Remote monitoring in industrial services: Need-to-have instead of nice-to-have

Abstract

Purpose – The purpose of this study is to better understand the efficient use of remote monitoring systems (RMS) to create business value for industrial services in manufacturing firms. A business view to RMS is a key prerequisite for the successful application of the Internet of Things (IoT) in industrial services.

Design/methodology/approach – A qualitative multiple-case study was conducted in six engineering companies. The main source of data was semi-structured interviews with 16 managers.

Findings – The findings highlight the role of RMS in enabling manufacturing firms to collect data from customers to complement their limited knowledge about their customers. The study demonstrates the business value of using RMS in industrial services, and the necessity of capturing the business value through advanced IT technologies.

Research limitations/implications – The qualitative research design and choice of six target companies limit the findings to business-to-business manufacturing firms. Further, the focus is on the manager's viewpoint. The findings imply new business value through an efficient use of RMS to complement direct customer contact.

Practical implications – The study draws attention to the skilled use of advanced RMS and information and communication technology (ICT) as a prerequisite for the successful application of the IoT in manufacturing firms that provide services for complex solutions and customers dispersed globally.

Social implications –

Originality/value – The research shows that utilising information collected through RMS is an important factor in creating business value in a manufacturing firm's customer relationships. The study contributes by integrating RMS into the customer information collection process to increase the amount, validity, and quality of data.

Keywords Customer information, services, remote monitoring systems, internet of things

Paper type Research paper

Introduction

In today's business-to-business (B2B) environment, a manufacturing firm cannot be successful by only focusing on its products; it needs to complement its products with various services. The implementation of advanced information and communication technology (ICT) to improve service delivery has received increased attention in manufacturing firms' operations. An important managerial issue is how manufacturing firms can create business value through these advanced technologies. Business value includes not only the productivity payoff from the technology, but also its impact on critical business activities, such as production, sales and marketing, and customer services (Mukhopadhyay et al., 1995; Tallon et al., 2001). This study focuses on remote monitoring systems (RMS) as representative of advanced ICT in manufacturing firms. Previous RMS research has primarily focussed on its technical enablers and condition monitoring. There is a need go beyond its technical implications and to understand RMS' broader implications on other business activities in manufacturing firms.

To achieve business value, manufacturing firms need to ensure the efficient delivery of customer value. According to Grönroos (2011), customer value is not only dependent on the main product, but also the entire range of relationships between the customer and the firm that supports the effective use of the main product. Thus, customer collaboration is vital in the B2B context. Customers provide a wide range of skills, competencies, interests and knowledge (Blazevic and Lievens, 2008), which can be acquired in different ways. Blazevic and Lievens (2008) argue that the majority of previous studies on the customer's role in innovations focus on face-to-face meetings, interviews, focus groups, and surveys. Collecting information through these methods can be expensive, time consuming and ineffective when considering a B2B environment with all its networks and interrelationships. Technological developments provide new opportunities for acquiring required data and information from the customer. Advances in sensors and communication technology have led to the effective collection and transmission of data and, subsequently, to transforming it to reusable knowledge (Westergren, 2011).

Over the past years, utilising sensors and sensor networks in the industrial sector has been in high demand in different business environments. Multiple technologies use sensors to enable services, including radio-frequency identification (RFID), machine-to-machine (M2M) communication, wireless sensor networks (WSNs), RMS, etc. All these systems have some similar elements, but they have some differences at the automation and function levels. The Internet of Things (IoT) is an umbrella term that encompasses these supporting technologies as well as other domains, including Internet technologies and applications of technologies (Miorandi et al., 2012). The IoT can be applied in several fields, such as environmental monitoring, smart cities, smart business, inventory and product management, smart homes, smart building management, healthcare, and security and surveillance (Atzori et al., 2010; Miorandi et al., 2012; Gubbi et al., 2013).

Previous research has covered some business applications of the IoT, such as automation and industrial manufacturing, logistics, business/process management, and intelligent transportation of people and goods (Atzori et al., 2010). Previous studies on the IoT have mainly concentrated on its technological enablers and have investigated novel ways to collect and analyse data. Technological enablers are “nice-to-have”, but they require much more to convert the IoT into new business opportunities. Some research studies have addressed the productivity gains from using ICT for services (Kowalkowski, 2008), but they have not covered RMS. Little research has explored business enablers and feasible ways to use the substantial amount of data efficiently, transform data into knowledge that enables the creation of new business, and develop new solutions in industrial manufacturing. This aspect of the IoT is the “need-to-have”, and it enhances the use of technology for manufacturing firms involved in industrial services.

