Modeling manufacturer's capabilities for the Internet of Things

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Abstract

Purpose – The study identifies a manufacturer's abilities to develop, build, sell and deliver IoT services.

Design/methodology/approach – A qualitative comparative case method that uses multiple sources of data, including executive interviews and secondary data, to understand a manufacturer's IoT capabilities.

Findings – Five Internet of Things (IoT) capabilities were identified: 1) digital business model development, 2) scalable solution platform building, 3) value selling, 4) value delivery, and 5) business intelligence (BI) and measurement.

Research limitations/implications – The main limitations are related to the qualitative research method applied. The results are applicable mainly to relatively large and global manufacturers.

Practical implications – Managers responsible for solution business development can apply the developed model to acquire and manage IoT specific resources, processes, and capabilities.

Originality/value – Existing studies have not addressed the IoT-specific resources, processes, and capabilities that manufacturers' possess. This is one of the first studies to conceptualize how these capabilities are employed.

Keywords – Internet of Things, Industrial Internet, servitization, resource-based view, Business Intelligence, digitalization

1. Introduction

The Internet of Things (IoT) is changing the competitive environment in traditional manufacturing industries and will eventually change manufacturers' value chains (Porter and Heppelmann 2014; 2015). Due to this changing environment, manufacturers are beginning to mirror software companies when implementing IoT. The rapid development of connectivity and sensor technologies allow manufacturers to develop new servitized business models, value-based earnings logics, and organizational capabilities. IoT has improved manufacturers' abilities to provide services throughout the product life-cycle, to enhance and optimize work, to serve their existing installed base, and to mitigate risks of product-related stoppages. Principally, IoT has enabled manufacturers to progress servitization of their business models by allowing them to determine their total cost of equipment ownership (TCO), and to prevent product breakdowns and abuses (Brax and Jonsson 2009; Rabetino, Kohtamäki, Lehtonen, and Kostama 2015). Business opportunities facilitated by IoT are tremendous. For instance, Strategy& report estimates that by 2020, digitization and IoT will increase annual revenues by €110 billion for the European industry sector, and *"European industrial companies will invest €140 billion annually in Industrial Internet applications."* (Koch et al., 2014: 6).

Earlier research on servitization focused on the transition from product manufacturing to services and integrated solutions, and from products to value (Baines et al., 2016; Lightfoot et al., 2013; Neely, 2008; Paiola et al., 2013). IoT and Industrial Internet play a central role in this transition, by enabling improved data acquisition, storage, analytics, and action. At the center of this transition, where Industrial Internet is used for increased customer value creation, are services related to remote technologies. The existing literature on remote technologies has focused on the various technical details (e.g., sensors, data analysis techniques, databases), thus providing case-based evidence (Vardar et al., 2007) and illustrations (Lee, 1998; Levrat et al., 2008), particularly from a technology perspective. Also, servitization research has examined the importance of remote technologies in collecting information on an installed base (Johnstone et al., 2009; Ulaga and Reinartz, 2011; Wise and Baumgartner, 1999). Studies have also emphasized the importance of using remote technologies for preventive and predictive maintenance (Brax and Jonsson, 2009; Huikkola et al., 2016). As a result, prior research linking servitization and IoT has focused on the technical details regarding IoT (Ala-Risku, 2009; Lee, 1998; Levrat et al., 2008; Muller et al., 2008; Vardar et al., 2007) mostly neglecting the strategy perspective (Eloranta and Turunen, 2015; Porter and Heppelmann, 2015). Hence, to capture the capabilities required from the manufacturers, IoT needs a clear model defining its use and value. Research is needed to analyze the capabilities needed to create and capture value in solution business.

To address this research gap, this study defines the role of IoT as a critical component of a solution provider's capability combination. As such, we address the research questions – what are a manufacturer's IoT-specific capabilities, and how do these capabilities manifest themselves when IoT is implemented? The study contributes to the servitization literature by using extensive comparative case data to analyze manufacturer's capabilities with respect to IoT. It also extends the servitization literature by developing a conceptual model that explains the capabilities required to successfully develop, build, sell, and deliver IoT enabled solutions. For managers advancing servitization, IoT and remote diagnostics, the study provides a framework to analyze and develop the capabilities required to implement IoT successfully.

2. Theoretical background

2.1. Strategic role of resources and capabilities

The resource-based perspective to strategy emphasizes the role of firm's possessed resources to sustain its competitive advantage (Barney, 1991; Grant 1991; Peteraf, 1993; Wernerfelt, 1984 The fundamental argument of this approach is that the key source of the firm's sustainable competitive advantage is its unique, valuable, rare, non-substitutable, and relatively immobile resources, such as personnel competencies, organizational culture, and reputation (Barney, 1986; 1991). The resource-based literature classifies resources into several categories depending on how critical, concrete, multidimensional, valuable, and long-term they are considered.

Scholars consider capabilities as *strategic* when they differentiate a company from its competitors (Raddats, 2011; Winter, 2003). Strategic capabilities, typically defined as a bundle of resources, enable the firm to achieve above-average returns in its industry because these capabilities are superior and rare in the industry, create special value for the customers, and are not replicable (Ray et al., 2004; Wright et al., 2001). Long & Vickers-Koch (1995) define strategic capabilities as the sum of core competencies, such as special knowledge, skills, and technological expertise that distinguish the firm from other firms, and strategic business processes that deliver special expertise via valuable products and services. Thus, strategic capabilities are the most critical, the most distinctive resources a company possesses, and the most difficult to copy when effectively linked with strategic targets in a value chain.

2.2. The domain under interest: industrial services

Manufacturers have been transforming from selling products and add-on services towards operational and performance-based services (Baines et al., 2013; Gebauer et al., 2011; Kowalkowski, Kindström, et al., 2013). Manufacturers have made this move to differentiate their products and to help them gain various economic and strategic advantages in the markets (Huikkola et. al. 2016). Thus, instead of selling pure products and services as add-ons, manufacturing firms are now providing life-cycle services and performance guarantees.

These combinations of products, services, and software are often described as integrated solutions (Brady et al., 2005; Davies, 2004; Nordin and Kowalkowski, 2010; Windahl and Lakemond, 2010; Wise and Baumgartner, 1999), hybrid offerings (Ulaga and Reinartz, 2011), customer solutions (Tuli et al., 2007) or, simply, solutions (Nordin and Kowalkowski, 2010). This transformation from a product to a services dominant business model is often termed as servitization (Vandermerwe and Rada, 1988), servicization (Hsieh et al., 2012; Santamaría et al., 2012), or service infusion (Eggert, Hogreve, Ulaga and Muenkhoff (2011); Kowalkowski, Witel and Gustafsson 2013).

Servitization studies that have investigated solution business capabilities (see Neto et al. 2015; Raddats and Burton 2014), have identified the need for manufacturers to develop new selling techniques and abilities (Reinartz and Ulaga, 2008), determine new value propositions for the dedicated customers (Storbacka et al., 2013), use the network of suppliers and intermediaries in a new way (i.e. developing system integration capability) (Ceci and Masini, 2011; Paiola et al., 2013), link strategic customers to its development processes (Tuli et al., 2007) and employ the extensive product usage and process data from their installed base (Ulaga and Reinartz, 2011). As such, servitization requires the same capabilities as traditional business products, while deploying the resources in new ways.

