERP system to allow for automation and operational efficiency. High number of touchpoints through condition monitoring, remote maintenance and telepresence portal.	Long term contract setting out obligations for Trumpf about: (i) service pricing; (ii) data access; (iii) data security and confidentiality. The buyer in turn is expected to cooperate with Trumpf and provide sufficient data.	As a PSS provider, Trumpf carries a larger part of the risk than before. Customisation creates a significant specific investment into the relationship, but Trumpf easily manages local adaptations through its subsidiary network across the globe.	Relationship is fuelled by the informal nature of interactions through the online telepresence system. Immediate support availability from Trumpf's technicians over the internet increases trust with the buyer.
MAN - Buyer **pre** *Telematics*	No formal information exchange after buyer purchases a truck from MAN.	Fixed interval or emergency maintenance is the only touchpoint/linkage of supplier and buyer.	Transactional sales process. No long term bonding after the truck is sold.	MAN customises the trucks composition for the specific operations of its buyer (construction vs long-haul)	Trucks are sold on a transactional basis, creating no desire for relational benefits.
MAN – Buyer **post** *Telematics*	Information exchange is essential for MAN's operator model, the buyers capacity demand and MAN's truck availability is matched through the Telematics software platform. This allows for appropriate maintenance windows to be found when the buyer is not using the truck.	MAN's 'uptake guarantee' is directly linking the buyers revenue to that of MAN. High number of touchpoints through condition monitoring, truck availability model and data analytics services.	Long term leasing contract setting out obligations for MAN about: (i) service pricing; (ii) availability of trucks; (iii) data access; (iv) fuel saving recommendations. The buyer in turn is expected to stay within an anticipated mileage parameter, after which surcharges are raised.	In the operator model, MAN carries a larger part of the risk than before. The operator model also forces MAN to expand its dealer/ repair shop network to ensure its 'uptake guarantee'. The buyer has to retrain its drivers to new technology.	Relationship is fuelled by the cooperative nature of the operator model. Immediate support, maintenance and truck availability from MAN increases trust with the supplier, while fuel saving recommendations increase overall satisfaction with the relationship.

Table 4: Business models in the IoT service space (Adapted from Oliva and Kallenberg, 2003; Koof et al. 2016)

	Product-oriented services	End-user's process-oriented services
Transaction-based services	*Basic installed base services (I.)* After-sales services Inspection/ diagnosis Repairs/ spare parts	*Professional services (II.)* Software solutions Training Consulting
Relationship-based services	*Maintenance services (III.)* Condition monitoring Preventive maintenance PSS contracts	*Operational services (IV.)* Managing operations Outcome-based contracts