This study sheds light, in particular, on RMS as the most typical solution to enable services in industrial firms. RMS are technology-based advanced sensors and information solutions that enable service delivery in manufacturing firms. RMS help companies to receive data from the installed base of equipment by remotely monitoring the products and their use from anywhere in the world. The literature on sensor-based systems has explored various applications, such as conditions monitoring, that enable services in an industrial environment (Kurada and Bradley, 1997; Owen et al., 2009; Vogl et al., 2009; Bogue, 2011, 2013; Gomes et al., 2013). Previous research has also addressed applications of RMS for predictive maintenance (Lee, 1998; Jonsson et al., 2008, 2009; Westergren, 2011; Westergren and Holmström, 2012). However, RMS applications to enhance service business have not been thoroughly studied. Customer-oriented companies might use RMS for their internal purposes, but of particular interest is using them in a manufacturing firm’s customer relationships. Such usage may enable manufacturing firms to offer new services to their customers, optimise the service delivery process, and activate completely new businesses.

The research goal and questions

This research focuses on manufacturing firms using the data collected through RMS to enhance their industrial service business. The purpose is to characterise ways in which companies can utilise RMS to enhance the use of customer information and create business value. The study shows that RMS are no longer *nice-to-have*, but that manufacturing firms *need to have* access to the real-time data from their installed base and to analyse the potential of using the remote data to enhance their service business. The following two research questions are addressed:

1. How do managers in manufacturing firms perceive the business value of RMS in industrial service business?
2. How do RMS along with other data collection channels help manufacturing firms to identify customers' needs and expectations in service business?

The empirical study focuses on manufacturing firms delivering complex systems and complementing their offering with services for business customers. Therefore, the focus is on a B2B environment, and consumer businesses are not considered. The research was conducted as a multiple case study in six large international firms with large global installed bases of equipment. Interviews were conducted with managers and, thus, the viewpoint is managerial.

Most prior studies have concentrated on the customer's benefits from RMS (Wu et al., 2006; Wang et al., 2007). This paper contributes by developing an understanding of how manufacturing firms can utilise RMS to create business value in their service business. This study highlights the manufacturing firms' business value through processes and customer information use, and analyses how they can improve their business through technology-enhanced services. In particular, the paper demonstrates the role of customer information in service business and explains how RMS can assist manufacturing firms in collecting and analysing relevant and valid customer information.

The remainder of the paper is organised in the following manner. First, a review of extant literature is provided to increase the understanding of the role of customer information in service business and applications of RMS. Then, the theoretical understanding is developed further with an empirical multiple case study. Finally, the implications of the findings are discussed, key contributions are reported, and the research limitations and suggestions for further research are presented.

Literature review

Manufacturing firms moving toward service business

Manufacturing firms in the B2B market offer various services to their customers (Mathieu, 2001). Services can greatly influence and complement a product's functionality, and their value can surpass the price, which comes as no surprise to many firms (Küssel et al., 2000). In addition to the value of the main product, customer value in a B2B environment is influenced by various types of relationships between the customer and the firm, supporting the effective use of the main product (Grönroos, 2011). Services can improve a firm's competitive position, making it hard for competitors to imitate the solution (Chesbrough and Davies, 2010). In contrast with a goods-dominant logic that proposes distinct roles for the supplier and the customer, service-dominant logic relies on interactive relationships between these two parties to create value (Vargo and Lusch, 2008). A firm that subscribes to service logic is involved in the customer's practices and business processes, meaning that they provide extended offerings to the customer to create value. Therefore, the firm provides business effectiveness instead of operational efficiency (Grönroos, 2011). In organisations that deliver complex systems and integrated solutions, goods-dominant logic and service-dominant logic typically coexist (Windahl and Lakemond, 2010).

The integration of services and products has attracted substantial attention in many industries (Davies et al., 2006; Lenfle and Midler, 2009). An integrated solution is a bundle of physical products, services and information. These long-term and cost-effective solutions fulfil a specific functional need for the customer (Brax and Jonsson, 2009). When manufacturing firms provide integrated solutions, they need to understand how customers see the value of the solution (Brady et al., 2005). Customers do not just buy an integrated package; they also pay for trouble-free operations (Davies et al., 2006). Customers focus on the lifecycle costs of the solution and its performance, and seek a more long-term commitment (Kujala et al., 2010). This view requires more attention to be paid to customer relationships and the related value-adding activities, because manufacturing firms are no longer passive receivers of the customers' specifications (Brady et al., 2005). A topical issue is how modern technologies, such as the IoT and RMS, enable manufacturing firms' service businesses and the creation of business value in their customer relationships.