2.3. Servitization and IoT

To develop service offerings, industrial companies leverage a variety of technologies that rely upon the information potential of their installed base. During the past two decades, scholars from operations, management, and industrial marketing, have defined these remote technologies, and the related services in various ways such as teleservice (Lee, 1998: 901), remote maintenance (Persona et al., 2007: 1289), and installed base information (Ala-Risku, 2009). These definitions illustrate the development of the field, but also describe how these issues of IoT, smart, connected products, remote diagnostics, and remote services are interrelated (Grubic 2014). The term Internet of Things dates back to research conducted by McFarlane, Sarma, Chirn, Wong, and Ashton (2003) in the MIT's Auto-ID Center. Lee and Lee (2015: 431) defined it as a "*new technology paradigm envisioned as a global network of machines and devices capable of interacting with each other*," which suggests the technical origins of the concept.

Servitization can be significantly supported by utilization of IoT solutions. Consider for instance Rolls Royce, which differentiates its offerings through Power by The Hour concept. Compared to pure equipment sales, power-by-the-hour services have enabled Rolls-Royce to generate more stable income, higher margins, deeper customer-relationships, and seven-fold profits through the product life-cycle. (Rabetino et al., 2015). By using IoT solutions, industrial companies can align their total offerings to support customers' processes, rather than selling products through an arm's length market transaction (Kohtamäki et al., 2013). As a result, these industrial companies increase the importance of customer knowledge, and in particular, the knowledge of the installed base. By leveraging the knowledge gathered through the installed base (Ulaga and Reinartz, 2011) and by combining customer knowledge with technological knowledge (Wise and Baumgartner, 1999), solution providers can benefit their customers, differentiate their solution offerings, and eventually, generate a competitive advantage.

Until recently, the field of research has leaned towards technical aspects with a few exceptions. Biehl et al. (2004) highlighted the topic's managerial importance, stating that in the future, all industrial companies will need Remote Repair, Diagnostics, and Maintenance (RRDM). From a production management perspective, Levrat et al. (2008) developed a framework through which the phenomenon could be observed from five different levels of abstraction: strategic, business processes, organization, service and data architecture, and infrastructure. Persona et al. (2007) stated that three fundamental aspects of E-maintenance – remote maintenance, information technology, and supply network integration – will influence to industrial company competitiveness. Since, it has become evident that the number of connected devices will grow exponentially during the current decade, thus creating huge potential for additional revenues in industrial solutions. For example, through 2013, General Electric generated $800 million in additional annual revenues by selling the benefits of improved jet engine performance (thrust generated) rather than relying simply on the transactional selling of engines (Iansiti and Lakhani, 2014). This is possible through novel IoT solutions that connect the engines to the manufacturer's network in real-time.

The despite that IoT has caught the interest of management and marketing scholars, building a feasible business model using the vast possibilities of IoT is a great challenge. Manufacturers are seeking opportunities by employing IoT and refining business models (Grubic, 2014; Porter and Heppelmann, 2014, 2015) Thus, manufacturers must identify the gaps in their internal capabilities and recognize the needs of the market before transforming themselves into IoT solutions providers (Lerch and Gotsch, 2015), and developing business models that support their overall strategy (Allmendinger & Lombreglia, 2005; Porter & Heppelmann, 2014).

2.4. IoT and Capabilities – the extant review

Servitization studies have acknowledged that manufacturers need new types of capabilities to develop, sell, and deliver more complex solutions to their customers. For instance, scholars have suggested that manufacturers need capabilities to build scalable business model and ramp up their solutions (Shankar, Berry and Dotzel 2009), sell value and solutions to the customers' top managers (Huikkola et al. 2016; Töytäri and Rajala, 2015), deliver value through the product life-cycle (Tuli et al. 2007), and develop capabilities related to business intelligence i.e. data acquisition, assimilation and analytics.

2.4.1. Building scalable IoT Business

In addition to a feasible business model, manufacturers face a challenging task of building a scalable infrastructure that is necessary to deliver IoT services. This requires extensive resource combinations from companies participating in this process. According to Dijkman et al. (2015) the essential factors needed to deliver IoT services successfully are key sources, key activities, key partnerships, and a low cost structure. The technology enabling to build the infrastructure has existed already for some time and the price commoditization of this technology that Biehl et al. (2004) forecasted has occurred; it has become cheap enough *"to make smart, connected products technically and economically feasible*" (Porter and Heppelmann, 2014: 68). In addition to sufficient sensor and communication technology also appropriate software is essential to form an optimal IoT platform. In a globalized world, this often sets some additional requirements that vary in terms of the customer segments and needs of different geographical areas, leading to challenges, such as scaling the internal knowledge distribution for the needs of diverse cultures and languages (Porter and Heppelmann, 2015). However, once the platform is in place, digital sensors can measure data and the system can predict failures with almost zero incremental costs (Iansiti and Lakhani, 2014), and offer numerous other benefits, such as decreased maintenance costs (Biehl et al., 2004) as well. The extant studies on servitization (e.g., Shankar, Berry and Dotzel 2009), have acknowledged that manufacturers typically lack capabilities to scale their service business. Thus, building capabilities that help manufacturers to scale their solution business is needed to master transition from goods to services. IoT can potentially help manufacturers to create a scalable business model.

2.4.2. Selling value through IoT solutions

As companies move to offer IoT solutions, they are simultaneously moving towards selling higher value and performance (Töytäri et al., 2015; Töytäri and Rajala, 2015). Dijkman et al. (2015) encourages value selling to articulate the value proposition of IoT solutions. Yet, manufacturers are struggling to articulate their value propositions in a way that would attract customers (Grubic 2014; Ulaga and Reinartz 2011). Brax and Jonsson (2009) suggest that companies should bundle solutions in layered offerings to address the needs of targeted customers. For example, remote monitoring with fast response time, increased reliability, and reduced downtime are good sales arguments to those prospects with critical production equipment (Biehl et al. 2004; Cohen, Agrawal, and Agrawal 2006). The extant servitization studies (e.g., Huikkola et al. 2016; Reinartz and Ulaga, 2008) have stressed the importance of building capabilities to sell solutions and value instead of selling product benefits. Therefore, manufacturers need to build, acquire or develop capabilities to identify, quantify, communicate and verify customers' key value drivers (Töytäri and Rajala, 2015). IoT can potentially address these challenges for the manufacturers.

2.4.3. Delivering value through IoT

In B-to-B services, as well as B-to-C, value capture and co-creation play a significant role (Coreynen et al., 2016; Kohtamäki and Partanen, 2016). Brax and Jonsson, (2009) highlight this fact by showing where manufacturers deliver novel solutions for customers. Swanson (2001) pointed out that remote technologies allow companies to reduce on-site maintenance operations, enable proactive maintenance, and guarantee less downtime, thus creating more value for the customer. However, the requirements from such after-sales services are often high, especially in the process industry, because stoppages and downtimes are expensive to the customer (Biehl et al., 2004; Cohen et al., 2006). For example, customers may see the company offering remote services as the one responsible for monitored equipment (Brax & Jonsson 2009), thus increasing the expectations of these remote services. Companies that begin to offer IoT solutions are moving towards the service end of the product-service continuum, yet their competitive advantage is based on their product. Many scholars suggest that applying IoT in solution businesses will enhance performance in the supplier-customer relationship and support the companies' position amongst their competitors (Brax and Jonsson, 2009; Jonsson et al., 2008; Persona et al., 2007; Ulaga and Reinartz, 2011). Overall, development of customer interactions is emphasized within the novel IoT solutions. Customers might need more personal assistance and tools for easy self-service (Dijkman et al., 2015). They might also require more interaction in general (Paluch, 2014) as both the provided solution and the technology behind it is new. The existing servitization literature (e.g., Baines et al. 2008) has noted that manufacturers suffer superficial customer relationships in product exchanges. To address this problem, studies have suggested them to develop capabilities related to manage long-lasting and deep customer relationship (Penttinen and Palmer 2007; Tuli et al. 2007). IoT technologies may be useful to enable value co-creation between the manufacturer and its customers.