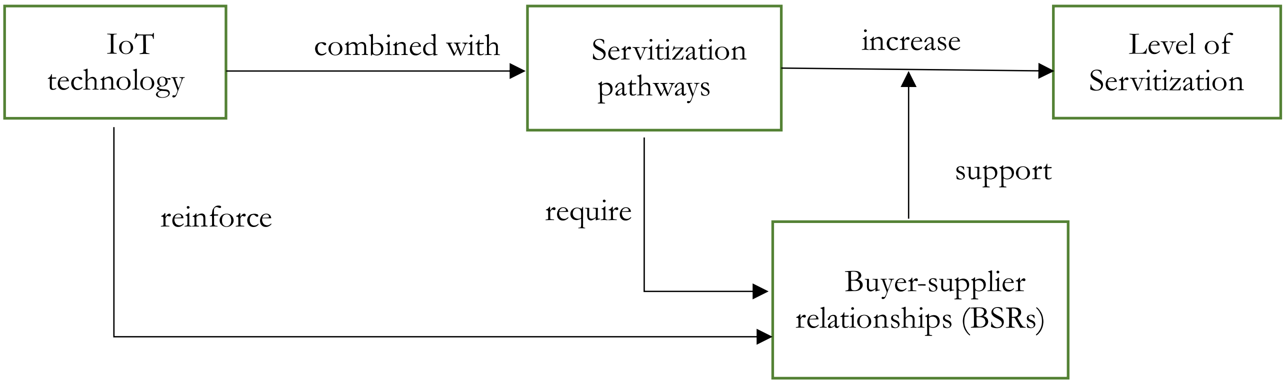

FIGURE 1: This paper's interpretive framework

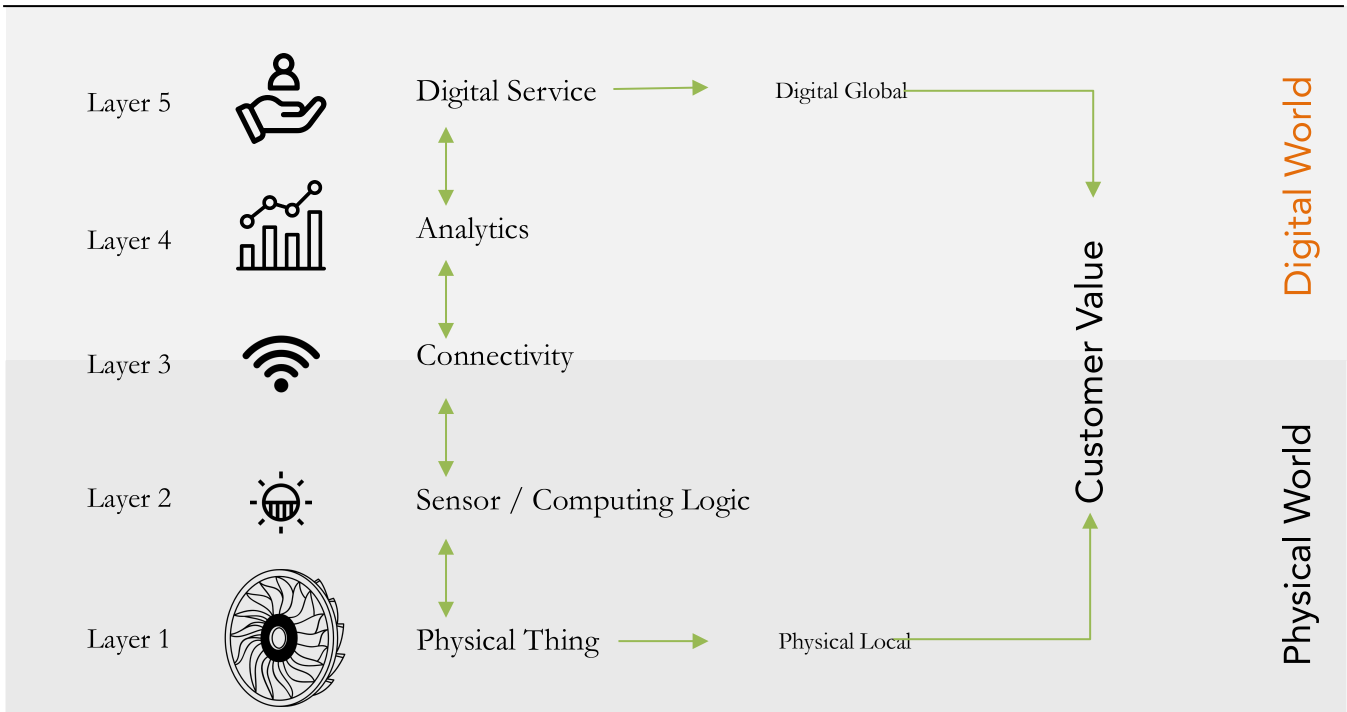

FIGURE 2: Value-creation layers in an IoT system (Fleisch et al. 2014)

FIGURE 3: IoT as a service enabler

Appendix 1: Summary of cross case analysis

Relationship	Product oriented (I.)	Service oriented (II.)	System Solution oriented (III.)	Value Creation oriented (IV.)
Information exchange	While the degree of information exchange increased, with the introduction of on-demand, customised products and maintenance contracts, it lacks the contractual obligations of PSS or value creation oriented models.	Information exchange is facilitated through the provision of a common IoT platform. Supplier provides detailed performance data and analytics to improve operational efficiency.	Supplier is staying in close contact to the buyer all over the globe through a telepresence/ telemetrics portal, enabling a secure audio-video information exchange and remote maintenance.	Information exchange is essential for operator models. Information is used to determine supplier compensation, capacity demand and maintenance windows. Conversations about potential improvements, based on analytical findings, arise.
Operational linkages	Operational linkages only slightly increased relative to other cases. Lowest degree of integration into the buyers operations.	Suppliers IoT software is fully integrated into the buyer's assets to increase availability and operational efficiency. High number of touchpoints through condition monitoring, predictive maintenance and cloud platform interface.	Suppliers service software is fully integrated into the buyer's ERP system to allow for automation and operational efficiency. High number of touchpoints through condition monitoring, remote maintenance and remote communication portal.	Supplier is fully integrated into the buyers operations and takes over certain activities. Buyers revenue is directly linked to that of the supplier in outcome based operator models.
Legal bonds	Legal contracts remain rudimentary, specifying maintenance intervals or delivery guarantees.	Detailed contract setting out obligations for the supplier about: (i) software pricing; (ii) data access; (iii) maintenance schedules. The buyer in turn is expected to cooperate with the supplier and provide sufficient data.	Long term contract setting out obligations for the supplier about: (i) service pricing; (ii) data access; (iii) data security and confidentiality.	Incentive mechanism rather than threat. 10-15 yearlong outcome-based contract link the revenue of both parties, forcing stronger cooperation.
Specific adaptations	Lowest degree of risk transfer to the supplier across cases, as product support services are highly standardised and ownership is transferred to the buyer.	Software solution is fully customised to the buyer's needs. The buyer adapts its maintenance scheduling to the suppliers software recommendations and is transferred ownership of the component.	As a PSS provider, the supplier carries a larger part of the risk than before. Ownership often remains with the supplier. Customisation creates a significant specific investment into the relationship.	Supplier covers the largest part of the risk across cases. Ownership of assets is never transferred to the buyer. Supplier has to fully customise IoT platform to industry specific needs.
Cooperative Norms	Relationship is strengthened by the cooperative nature of maintenance services. May be harmed by falsely timed maintenance causing breakdown.	Relationship is fuelled by close interaction through predictive maintenance software, and higher availability and service quality is key factor for buyer satisfaction and loyalty, potentially leading to reciprocal action into the relationship	Relationship is enhanced by the informal nature of interactions through online telepresence systems. Immediate support availability from supplier's technicians over the internet increases trust with the buyer.	Trust and loyalty in the relationship increases through the cooperative nature of the operator model. Incentivised pay-model increases perceptions of fairness for the buyer.
Cases examined	(3) Trumpf	**(2) Siemens MindSphere** (1) GE Predix	**(3) Trumpf** (5) MAN Telematics	**(1) GE Predix** **(5) MAN Telematics**