The IoT and RMS as technology enablers for service business

The development of various information and communication technologies (ICTs), such as WSNs, RMS, RFID and M2M, aims to enhance the exchange and analysis of massive amounts of data in different industries. The dynamic networks of devices form the IoT and feature such key components as sensing, heterogeneous access, information processing, applications, and services (Chen et al., 2012). The IoT is mainly about exchanging and analysing massive amounts of data (Miorandi et al., 2012). Thus, IoT technologies enhance data collection abilities considerably. New types of sensors help to detect information that people cannot and also to collect information anytime and anywhere (Chen, 2012).

This paper explores the business value of the data collected through IoT technology as an important area in industrial service business. RMS are the most typical solution for enabling services in industrial firms. RMS are a collection of sensors and data transmitters that are placed on the products and enable the manufacturer to monitor products from a distance, collect data to create services based on data analysis, and improve their understanding of product utilisation (Westergren, 2011). RMS can provide business value both for the manufacturing firms and customers. Some of the identified dimensions of value in previous research include improving customer relationships, generating new turnover (Küssel et al., 2000), reducing after-sales costs (Biehl et al., 2004), increasing machine uptime (Jonsson et al., 2008; Westergren, 2011; Westergren and Holmström, 2012), and improving safety (Wu et al., 2006).

Most of the previous research on RMS and sensor-based solutions have used a literature review as their main methodology, and they tend to be more technical and place less focus on service opportunities or the business value of the solutions (Kurada and Bradley 1997; Everall et al., 2000; Sion and Atkinson, 2002; Owen et al., 2009; Vogl et al., 2009; Bogue, 2013; Gomes et al., 2013; Huang, 2014). However, some valuable single case studies have focussed on applying RMS to monitor an installed base of equipment at the customer's location (Nieva, 1999; Mori et al., 2008; Jonsson et al., 2009; Westergren, 2011; Westergren and Holmström, 2012), open innovation and trust as a key precondition for openness between the manufacturers and customers (Westergren, 2011; Westergren and Holmström, 2012), the use of IT solutions to provide value-adding services in industries, and the role of customers to become either co-creators of value or receivers of the created value (Jonsson et al., 2008, 2009; Kowalkowski and Brehmer, 2008). Such studies have shown that manufacturing firms face many requirements and challenges in deploying RMS and convincing customers to accept and implement the technology. Adopting the IoT is necessary for the manufacturing firms' customers to gain the full benefit of services and for the manufacturing firms to achieve business value.

IoT adoption in the manufacturing firm's customer relationships

Advances in technology and industrial structures enhance the applications of the IoT. Industries try to use IoT devices to develop industrial applications such as automated monitoring, control, management and maintenance (Da Xu et al., 2014). However, IoT applications are at an early stage and quite a few applications are being developed or deployed in different industries (Da Xu et al., 2014). Thus, studying IoT adoption in this developing environment can help industries benefit from IoT solutions.

Technology adoption has received attention in various technological domains, including IT and related applications (DeSanctis and Poole, 1994; Orlikowski, 2000; Forman and Lippert, 2005; Hernandez et al., 2009). Achieving business value from technologies requires that customer firms adopt them, i.e. are willing to purchase and use them. In line with general theories of technology diffusion (Rogers, 1995), many studies associate various firm-level and contextual antecedent factors to the overall degree of adopting a certain technology (Patterson et al., 2003; Fuentelsaz et al., 2003; Forman and Lippert, 2005; Zhang and Dhaliwal, 2009). It is possible that customers will actually reject or fail to use new technologies for various reasons (Lanzolla and Suarez, 2012). Adopting a technology requires that the customer perceives it as useful and easy to use and intends to use it in the future (Forman and Lippert, 2005; Hernandez et al., 2009).

Several important factors affect the wide adoption of the IoT in particular. In general, IoT literature mainly focuses on technical issues and requirements for adopting IoT technologies and gives little attention to business issues (Riggins and Wamba, 2015). Forming an IoT ecosystem, which includes common or dominant standards, platforms, and interfaces, is the main factor identified in the literature to enhance the growth of IoT adoption (Mazhelis et al., 2012; Miorandi et al., 2012; Belli et al., 2015). Other requirements for the wide adoption of the technology are security and privacy mechanisms (Babar et al., 2010; Miorandi et al., 2012; Bekara, 2014; Lee and Lee, 2015). However, the substantial amount of data generated by the connected machines creates challenges for IoT-adopting companies, including data management and data mining (Lee and Lee, 2015).

While most prior studies on the IoT have focused on the technical aspects of IoT adoption, and RMS literature has specifically addressed the advances in technologies and their effects on improving the quality of life and industries, they have not dealt with the issue of creating business value in the manufacturing firm’s customer relationships. For example, Kowalkowski’s study (2008) focuses on the use of ICT to standardise service production and reports various productivity gains, but does not cover RMS. This paper highlights the relationship between manufacturers and customers and seeks opportunities for manufacturers to improve their business through RMS. Manufacturers use different channels to collect customer information and enhance their service business, which presents the manufacturers with various benefits and challenges.