2.4.4. Business intelligence and measurement in IoT

Information technology and built-in business intelligence capabilities are becoming integral parts of the IoT products themselves. Data on the installed base is provided for storage, analysis, and application (Porter and Heppelmann, 2014) to facilitate preventive maintenance, customer value creation, and solutions development. The IoT system, together with coordinated cooperation between R&D, the sales department, and service delivery, enables the development of new service offerings that are based on the data acquired from customers' equipment and operations (Grubic, 2014; Porter and Heppelmann, 2014, 2015; Reinartz and Ulaga, 2008). The data and the derived conclusions enable companies to offer their services for lower prices and with higher margins (Ulaga and Reinartz, 2011). When the data collected is exploited optimally, IoT solutions can also evolve to *"a key source of competitive advantage"* (Porter and Heppelmann, 2015: 100). As such, IoT professionals recognize that complex business models are needed to provide IoT solutions (Dijkman et al., 2015). Scholars and practitioners have stated that "the data is the new oil". However, the data collected through IoT technologies need to be exploited to create customer value. To exploit the data successfully, manufacturers need to develop new capabilities to acquire, assimilate, analyze and make use of the data.

2.4.5. Modeling IoT capabilities

The extant servitization studies have widely described the new capability requirements for manufacturers to help them to succeed in the solution business. However, the extant studies have mainly focused on particular capability blocks, thus neglecting the interplay between these strategic capabilities. This study is one of the first to study how IoT can facilitate manufacturer's materialization of strategic capabilities, highlighting the necessity of identifying and building optimal resource combinations through alignment of dedicated resources and strategic business processes. The presented holistic framework helps researchers and managers to map different strategic capabilities for the Internet of Things in manufacturing context.

3. Methodology

This study employs qualitative comparative multiple case study method to study a new and complex phenomenon comprehensively and from different perspectives. Flick (2009) recommends to use the method when studying the development, acceptance, and use of new technologies. This study describes how the IoT-specific resources, processes, and capabilities are employed in manufacturing companies, and how these tie together to generate a competitive edge in the market. Exploratory and qualitative approaches were used to gather results and form a generalizable conceptual model (Eisenhardt 1991; Yin 2009). Five industrial companies were examined by using multiple sources of data (interviews, executives' presentations, Internet pages, sales and internal training materials, annual reports, seminar observations, etc.) to triangulate the information gathered. (Eisenhardt 1989; Huberman and Miles 1994; Yin 2009)

The methodology includes three steps: 1) a pilot study to build a rigorous research framework, 2) a comparative case study with two rounds of interviews for data collection, and 3) data analysis that includes within and cross-case analysis and the development of conceptual models. In all cases, the authors interviewed a minimum of two persons from each firm (a key development manager and a key sales support manager or account manager) to ensure the breadth of the data collected. Figure 1 presents the steps of the research methodology used in the study. The steps are described more accurately later in this section of the paper.

Figure 1. Research methodology

Pilot study (2011-12)

Interviews
2 interviews in the pilot company
- Senior R&D specialist of condition based maintenance systems
- Vice President of solution business

7 supportive interviews with Finnish manufacturing companies. In average 92 minutes per interview

152 pages of transcribed interview data

Other data
Discussions with academics from 2 research institutes, and other professionals that were developing remote services in industrial companies

Exploring industrial manufacturing companies' service offerings in the internet

Previous articles and Ph.D. theses from the area, sales material, remote service reports, internal service reports

A visit in a condition based maintenance center

Comparative case study (2012-15)

Interviews
5 Finnish multinational manufacturing companies

21 interviews of service business developers, sales trainers, and R&D managers. 19 in Finland, 2 in Europe, and 1 in the US. In average 95 minutes per interview

506 pages of transcribed interview data

2 interview frameworks used
- Remote service directors / developers
- Sales / support / key account managers

Other data
Sales materials, sales training materials, internal service reports, company webpages, remote service reports, customer magazines, press releases, benchmarking and seminar presentations

Data Analysis

Nvivo 11 program used for coding and analyzing the transcribed text and the linkages to the previous literature

Within-case analysis from remote servuces offered by 5 SBUs

Development of a conceptual model for capabilities of IoT in industrial solution business (Figure 2)

3.1. Pilot study

The pilot study was conducted to understand how companies use remote technologies to benefit their solution business. We used this knowledge to craft the interview framework (Yin, 2009). The first step was to review the latest studies in the field (see e.g. Ala-risku 2009; Jonsson 2010; Westergren 2011). Next, a pilot case was chosen and the researchers visited a large multinational manufacturing company's condition based maintenance center. The first pilot interview targeted a retiring expert who in charge of the remote condition monitoring development for the past two decades. In addition, we interviewed the vice president responsible for solution business development to better understand the strategy behind Remote Service or IoT development. While conducting these interviews, the authors also met with academics from two research institutes to better understand the field. The authors then conducted pilot interviews with six managers, all holding key roles in Remote Service or IoT development. During one interview, a system supplier provided an in-depth view of the technical side of Remote Service or IoT development. From the pilot study, the researchers developed a comprehensive understanding of Remote Services or IoT, including the supplier's perspective, and completed a semi-structured interview framework for the research. The semi-structured interview framework included questions about perceptions of Remote Service or IoT from business development, resources, processes, sales, customers, suppliers, internal stakeholder and future development perspectives. Finally, the authors worked with the previously mentioned academics to establish a benchmark for the developed framework. (Yin 2009)

3.2. Case selection

An ongoing large research project facilitated by DIMECC (Digital, Internet, Materials & Engineering Co-Creation Group) allowed the authors to collect data from the largest industrial companies in Finland. The authors selected the best possible examples among companies to include in the case study where Remote Services or IoT plays a major role in their business strategies. A purposive sampling technique was applied when selecting the case firms. To provide as diverse a basis for analysis as possible, the authors collected the sampling in three stages. First, a review of the development stage, which included only companies that had developed Remote Services and/or IoT as a fundamental element of their solution business. Second, only key managers were interviewed. Finally, companies operating in consumer markets were excluded. In line with Eisenhardt's (1989) suggestion, five companies was as an appropriate number of cases, after which the data began being duplicative.

3.3. Case presentation

The comparative case study was conducted among five industrial companies that use remote services in their solutions business. Table 1 provides a brief overview of the companies as a basis for the within-case and the cross-case analyses and conclusions.

Table 1. Presenting the characteristics of case study SBUs

Company	Power Gmbh	Thrust Co	Process Automation Ltd	Manufacturing Process Ab	Machine Oy
Total revenue	Multi billion	Multi billion	Multi billion	Multi billion	300 million
Service business share of the revenue	40 %	40 %	40 %	40 %	25 %
Number of employees	20000	20000	50000	12000	2000
Main products/ services/ solutions related to remote service	Engines and power plants 4 level of service agreements from spare parts to operation services.	Different kinds of propulsion systems. They offer services worldwide.	Automation systems for process industries, platform of their performance optimization solution.	Various types of cranes, has a worldwide service network with 5 levels of service agreements.	Machine tools and production lines. Offers services both through own service units and through outsourced service operators in 3 continents.
Name of the service	Condition based maintenance	Condition monitoring service	Remote monitoring service	Remote service	Condition based maintenance
Typical remote service customer	Transportation company	Transportation company	Large process business company	Transportation company or factory	Manufacturer
Remote Services launched	1995	2010	2005	2012	1987
Competitor position in remote	1st mover	Advanced	Advanced	1st mover	Advanced
Informants	8 (2 pilot, 3 IoT developers, 3 sales / key account managers)	2 (1 senior sales manager, 1 IoT developer)	3 (2 IoT developers, 1 business manager)	5 (1 IoT director, 1 product manager, 3 key account managers)	5 (1 R&D director, 1 IoT developer, 2 sales managers, 1 product manager)
Secondary data	Customer magazine, service reports, sales presentation, annual reports	Press release, customer magazine, sales presentation	Benchmarking presentations	Marketing brochures, press leases, customer magazine, annual reports	Seminar presentation, sales presentation

The companies chosen for the study are large industrial manufacturers that derive a significant share (25%-40%) of their revenues from services. All the case companies are multinational organizations and all except one have over 10,000 employees and billions of euros in revenue. The main products and services the companies offer vary significantly across industries. Because of the different operating environment and types of customer relationships, the companies also use a variety of different concepts to describe the remote services they are offering to their customers.