Different channels for collecting customer information in service business

An ample amount of research can be found in the marketing literature on customer information and, more specifically, customer relationship management. These studies mainly focus on the role of customer information and different strategies to maximise customer and shareholder value (e.g., Ulaga and Chacour, 2001; Payne and Frow, 2005). Particularly relevant to this study is the role of customer information in service development.

One of the key elements for developing services is interacting with customers (Gallouj and Weinstein, 1997; Kandampully, 2002; Hipp and Grupp, 2005). This interaction helps companies obtain the latest information on their customer's needs and expectations, and the changes therein (Kandampully, 2002). Fulfilling the customers' specific needs and increasing customer satisfaction require consideration of the customers' viewpoints to develop customised offerings (He et al., 2014).

Gebauer et al. (2005) argue that receiving inclusive information on the customers' needs requires a market-oriented approach that includes wide-ranging market research, conducting workshops with selected customers, and building a network of sales, technical staff and external experts who systematically collect and record current and future customer needs. This approach concentrates on understanding the customers' expressed needs. To understand the unexpressed needs of customers, the literature on market-oriented businesses suggests observing how customers use the products or services in their normal routines and working closely with lead users (Slater, 2001). The customers' requirements can be better understood in their own natural setting than in an artificial setting (Nambisan, 2002).

In spite of all benefits gained through these approaches, they do not provide a continuous exchange of information between the manufacturing firm and the customer. The customers' locations, their motivations for participating in the service-development process, and the validity of the provided information, among others, are issues for using some additional means to collect information from customers in service development (Bitner et al., 1997; Slater, 2001; Matthing et al., 2004). Enhanced technology solutions can assist manufacturing firms with collecting data from the customers' sites. New technologies can improve the connectivity between customers and firms and involve customers in the development of new solutions (Nambisan, 2002). In addition, closer cooperation between manufacturing firms and customers through ICT enables manufacturing firms to provide more extensive offerings (Kowalkowski and Brehmer, 2008). Since the role of new ICTs in collecting customer information and creating business value has not been studied thoroughly thus far, this paper focuses on the IoT, and particularly RMS as a widely used solution for customer information collection in service business.

Methodology

Research design

This research is a qualitative multiple case study. A qualitative case-based research design was chosen as the business aspects of RMS in industrial services have not yet been well developed (Eisenhardt, 1989; Strauss and Corbin, 1998). The research goals had an explorative character, with the intention of understanding the experiences and opinions of people in their real-life context (Yin, 2003). To better identify the various opportunities of technology-enhanced solutions for manufacturing firms, a multiple case study approach was implemented (Yin, 2003). This provided an opportunity to re-address the research scope and acquire complementary data during the research (Beach et al., 2001; Voss et al., 2002). This research design also provided opportunities to reveal the variety of approaches to customer information and utilising RMS in service business.

Six B2B engineering companies were selected as targets of the study as part of a broader research project. The cases were selected within the same industrial domain to enable sufficient depth of analysis and replication of findings (Eisenhardt, 1989), in the application of RMS and creating business value through RMS. Currently, B2B engineering firms globally are in the process of implementing IoT solutions and enhancing their service business, and the firms we selected are examples of this trend. The companies were selected on the basis of their voluntary interest in the topic, as well as them representing somewhat different markets, customers and offerings, which implies that the companies are not competing with each other. All six companies operate in a global market, and design, sell and deliver complex technology-based solutions, and each considers servitisation a relevant strategic option for expanding their business. The companies provide various technical and support services for their installed base and have begun developing and utilising technology-based solutions in their deliveries. Fictional names – Company A, Company B, Company C, Company D, Company E, and Company F – have been used to maintain anonymity. Table 1 presents the background information of the case companies.

Table 1. Background information of the case companies.

	Company A	Company B	Company C	Company D	Company E	Company F
Net sales (million Euros)	<100	>1000	<100	<100	>1000	>1000
Employees	<1000	>10 000	<1000	<1000	>1000	>1000
Service share of net sales, %	30%	40%	20%	30%	51%	17%

All six companies are global equipment and component manufacturers and deliver their solutions through projects or transactional deliveries. The products include machines for mining, electricity, waste management, paper and plywood industry, and automation systems for factories. Their customers are manufacturing firms that use the equipment and components in their own manufacturing processes. Companies A, C and D provide certain products in different versions which are complemented by various specific services. These companies have narrow but global markets. Companies B, E and F have multiple business units and provide multiple product families and various services to their broad global markets.

Data collection

The main sources of data were semi-structured interviews and public documents. The study followed a managerial perspective and relied on interviews with managers involved in service delivery and development as the primary source of data. The main themes of the interviews included interviewees' perceptions of the importance of service business (types of services, current share of services, future plans), the service design and delivery process (process of service design and delivery, standardised and customised services), identifying customers' needs and expectations (existing channels, accuracy of information, role of customers, new possibilities), the role of RMS in the service business (knowledge about RMS, value drivers for companies and customers, risks and barriers), and possibilities for utilising remote data (applications, requirements, possibilities). Table 2 summarises key information from the interviews.

In total, 16 respondents were interviewed. Most of the interviews were held individually, but on three occasions, the interview was held in pairs or a small group. In two companies (D and E), only the contact person was interviewed, and these interviews are included in the findings as they were the most knowledgeable key informants concerning RMS and servitisation in those firms. The interviews ranged from 45 to 90 minutes, with an average of approximately 60 minutes. Most interviews were performed on site, which enabled the researcher to become familiar with the interviewees' working environment at the factory. This also presented the opportunity to observe the documents of the service processes, development plans and service people who were providing remote services. The interviews were audio recorded and transcribed. After the analysis, the interview findings were discussed in a workshop with participants, including interviewees and additional people from all six companies, to validate the findings and compare them to prior studies.

Table 2. Interview data.

	Company A	Company B	Company C	Company D	Company E	Company F
Number of interviews	3	3	1	1	1	2
Respondents	CEO, Technology director, Service managers N=4	Field services director, Product manager, Research and development manager N=3	General service managers, Life cycle services manager, Product manager N=4	Technology manager N=1	Product manager and Project manager of new service systems N=1	Service product manager, product manager, global service project manager N=3
Average duration, min	45	45	80	45	60	90

The secondary sources of data were the companies' public documents. Related websites pages, brochures and annual reports were studied to locate relevant information for the research topic, such as different types of services, position of services in the companies' offerings, advertising and sharing information about RMS. These sources were used to collect background information on the companies and collect supporting material to design and improve the interview outline.

Data analysis and validation

An external service provider transcribed all recorded interviews. The authors reviewed all transcriptions to identify and correct any mistakes or gaps. The level of analysis is the company, and the unit of analysis is the company's approach to using customer information and RMS. The data analysis included four steps. First, the interview transcriptions were coded on the basis of the interview outline manually. Second, case-specific stories were developed on the basis of the collected data. Third, a cross-case analysis was performed to identify similarities and differences between the case companies. At this stage, the focus of analysis was on the different approaches of using customer information, as well as experiences of business value from using data from RMS, which is in line with the research questions. Finally, the cross-case analyses were contrasted with previous literature to highlight the key phenomena emerging from the interviewees' experiences. Excerpts from the interviews are used in the Findings section to highlight the main issues.

Data validation consisted of three steps. First, the case-specific findings were reviewed and validated by the representative from each company. Some parts of the report were modified based on the companies' feedback; however, these modifications concerned confidentiality issues and did not reduce the accuracy of the data. Second, a workshop was held to validate the findings and to enable a cross-case comparison. The findings of each research subtheme were presented in the workshop and discussed among the participants, which helped the authors ensure that the findings were not solely based on individual perceptions, and that they matched company-level experiences. Third, the case-specific and cross-case analyses of the findings were sent to the companies for possible final modifications. No modifications were requested at this stage.

Findings

Business value of using data collected through RMS

The researchers explored how the companies used data collected through RMS to create business value when promoting the adoption of IoT technology. The interviewees in the case companies expressed data utilisation as a key requirement to enhance the adoption and deployment of RMS. An important concern in using RMS is how manufacturers can utilise the substantial amount of data collected through the system. The managers of the studied companies frequently stated in the interviews that they need to provide some value-added solutions to their customers and their own organisations to be able to create business through RMS. A service manager in company A stated, *"At the moment, the customers think that it is nice to receive information through RMS, but there is no difference that the information comes from RMS or traditional methods like physical inspections."* This "nice-to-have" attitude to RMS can be changed if the companies can show the business value of their system.