The case-companies' advancement level in relation to their competitors is relatively high, or even superior, as every company can be described as a first mover and advanced in their deployment of remote technologies or IoT. The reason for this is because the case selection process excluded companies that were *not* deploying the technology as a major part of their solutions business.

3.4. Comparative case study

The data collection of the comparative case study was conducted in two phases. In the first phase, a key manager responsible for the Remote Service or IoT development process was interviewed. In the second phase, at least one internal sales support manager or key account manager was interviewed. Depending on the case, discussions with some of the solution business managers were also included to provide a more comprehensive picture of the area. Every session that was conducted was in person to ensure straightforward communications and to allow for additional questions during the interviews. All interviewees received the semi-structured framework of questions beforehand to reflect on the studied phenomenon. To ensure consistency among discussions during this stage of the study, every interview was conducted by the same researcher. Each interview was recorded and then later transcribed for data analysis.

For the first phase, interviewees within the companies were chosen based on their overall knowledge of Remote Services or IoT development and their understanding of the solution business in general. In all cases, the interviewees held a major managerial or expert position in the Remote Service or IoT development. The interviews lasted from 99 to 180 minutes, which was necessary to gather enough information to develop a holistic view of the case companies' products, business logics, and Remote Services' role in the total solution offering. Altogether nine interviews were conducted in this phase and, in two occasions, two interviewees were present in an interview. Eight of the interviews occurred in Finland, and one in Central Europe.

The second round of interviews was conducted amongst solution business, sales support, and key account managers to triangulate the collected data with other respondents' views. Altogether, twelve interviews were conducted during the second phase, ranging from 47 to 169 minutes. One interview was conducted in Central Europe, one in the U.S., and the rest in Finland. In six of these interviews, two people were present. The total number of informants met and interviews conducted in the actual study was 21. On eight occasions, two informants were interviewed at the same time. In table 1, the total distribution of the interviewees between different case companies is presented.

3.5. Data analysis

During the data analysis, the existing literature, transcribed interviews, and other sources of data (see table 1) were read and notes made in an iterative manner to enhance the quality of the study. Guidelines for a rigorous data analysis were drawn from Huberman & Miles

(1994). The analysis began with separate investigations into the data to find patterns among the cases. First, we conducted the within-case analysis by reviewing each case company. We identified the resources and competencies that are required to provide IoT solutions. Next, we focused on identifying the most critical business processes regarding to provision of the IoT solutions. Finally, by analyzing patterns in the data, we generalized our findings through cross case analysis, where we identified the strategic/core capabilities that help manufacturers to develop, sell, and deliver IoT solutions successfully.

We used NVivo 11 software to categorize the findings under different levels of studied capabilities. The conducted categorization and analysis produced a theoretical model of IoT capabilities in industrial solution business presented in the figure 2. To enhance the construct validity of the study, all results drawn from both the within and cross case analyses were sent to the respondents to verify the interpretations made from the collected data (Huberman and Miles, 1994).

4. Findings

4.1. Core capabilities in case companies

From the case analysis, a conceptual model was developed that captures industrial companies' primary sources of competitive advantage from offering, selling, and producing IoT solutions. The model builds on five core capabilities: 1) Digital Business Model Development, 2) Building Scalable Solution Platform, 3) IoT Value Selling, 4) IoT Value Delivery, and 5) Business Intelligence and Measurement. As illustrated in figure 2, the fifth capability is holistic and integrates the first four capabilities. Overall, the five capabilities reflect the resource and process combinations that generate a competitive advantage for industrial companies offering remote services or IoT. Table 2 illustrates how different core capabilities are present in the studied case companies.

The left column lists the key resources and competencies (bolded) that allow a firm to build such capabilities. Below the resources and competencies, we define the key strategic business processes needed to foster the capability. Altogether, we have identified four key strategic business processes that are necessary to develop, sell, and deliver IoT solutions. These processes are: 1) value identification, 2) value quantification, 3) value communication, and 4) value verification (see Töytäri and Rajala, 2015). The value identification process is critical when developing a digital business model capability. It indicates that the manufacturer can determine the interests and drivers of its customers, suppliers, and other stakeholders. The process also recognizes how the manufacturer's IoT solutions can help to fulfill their stakeholders needs economically. The value quantification process captures the customers' key purchasing criteria. The value communication process refers to the sales and field personnel's ability to communicate the value achieved through IoT solutions. Typically, this is the sales and field personnel's skill at communicating the total cost or productivity of equipment ownership to decision-makers. The value verification process accords with the manufacturer’s ability to verify the promised and delivered value to the customer through reports or documents. In addition to the core capabilities, we also illustrate in table 2 how these four key strategic business processes are present in the case companies.

Table 2. Key resources, competencies and key strategic business processes enabling the IoT in the case companies

Key resources and competencies identified per capability per company (what) / Key strategic business processes manifested per company (how)	Power Gmbh	Thrust Co	Process Automation Ltd	Manufacturing Process Ab	Machine Oy
Digital Business Model Development Capability	Company has specific business development teams locally in each service unit and close relationships with key customers.	Company has close relationships between account management and business development.	The business model is based on monitoring the equipment remotely. Thus, the business development is operating closely with R&D, account management and customers.	Company is committed to develop the IoT solutions on top management and strategy level. It has a tight cooperation with a few pilot customers in IoT development.	Company has a competent and initiative R&D unit that drives also the business development in terms of the IoT.
Value identification	Most of the equipment life-cycle cost is in the services and maintenance. For provider company, this provides growth potential through efficient IoT systems.	Certain customer segments are very dependent on the equipment; extra service break might cost even millions.	Customers are in capital-intensive business where cost savings and performance increases of 1% mean large sums of money.	Company wants to be a forerunner in digitalization. Customers appreciate safety.	Large number of service visits can be avoided if the fleet could be monitored accurately from distance.
Capability of Building Scalable Solution Platform	Company has developed the platform over several generations since 90s. The company has solid experience from bundling and offering solutions.	Company has a small, but very competent internal IoT development team.	IoT development is the backbone of their solution business. Company's R&D team is exceptionally highly educated and experienced.	Company has strong and holistic IoT development unit, which has built different families of IoT equipment for variety of product types.	R&D unit has developed remote diagnostics since the 80's. They run agile solution development with customers and service business unit, and actively benchmark IoT leaders in other industries.
Value quantification	With good relationships to key customers, the company has a good understanding about customers' needs and can quantify the value in a way that is appealing for the customers.	Through IoT solution and sophisticated algorithms, the company can model the wear on the equipment very accurately and reduce up to 90 % of the failures.	Customers' processes are extremely well known, and therefore company can do accurate estimations on how much each developed solution can save.	Customers suffer from unexpected breakdowns when the equipment is not measured remotely. This is a bigger issue for customers that use the equipment in a vital part of their production process.	Maintenance costs for both the company and customers can drop significantly.
IoT Value Selling Capability	Sales teams are closely networked with the most important customers. In developing markets there is space to grow through IoT solutions.	Experienced sales team is working closely with development and customers.	For aftersales market the company sells purely performance solutions based on IoT. Sales personnel have strong experience of customers' business.	Company has produced a vast variety of IoT sales materials for different market areas, market segments and different service levels.	Service personnel actively seek for potential sales cases when visiting customers and report those for the account management and sales through fleet management software.
Value communication	Based on experience they can promise up to 90% less breakdowns and 50% extension to service intervals. This is equivalent to 30% lower maintenance costs.	With 90% reduction to the failures making the IoT solution very appealing to mentioned customer segments.	Solutions are always tailored per customer, but the due to company's solid expertize they can use accurate performance improvement estimates in their sales pitch with high credibility.	The uptime can be increased as the IoT system monitors wear and predicts failures. Company can advise the customer to buy the right equipment for the need based on benchmarking data.	The developed IoT solution will increase customer productivity through quick and efficient remote troubleshooting.
IoT Value Delivery Capability	Company has field presence in service business that enables exploiting IoT systems on a global scale. It has project management competence to deliver turn-key solutions for	System can create demonstrated value delivery for both own and 3rd party equipment. The solution teaches the user to operate the equipment in a way, which reduces the wear.	Customers' operations are monitored 24/7 and the system provides them with live guidance. Company has 24/7 helpdesk ensuring that problems are dealt with short response time.	Company has a global service network trained to serve IoT equipment proactively. In addition, they have a 24/7 global technical support to help the service personnel in IoT-related issues.	Service engineers use the IoT system to increase efficiency of the service operations. They can deliver the needed value for the customer from distance by giving holistic advice and instructions to

	many customer segments.				overcome bugs and production problems.
Value verification	Easily readable condition reports, safety and wearing notifications and dynamic maintenance planning are essential part of the solution and used to verify value for the customer.	Through condition reports, customers can monitor how the improved operation skills have decreased the wear, and schedule service breaks in the moments that fit for their operations.	Solution pricing is performance-based and the generated value is measured and reported daily through the IoT system. Customers can also compare the performance between their production lines.	Customer can monitor equipment online, and receive alerts if it is not working properly. They also get monthly reports on wear, expected life-cycle and other relevant usage data to improve their processes.	Customer receives monthly report of their equipment's wear.
BI and Measurement Capability	Company has built an IoT center to monitor the equipment remotely, develop the data analysis, and to distribute the information across the organization for R&D and other purposes.	IoT system is enabling information acquisition from the equipment for R&D department. For every 40 installations, there is a data analyst to serve both internal and external stakeholders.	Company collects extensive amount of IoT data from customers, combines it in a data warehouse and utilizes it also internally in R&D and analyzing sales potential.	Company combines the maintenance and IoT data with BI means, R&D, up-to-date knowledge for account management, and other personnel operating in the customer interface.	Through the IoT system the company gathers knowledge for their R&D, optimizing service operations, keeping up-to-date information about their installed base, and getting concrete ideas to answer customers' needs by learning from their processes.

4.2. Remote Service and IoT Capabilities

Cross-case analysis revealed five distinct capabilities that can leverage IoT strategy, 1) Digital Business Model Development, 2) Scalable Solution Platform Building, 3) IoT Value Selling, 4) IoT Value Delivery, and 5) Business Intelligence and Measurement. These capabilities vary among the cases and enable manufacturers to create wealth from IoT solutions. Digital business model development refers to a manufacturer's ability to build a novel and viable business model and a practical earning logic that successfully links the interests of the supplier and customer. Scalable solution platform building represents a manufacturer's ability to combine its hardware and software competencies in a solid way. The heart of this capability is the ability to scale the business through IoT solutions. Value selling refers to a manufacturer's ability to address customers' needs with good communication skills. IoT value delivery addresses a manufacturer's ability to interact with the customer in a valuable manner. Business intelligence and measurement refers to a manufacturer's analytics, decision-making and systems integration abilities.

Digital Business Model Development

Digital Business Model Development consists of a combination of back-office development work and interactions with customers that provide an IoT business model with a unique value proposition. The company's goal is to maximize not only the customer perceived value, but also the revenue and profit generated for itself. When developing new IoT solutions, the company operates in an environment of high uncertainty. The importance of business model development is emphasized more than in building more conventional new services.

> "… this issue is not technical in a sense… But turning this as a business model – that is extremely difficult thing… anyone can do this kind of a traditional engineering work,

> and super cool things. But when you turn it into a business model, that you make money with it, that is the tricky thing… we had all kinds of business-related consultation – productization experts, value production experts – I used a lot of suppliers in this. We coordinated this action and the central issue was to find top experts from Finland for all sectors." –Remote Service Development Director, Manufacturing Process Ab

Top management commitment plays a central role in the change. Without it, the implementation of new processes, practices, and ideas gets challenging.

> "I can say that this cannot be done without top management commitment, because every changes in here: the business model, way you do things, global processes…" –Remote Service Development Director, Manufacturing Process Ab

Key customers play an important role and act as a key resource in building successful IoT business models. Companies must engage them into the development process, and use fast iterations to build a viable business model.

> "We had 3 pilot customers from different industries, who we met on a monthly basis. We developed an improvement, showed how it looks like – they gave feedback – good or bad – and then we developed it further." –Remote Service Product Manager, Manufacturing Process Ab

The ability to recognize a customer's key value drivers is also essential when building solutions with appealing value propositions. This is a central business process that is often neglected, and unnecessarily prolongs the development of value-creating business models:

> "Since its introduction in 2010, we have installed more than 200 condition monitoring systems. We have now carefully analyzed our customers' needs, changing business environment and classification requirements that have evolved over time. Based on all this information, we have developed the versions to meet the different customer needs," Quote of IoT Development Manager from a Press release of Thrust Co

Moreover, the respondents highlighted the importance of integrating remote services with a firm's existing business model and current strengths. For instance, possessing a global service network may play a central role in building the business model.

> "… how you sell remote services, and how it is bundled into service concepts…if you don't have this kind of global maintenance network – for example one of our biggest competitors, they cannot do similar remote service portfolio. They can offer you a report, and install all kinds of remote technologies, but that's it. You get the info remotely, but so what? We can take that one step further because we have the established and extensive service network" –Remote Service Product Manager, Manufacturing Process Ab

Overall, as Parida, Sjödin, Wincent, & Kohtamäki (2014) suggest, the ability to design an appealing business model is a key capability that companies need to possess. We adopt the Osterwalder et al. (2005) definition of a business model as an architecture to generate profitable business, from both the manufacturers and the customers' point of view. Thus, it should be considered as the first step towards building a sustainable business based on IoT.

Capability of Building Scalable Solution Platform

The second identified capability includes the key resources and processes necessary to build a scalable IoT solution, and an infrastructure to provide optimal solutions. Key to IoT solutions is technological expertise. Companies must possess key resources that enable information and communications technology (ICT) and software development, and that integrates these with research and development (R&D). The companies need highly competent teams accompanied with state-of-the-art project management, that can use the supplier resources optimally. The customer and business model should be the center of the development process. The company needs to be able to identify, quantify, and build a solid basis for measuring the value they produce through their system development.