According to the interviewees' experiences, the collected data can be used to improve preventive maintenance. Companies can predict any probable breakdowns and attempt to solve problems in a timely manner on the basis of the alarms received from the installed base of equipment and by analysing trends for different attributes of the machines. The service product manager in Company F gave an example: *"We can tell the customer that this pump usually lasts for 4,000 hours and now you have run it for 3,500 hours; so, you should change it as soon as possible to prevent any breakdowns."*

By collecting data from many processes and pieces of equipment located at different sites, the manufacturer creates a valuable database. Meanwhile, by conducting an appropriate analysis on the collected data, the companies can identify similar problems in their machinery and use this as input for their product development programs. One of the companies has already begun using the collected data to upgrade a specific product. The lifecycle services manager in Company C explained, *"We are developing a new version and new generation of that product, and the collected data was helpful in this case."* However, he continues, *"But it is not a daily task that we are doing at our company."*

All case companies provide customised solutions to their customers. They tailor their projects on the basis of the specific needs of the customers. The global service project manager in Company F explained, *"We have different industrial segments, safety needs, environments, customers' needs and process needs. Thus, the demands are so different and the solutions are different."* The interviewees in the case companies see the opportunity to provide customised services by using increased knowledge regarding the customers' operations and performance via RMS. A service manager in Company C explained:

> *"We could see how the systems are run by the customers because they are running the systems in different ways. We could see which features they are using or utilising and which features they are not using. That might give us a better picture to know where to concentrate or what to do in the future."*

Frequent remote access to the installed base can also help the case companies evaluate how the machines are supposed to run and how customers are running the machines. Therefore, they can provide customised training for the customers to improve equipment performance. The product manager in Company E explained, *"We can inform them that if you change that parameter to less or more, it will affect the end product by this amount."* It is also helpful for evaluating a situation whereby a customer requests a refund due to an unexpected breakdown in the machinery. The product manager in Company E continued, *"So we can go to the logbook* *and have more accurate data and – if it is relevant – we can explain that you did not check your oil temperature or you were running with too much load."*

Organising the collected data properly and selling it as reference data to the customers represents another possible use of the collected data, thereby enabling customers to compare their performance to competitors. The technology director for Company A put it in the following words: *"We can tell them anonymously that these are your competitors and this is your level compared to your competitors and there is potential for improvement."* Another identified opportunity in this field is using the collected data in sales and marketing to calculate the benefits of new versions of products. The company can figure out the downtime of equipment due to some specific problems and can calculate the cost of the downtime for customers. This kind of report supports companies' justifications for new offerings in their sales plans. The product manager for Company B explained the situation in the following manner:

> "*It gives you the appropriate tool for marketing because in this industry, you always need something to show in statistics or based on real data. That is basically the only thing which can really sell it. Otherwise, they feel like it's nice to have it, but they do not buy it or they do not pay a good price for it."*

Table 3 summarises the core issues through which RMS were identified as a source of business value, according to the interviewees' experiences.

Various approaches to collect customer information

The case companies use different ways to identify customers' needs and expectations. Utilising advanced ICT has drawn considerable attention in all six case companies. The main technology-based solution that can be utilised in the case companies to collect customer data is RMS. The interviewees saw the opportunity of increasing their knowledge regarding their customers' operations via RMS. The technology director in Company A said, *"RMS can help us to understand the customer's operation. By understanding what is going on there, we are able to provide the right service at the right time."* The data collected through RMS can also help manufacturing firms to obtain deeper knowledge regarding their own products in different situations. The product manager in Company E explained, *"It can be a valuable tool to understand how the machines are operating in different market areas and different climates."*

Therefore, it enables firms to provide customised solutions for the specific characteristics of the customers in their unique contexts.

Table 3. Means to create value from RMS in the manufacturing firm's business processes.

Value-creating business process	**Role of RMS**	**Benefit for business value**
Customer relationship management	Data collection on equipment, its use and different user profiles	Enables timely or preventive maintenance and early identification or even foresight of problems; thereby can reduce costs and equipment downtime.
Marketing	Data collection on equipment performance	Enables calculation of financial effects of problems in equipment use, and benefit of the remote services, and calculating the value proposition / business case for the customer.
Product development and customization	Continuous monitoring of equipment status, use, problems, and performance	Enables increased understanding on the customers' operations and performance, design of better customized solutions, and targeting of the right solutions to the right customers.
Performance improvement and after-sales service	Evaluating the equipment use and comparing to specification	Enables offering solutions for performance improvement and avoiding faults and breakdowns.
New business development	Organizing the data and summarizing at the level of customer segment or area	Enables creation and selling of reference data; enables customer to compare with "best in class" or a reference market; enables offering targeted new services depending on equipment use patterns.

Using advanced technology is a relatively new way of collecting information for the case companies, which became apparent through the interviews. They have established and used other channels to identify customers' needs and expectations in previous years and continue to use them in parallel with RMS. Close customer relationships and deep knowledge of their industry and technology have been the case companies' main approaches to using customer information. The CEO of Company A stated, *"We are talking with the customers on the management level, operator level and anything in between."* Feedback from sales people and customer relationship management systems are among the possible channels for some case companies to identify customers' expectations. The research and development manager in Company B stated, *"Sales people who meet the customers receive feedback from them and save it in a [information technology] platform to be available for future analysis."* The main challenge of these relationship-based approaches is that they are usually effective for customers who already have an established, long-term relationship with the firms and trust in them.