> "The most critical is the technology. You need to have good enough project manager who can combine ICT-technology and our hard technology know-how together, and can lead the project forward, a fantastic coordinator that can have a good dialogue with our suppliers and define these agile projects in a way that they not only start, but also end at some point. You need robust marketing knowhow, product management knowhow, people that are willing to travel, do this work and know the things. Then the third is the productization – it's totally different than the traditional R&D. Where the traditional R&D ends, that is just where the service development starts: an iterative development model." –Remote Service Development Director, Manufacturing Process Ab

The business model sets the requirements for an IoT solution's scalability. When the goal is to connect thousands or millions of devices, the acquisition cost of the equipment becomes an essential consideration – a connected device's potential revenues and acquisition costs should correlate.

> "What one thousand units means…the driver was that we needed to gain high volumes. …it started to get clear, that in small equipment we aim to costs around one hundred euros per equipment, in a bit larger to one thousand, and so forth… …in large volumes you need to get to insanely small unit costs. I said to these guys that everything you do, you need to remember that we are a global company and that is the center of our actions… … the unit cost is determining when we aim to generate millions of connections." –Remote Service Development Director, Manufacturing Process Ab

Companies who aspire to become global IoT solution providers must acquire a substantial amount of knowledge. Finding and integrating these new key resources to a company's current processes and personnel is not easy. It also creates a big communications challenge – the organization needs to be convinced of the importance of the IoT.

> "What I've noticed is that the amount of required internal marketing is in totally another level than before. We are just a few people truly involved in this - so you need

> to get the rest 98 per cent convinced, that this is a good thing." –Senior Service Manager, Machine Oy

In addition to the existing delivery processes, companies need to determine how to meet the requirements of large-scale IoT equipment and connection delivery processes that span from the equipment providers to the customers.

> "Then there are information system coordinators – people who manage the connections. Creating a connection, technically, from opening the SIM-card to that the data are actually transferred to our datacenter and to the screen, that is unbelievably complex trick. And we are quite proud of automatizing this process. In this we apply also network thinking – we utilize our supplier network and our people operating in different countries and so on." –Remote Service Development Director, Manufacturing Process Ab

Regardless of the business model, it is essential to have the expertise to identify what data are needed to deliver value for all parties employing the IoT solution. In addition, the development of appropriate algorithms is essential.

> "We might sit here for many weeks and think how an algorithm is done, in a way that the data analysis is actually fast and efficient. That's not our customers' business." -Technology Manager, R&D, Manufacturing Process Ab

The IoT platform can also evolve into an ecosystem and changes the business model. This change requires the company to acknowledge the needs of other potential contributors to the ecosystem.

> "… IoT platforms can also be transformed into ecosystems – it can act as a platform for other service providers – the question is – who will be the leading ecosystem provider.." –IoT Manager, Power Gmbh

Companies building a scalable IoT solution platform must address information security. The entire network must commit to certain data security objectives. Often, the stakeholder with the tightest policies defines the minimum level of security required. Yet, in regards to security, there is a great difference between countries and cultures.

> "We need an information security agreement with the customer that enables the usage of the data in service and maintenance operations. We agree that the information is confidential – these issues are subject to the industry. We haven't met over-strict policies except when operating with companies with American ownership. We are not crypting the content, but the connection." –Seminar presentation of Machine Oy

When companies operate in the global market, building processes to support a complex IoT solution is a challenging task. It requires vast resources and competence from a company to sufficiently manage this capability.

IoT Value Selling Capability

The third recognized capability consists of key resources and processes that are required to sell integrated, value-based (see e.g. Töytäri and Rajala, 2015), IoT solutions in business-to-business markets. The capability requires knowledge about customers' most important business processes, and an ability to identify the key purchasing criteria customers are applying. It requires the ability to communicate the value of the IoT solution to customers and guide them to solutions they need.

> "It needs to be based on evidence that we can point out to the customer that we can help them to operate their equipment better, save costs, even if we take a share from those savings." –Business Development Manager, Power Gmbh

Sales and service personnel who work closely with customers should be trained to communicate the value of the solution. Companies must provide their personnel state-of-the-art technical support and structured training programs for the various customer segments.

> "We create the framework for the sales materials here in the headquarters and the local people build the final material and we are happy… We bring ready-made package for them and then it's finalized per country and per industry. … it's a daily activity for me as I act as a global sales support person for IoT." –Remote Service Product Manager, Manufacturing Process Ab

> "Then we have this kind of reporting software, if the service guy is at the customers site to do something else. If he recognizes that there is something that will soon materialize to a sales case, he can snap a photo from the object, add some comments and then it comes to our fleet management software as a task that is waiting for an action from the account manager or sales guy." –IoT Product Manager, Machine Oy

Sales arguments vary by industry, type of IoT solution, level of service agreement, and by the cultural aspects of the country. In process industries, arguments lean heavily towards cost-savings and short pay-back-time, whereas in some industries, safety issues are stressed more. An ability to recognize a customer's value drivers, key purchasing criteria, and benefits are highly important. Companies use IoT solutions to strengthen and extend their customer relationships, improve customer lifetime value, and create a more solid market position and a steady revenue stream.

> "… we always aim to advertise that we are not the cheapest option in any case [when you look at the cost of the purchase] ... but we say that we are cheaper in the life-cycle costs because we have so damn good service organization. If our equipment costs X, our competitors might cost 0,7X – but when we start to think what it will the services cost in the future – in the end the life-cycle cost is lower and remote supports all of this." –Remote Service Product Manager, Manufacturing Process Ab

> "Some are more interested in safety, but in developing countries the cost is the most important factor. In Europe, *maybe* you can act a bit snobbishly – you get a few more features because you have budget and its 'nice to know', but merely a necessity. In Asia the cost part is much more important – they are interested in the price more than

> the safety features, so we modify the sales arguments a bit according to the country and culture." –Remote Service Product Manager, Manufacturing Process Ab

Globally operating manufacturers need a solution-savvy sales force that can communicate the delivered value to customers properly. This requires a proper understanding of the customer's key processes and how IoT solutions can support and boost the customer's core business appropriately.

IoT Value Delivery Capability

The fourth recognized capability refers to the manufacturer's ability to accomplish its value proposition to the customer. As Töytäri and Rajala (2015) suggest, companies should communicate and verify the produced value for the customers. They need the ability to deliver IoT services on-time and cost-efficiently. They must competently manage customer relationships, and ably train the personnel who deliver customer value.

> "We aim to generate standard daily reports which are then tailored always a bit according the customer needs." –Manager, Advanced Solutions and Industrial Internet, Process Automation Ltd

> "If we think about the continuous communication, we hold larger project and follow-up meetings bi-annually with the customer factory management – there we collect a summary about financial benefits." –Product Manager, Process Automation Ltd

> "We can provide benchmarking information for our customers to observe their operations from outside and support their personnel training aiming to decrease fuel costs." –IoT Manager, Power Gmbh

In global business, the ability to deliver value through IoT solutions to different markets is crucial. Yet, global operations require more support in terms of IoT knowledge. A technical support process is required to assist the service engineers and technicians daily.

> "For example one of our biggest competitor cannot offer the same kind of remote portfolio. They can offer you a report and install all kinds of remote technology, but it ends there. You get the information and then someone says that so what, what are they going to do then? We can take it further, because we have very extensive service network. That is our thing." –Remote Service Product Manager, Manufacturing Process Ab

> "In the delivery, as well as in R&D, there is also a need for ICT and technology knowhow. We have understood that we need to have this kind of global technical support. …it took roughly a year that I managed to hire the people, get the facilities to work etc." –Remote Service Development Director, Manufacturing Process Ab

Companies also need to possess an in-depth knowledge about customers' processes. The more complex the process, the more understanding required to meet customer expectations and deliver value. This is especially important in process industries, where customized solutions must be developed cooperatively with customers. Conversely, companies need to combine data that is generated by IoT solutions with external data, to deliver true value for their customers.

> "The experts that are planning the solutions, have very long experience from these end customers' processes. Many have been working in these factories and operated the processes. The knowledge of customers' production processes, also their business processes, that is a key competence, what you need to have." –Manager, Advanced Solutions and Industrial Internet, Process Automation Ltd

> "We need to be able to recognize from the operations profile that something is not good for the equipment and if you do this, the risk that something will break increases this much. You have to be able to tell the customer if their operation procedures increase the risk for component breakdown." –Service Agreement Manager, Power Gmbh

To provide quality IoT services, companies must be knowledgeable about their customers' operations. It is essential that the communication is fluent and that both the solution provider and the customer understands and verifies the value being delivered.

Business Intelligence and Measurement Capability

Business Intelligence and Measurement ties together the other four capabilities. To develop new digital business models successfully, build scalable solution platforms, and sell and deliver valuable IoT solutions, Business Intelligence and Measurement is required to collect and distribute the data and the accumulated knowledge to support the business. Companies need to have a solid ICT infrastructure and appropriate Business Intelligence tools to identify, quantify, communicate, and verify the information and value that IoT solutions produces. Companies need the expertise to measure the overall capability and performance of their business operations.

> "… then business intelligence is definitely there – without analytics you cannot do anything with the information…, but without BI there is no sense in this activity." –Remote Service Development Director, Manufacturing Process Ab

> "Of course all data collection concerning the customer, and to think how this is distributed within the customer sites, and then the centralized data warehouse, that is in the core of the IoT..." –Manager, Advanced Solutions and Industrial Internet, Process Automation Ltd

Correspondingly, companies use the data gathered to develop their service operations, to support their front-end personnel, and to provide information their R&D department.

> "We need a real-time web-based tool through which right stakeholders can access the remote data… through a fast development process we created a tool that allow us to share knowledge internally to central stakeholders – these are R&D, product owners, sales and global technical support. …we use this remote information in absolutely all development activities that comes to R&D or service development." –Remote Service Development Director, Manufacturing Process Ab

To deliver on the value proposition, companies should also provide analysis on the collected data. Through state-of-the-art business intelligence tools, companies can then distribute essential information to customers at any time, regardless of customer location.

> "To keep it up we need one data-analyst for every 40 equipment out there. And then these data-analysts are not of course analyzing all the time. When they're not analyzing, they are improving the system. And we need roundly two guys besides the data-analyst who were just maintaining and improving the system." –IoT Development Manager, Thrust Co

> "In services we have an analytics team which seeks for benefits, not just from remote data, but combining it with maintenance data. We try to combine remote data with maintenance data with business intelligence means." –Remote Service Development Director, Manufacturing Process Ab

Overall, with the use of high-quality data, companies can provide thoughtful strategic and operational decisions, serve customers at a high level, and gain competitive advantages against their competitors.

From the study, the authors created a theoretical model that consists of the core capabilities required to develop, build, sell, and deliver IoT solutions. The model consists of five identified core capabilities and the key resources, processes, and competences required to define the capabilities. The fifth capability lays out the key business processes that encapsulates the other four. The case companies emphasized two of the five identified capabilities, the capability of building a scalable solution platform, and an IoT value selling capability. We suggest that the reason these two capabilities are most emphasized is because they are the most properly understood within the companies. However, to offer, sell, and produce IoT solutions successfully, all five capabilities, described in figure 2, must be in place.

Figure 2. Capabilities required to develop, sell and deliver IoT services

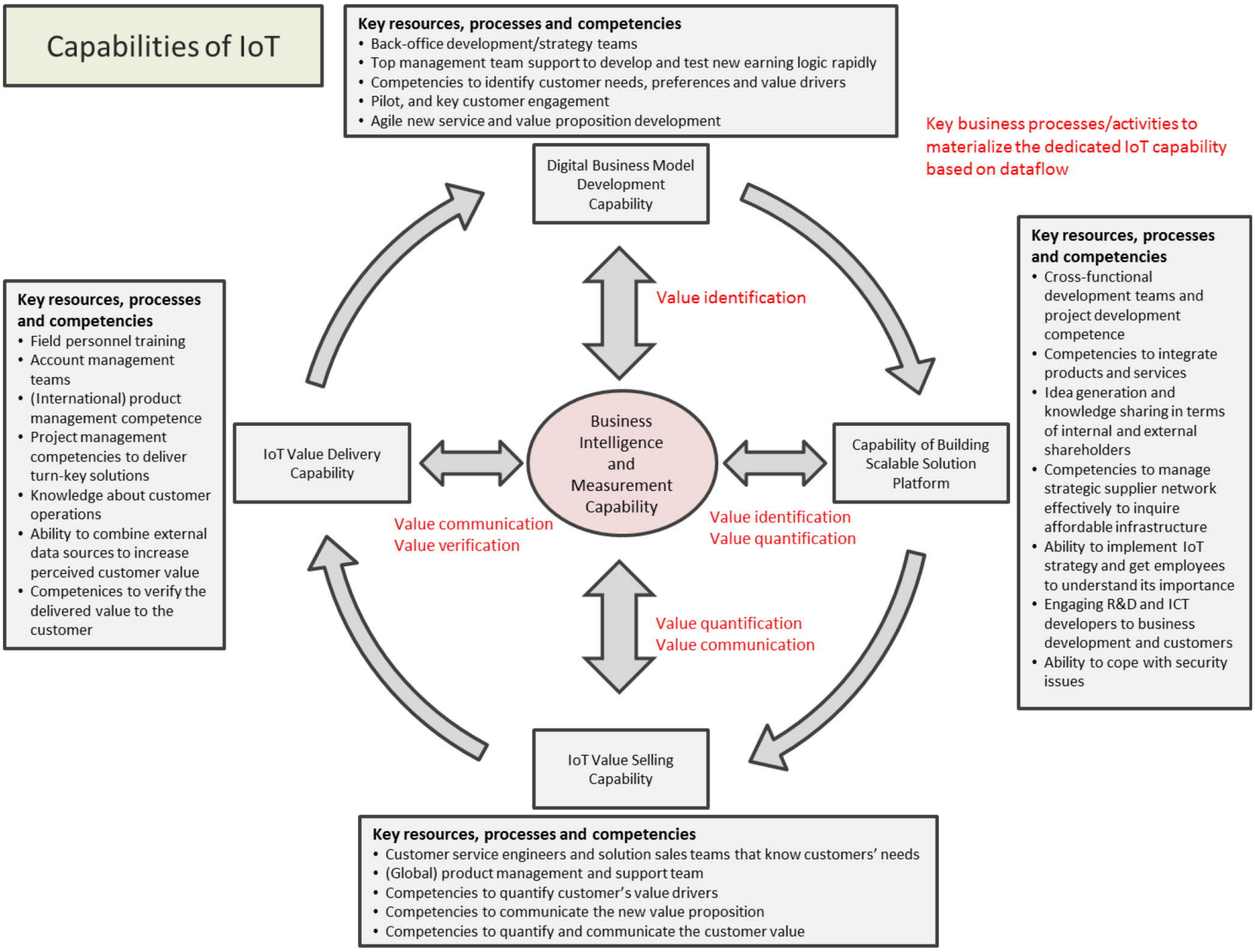

Figure 2 summarizes the five manufacturer's distinct strategic capabilities for the IoT. First, it identifies the key resources, processes, and competencies under the dedicated capabilities. Moreover, it presents the key strategic business processes (value identification, quantification, communication and verification) through which the resources are transferred to strategic capabilities. These strategic capabilities enable manufacturer to outperform its rivals in the industrial markets by utilizing IoT.