However, occasionally it does not provide a real picture of the customers' expectations. The field services director in Company B explained:

> *"Sometimes, we are offering too much to the customers. That means the price tag is too high, so the customer asks the same solution from our competitor with a lower price. On the opposite side, sometimes we do not know what to offer."*

Holding customer focus groups and workshops were clearly less frequently used among the case companies, but for some companies, they provided an opportunity to discuss different topics directly with certain customers. The global service project manager in Company F demonstrated this by stating, *"We have different sessions where we give the customers the chance to talk about everything and, especially, their needs and expectations."* However, these approaches are more effective for analysing specific issues with those customers who already have more experience, knowledge and understanding of the topics under discussion. According to the interviewees, inspections at the customer's site were considered an effective method for observing the customer's business and identifying potential needs and opportunities.

According to the interviewees, RMS have reduced the need for physical inspections at the customers' sites, provided continuous or more frequent connections with the equipment, and, consequently, resulted in a substantial amount of data with less cost than if the data were collected manually. Most customers play a limited and passive role in the development of new solutions, based on the data. With the exception of some more advanced customers, a large majority are not active and only benefit from the developed solutions if the manufacturing firms first envision the customer's needs and offer them proactively. This is mainly due to the complexity of the products and solutions. The product manager in Company F confirmed, *"You have to always wake them up. You have to ask the right question and guide the customer a little bit."* Thus, the latent needs of customers are not necessarily expressed by customers through relationship-based approaches.

Discussion

Business value of RMS for manufacturing firms

The study has taken a step towards better understanding the business changes enabled by IoT adoption and the use of RMS in manufacturing firms' customer relationships. The first research question asked how managers in manufacturing firms perceive the business value of RMS in industrial service business. RMS and the IoT, in general, hold high hopes for positive changes in industries, but RMS have previously been considered primarily as technology enablers, and manufacturing firms and their customers adopt technologies slowly and cautiously.

Where previous research on IoT adoption has focused on common/dominant standards, platforms and interfaces (Mazhelis et al., 2012), and security and privacy mechanisms (Miorandi et al., 2012), this paper has discussed creating business value through RMS as a need-to-have driver for adopting the technology. The findings have indicated that changing the mindset towards RMS is one of the key concerns of the manufacturing firms that provide complex systems to their customers. Basic RMS-enabled services, such as assessing spare parts needs and calculating machine hours, are not sufficient; manufacturing firms need to learn ways to provide more advanced business value to convince customers to accept and even pay for the services.

RMS and IoT technologies open up new kinds of service domains for manufacturing firms offering industrial services. Most previous studies on RMS have focused on maintenance as the main application of RMS (e.g., Nieva, 1999; Biehl et al., 2004; Jonsson et al., 2008, 2009; Mori et al., 2008; Brax and Jonsson, 2009; Westergren, 2011; Westergren and Holmström, 2012). In addition to improvements in maintenance and spare parts delivery, the researchers argue that RMS can be effective in other types of services, such as inspections, modernisation, extensions, and training. To convince customers that RMS are a necessary part of service business, manufacturing firms should show that continuous technology-based customer interactions can supplement the benefits of periodic and scheduled customer interactions. The interviewees emphasised the current and potential benefits of RMS regarding interaction continuity and customer closeness, as well as providing specific services based on the customers' requirements at the right time.

The role of RMS has earlier been covered primarily in the after-sales phase. Previous studies on RMS have focused on the benefits for manufacturing firms and, particularly, for customers from condition monitoring (Nieva, 1999; Mori et al., 2008), and the value creation process by improving maintenance (Jonsson et al., 2008). However, condition monitoring and improved maintenance are the direct payoffs from the technology; the impacts on other critical business activities also form a significant part of the perceived value of RMS. This study contributes to industrial service research by showing the ways in which RMS enable business value in various business processes more broadly: customer relationship management, marketing, product development and customisation, performance improvement and after-sales service, and new business development. Efficient data utilisation is needed, and the case companies put their efforts into analysing the collected data from different locations, providing analytical reports, and assessing trends to create customer value and capture business value. This study suggests that manufacturers cannot succeed in increasing the adoption of RMS by focusing on technical enablers only; they should utilise the potential capabilities of RMS in their business processes more broadly to increase customer knowledge and knowledge of product use, and convert the substantial amount of collected data into business value.