5. Discussion

5.1. Theoretical contribution

The study contributes to the servitization literature by using extensive comparative case data to analyze manufacturer's capabilities with respect to IoT. The study extends the literature by developing a conceptual model of five core capabilities that industrial companies need to develop, build, sell, and deliver IoT enabled solutions successfully. The results demonstrate the importance of obtaining capabilities in 1) Digital Business Model Development, 2) Building Scalable Solution Platforms, 3) IoT Value Selling, 4) IoT Value Delivery, and 5) Business Intelligence and Measurement. The five core capabilities enable the manufacturer to develop and produce solutions to create and derive value from IoT. The capabilities enable manufacturers to offer preventive maintenance, optimize maintenance operations, increase product safety, reduce operating costs, and gather information to improve solution development.

As the main contribution of the study, five capabilities were identified. The first identified capability is to build a successful digital business model based on manufacturer's capabilities and strengths (Parida et al. 2014). IoT business model is significantly different from the conventional manufacturing and product-dominant logic of selling products and add-on services (Oliva and Kallenberg, 2003; Ramirez, 1999; Vargo and Lusch, 2004). In IoT, a manufacturer needs a business model, based upon effective data acquisition, warehousing and analytics, where it can guarantee performance, prevent breakdowns, increase customer's productivity, and share the benefits of preventive maintenance. When implementing an IoT business model, a manufacturer builds on its capacity to create and demonstrate value from real-time analytics. Real-time analytics enable the manufacturer to create customer value for example by preventing breakdowns, saving energy costs, or decreasing emissions. Hence, the value creation and capture from IoT should be inherently embedded in the manufacturer's business model. In line with the extant servitization research (Parida et al. 2014; Storbacka et al, 2013), the findings of this study support the finding that building and implementing a novel business model may be a key capability for the manufacturer.

The second identified capability involves resources and processes necessary to build a scalable IoT solution, and an infrastructure to resolve issues. As the case companies demonstrated, building scalable IoT requires much more than adding sensors to machinery. Scalability requires a cost-effective means to collect, store, analyze and visualize data to make effective decisions. Above all, the technological solutions for IoT should be bundled with products to create an effective service model, which builds on autonomous data processing that increases productivity. This bundling of different technologies and processes requires the cooperation of suppliers and customers. Foremost, a scalable solution requires an optimal bundle of sensors, software, and services, to co-produce knowledge for improved offerings, and co-create value for improved customer experiences (Porter and Heppelmann, 2015). Interestingly, the findings of this study indicate that manufacturers can resolve their problems to scale the solution business by utilizing IoT. Hence, this study shows that the identified capability gaps related to solution business development (Shankar et al. 2009) can be fulfilled by taking advantage of the new technologies.

Thirdly, we identified how the capabilities of value-based selling manifest in the IoT context. Selling IoT related offerings rather than traditional products and add-on services requires significant changes from the sales processes and resources (Töytäri and Rajala 2015). Based on the studied cases, selling IoT requires persuasion of customer's buying department to adapt preventive, proactive performance oriented buying, to adapt customer and service-led instead of product-based thinking (Storbacka et al., 2013). This means that the manufacturer must be able persuade customers to emphasize the performance of the purchased solutions, instead of bundling together the cheapest possible sub-systems of components and add-on services. Hence, selling IoT means that the solution sales personnel should be facilitating change in the customer side – to create a value proposition that benefits both the manufacturer and the customer in contrast to the traditional proposition. Thus, selling IoT requires capabilities of developing win-win relationships with customers, by quantifying value created. A successful relational engagement would enable true co-production of innovative digital solutions and the ability to create and share value (Kohtamäki and Rajala, 2016). The results of this study support the findings of the prior value selling and servitization literatures (Reinartz and Ulaga, 2005; Töytäri and Rajala, 2015). In addition, this study emphasizes that IoT can help manufacturers to map the key customer drivers in the markets, and address them more easily.

Fourthly, the study identified key processes and resources required to deliver IoT value to customers through IoT. During the process, a manufacturer needs capacity to deliver the co-produced solutions needed to co-create an improved customer experience (Iansiti and Lakhani, 2014). Knowledge about the customer needs and customer operations, the field personnel training and technology data access, and the competence to verify and document the created value for the customer, hold a key position in value delivery through IoT. This capability highlights the companies' ability to monetize the developed IoT solution. When all the capabilities are in place and leveraged efficiently, the capabilities should facilitate attainment of profitability targets. This study's findings support the evidence of the prior servitization literature (Penttinen and Palmer 2007; Tuli et al. 2007) that deep and intimate customer relationships may be key source of a manufacturer's competitive advantage. On the other hand, this study highlights that IoT can facilitate co-development and co-creation between manufacturer and its customers because of increased relational knowledge.

Fifth, the analysis from the case companies demonstrated the importance of managing the ecosystem. The manufacturer needs real-time business intelligence that allows for follow-up and measurement of the installed base in order to improve performance continuously (Kaplan and Norton, 2000). To support its operational processes and the customer, company needs to collect and distribute the data and the accumulated knowledge effectively. The IoT solutions set higher requirements for both internal and external knowledge distribution and thus requires a solid business intelligence and measurement capability from the manufacturer. Effective management of the ecosystem is key to generating and capturing customer value. This finding adds one key capability into theoretical discussion as this type of a metacapability requires ability to acquire, assimilate and analyze extensive data collected through IoT.

5.2. Managerial contribution

The created model (figure 2) provides a good starting point for developing IoT related capabilities in manufacturing companies. The transformation from a traditional product and service provider to an industrial company using IoT solutions is challenging. The transition to an innovative business model requires a significant adjustment of resources and processes to reconfigure new core capabilities. Developing such capabilities requires a commitment from both top and middle management to make the needed investments. Perhaps it is the lack of such a commitment that has led to the servitization – de-servitization movement.

When implementing the five capabilities of our theoretical model, companies have a good starting point to develop, build, sell, and deliver IoT solutions. The issues from implementing each capability, key process, and key resource should be considered subject to the industry and the firm's business model. As some of our case studies suggest, achieving global IoT solution coverage can be done with just a handful of people. Alternatively, many people will be required if the objective is to monitor millions of pieces of equipment, disregarding the impact on all the traditional processes within the company. Regardless of the amount of resources and effort invested in the development IoT solutions, novel development methodologies with fast iteration and close customer involvement should be applied in the process. In general, the capabilities required to offer, sell, and produce IoT solutions is becoming even more important for industrial companies. Soon, 5G services and its extremely fast internet speeds will be available and, thus, ubiquitous connectivity will be realized. Companies that have experience in testing different business models are more likely to succeed when the world and industrial companies actually become connected.

5.3. Limitations and suggestions for future research

This study has limitations that readers should consider when evaluating the results and contribution. The sample of the study was taken from industrial manufacturing companies that operate in Finland and use, or were developing, remote services or IoT as part of their solutions offering. In case studies, context is always unique, and therefore the results and conclusions cannot be generalized to the population. Thus, both single and multiple case studies from different industrial and cultural contexts would bring value to this new area of research. Moreover, the case firms are manufacturers operating in global service and solution businesses and the results may not be generalized to smaller technology firms.

Additional studies are required to collect information on the capability requirements concerning IoT. Not only is further evidence needed on transition processes, but also the related managerial practices. Studies could also focus on the changing business models and earnings logics when moving towards IoT, as well as processes of value creation and capture, for instance, how solution providers co-create and capture value through IoT with their customers.

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