Improving customer data collection through RMS

In the second research question, we inquired how RMS along with other data collection channels help manufacturing firms to identify customers' needs and expectations. The findings show that the case companies use multiple ways to acquire knowledge about their customers' needs and expectations. Predominantly, all six case companies mostly depended on their relationship-based methods for customer information collection at all levels of their organisations. The importance of direct customer participation and maintaining conversations with customers to develop new ideas has been highlighted in the literature (Alam, 2002; Nambisan, 2002). The findings of this study, lending support to previous research (Bitner et al., 1997; Slater, 2001; Nambisan, 2002; Matthing et al., 2004), not only confirm the benefits of these methods but indicate some issues that may decrease the efficiency of relationship-based customer information channels in manufacturing firms: customer's limited product knowledge; long distances between manufacturing firms and customers; and the validity and quality of the customers' data. The case firms see advanced ICT as a valuable tool to overcome these issues and bring new insights to the firms.

The first issue reducing the efficiency of relationship-based customer information use deals with the customers' knowledge. The advanced equipment offerings of manufacturing firms are complex, and considerable knowledge is embedded in their technologies. Market-oriented firms have traditionally used focus groups, surveys and close relationships with customers to increase their understanding of customers' needs and wants, but these approaches are mainly dependent on the expressed needs of customers (Slater, 2001; Matthing et al., 2004). In the case firms, RMS were experienced as enablers for continuous connections between the manufacturing firms and the customers' sites, and for pointing out bottlenecks, equipment misuse, and other important factors in the production process, and consequently, to understand the technical needs that are not explicitly expressed by the customers.

Second, globalisation and providing equipment to customers in different locations add to the challenge of collecting information from customers in a cost-effective manner (Nambisan, 2002). This implies that companies cannot use the old-fashioned way of collecting information, which requires direct physical contact between the manufacturing firms and customers. One of the main benefits of RMS identified in this study is reducing the need for site visits, since the manufacturing firm's technicians can monitor their installed base of equipment remotely through RMS. This can have positive implications on service costs, in terms of reducing the need for on-site service resourcing and traveling.

Third, one of the main obstacles of relationship-based approaches to customer information collection is the validity and quality of the data provided by the customers (Bitner et al., 1997). This issue is mainly due to the customers' lack of knowledge regarding the product, motives of customers' employees, and limited experience with the product. In the identified customer information collection methods in previous studies, such as face-to-face interviews, user visits and meetings, users' observations and feedback, and focus group discussions (Alam, 2002), manufacturing firms assume a more passive role in collecting customer information, implying that they are more dependent on the information provided by the customers. The findings of this study show that while the information provided by the customers is helpful for manufacturing firms in identifying service needs and requirements, the information may not be relevant, accurate or valid for the manufacturing firm's exact use, such as defining service scope, i.e. which services for which equipment, timing, and alignment with, for example, other customers. Therefore, they need to have other channels for collecting and validating relevant data. This kind of proactive information access enables avoiding the validity concerns stemming from second-hand data.

This study contributes to previous research in service business regarding the role of customers and customer information within service development by emphasising the necessity of using multiple ways for collecting customer information to have a clear picture of the customers' current and future needs. Advanced technologies such as RMS cannot be isolated from other customer information channels. The manufacturing firms need to strike a balance between automation resulting from advanced technologies and the quality and value of services for the customers (Kowalkowski and Brehmer, 2008). Relationship-based processes are necessary not only for collecting data but also to enhance customer relationship management. Superior technical knowledge of service developers can limit their ability to provide original ideas and, thus, customers or users can be considered inspirers of new services (Magnusson, 2003).

However, the interviewees admitted that occasionally they are unable to make the right assumptions about their customers' needs and expectations by using these traditional methods. The respondents discussed accessing equipment on dispersed sites simultaneously to analyse a problem based on real-time data. Thus, advanced technologies must be increasingly integrated into information collection processes of manufacturing firms to find the unexpressed needs of customers, decrease data collection costs, and increase the validity and quality of the collected data.

Conclusion

Research implications

This study contributes by offering new knowledge on the creation of business value through the use of IoT-based technologies such as RMS in industrial service business. The empirical findings in six engineering firms have led to a better understanding of the value added by RMS in different business processes. Most prior studies on RMS have focused on preventive maintenance as the main application area, which always occurs in the after-sales phase. This study highlights possible broader applications of RMS in a manufacturing firm's business, in customer relationship management, marketing, product and service development, and the customisation process. The findings highlight the potential for creating business value from the substantial amount of data collected through RMS. As RMS and IoT-related technologies are adopted, they can be used to complement other customer information collection channels and, thereby, improve the efficiency of services through improved knowledge access, removal of physical distances, and better validity and quality of data.

Managerial implications

This study draws attention to IoT adoption and the role of different data collection channels in manufacturing firms' service business. Although the technological enablers of the IoT are largely available to manufacturing firms, we have shown that adopting RMS specifically and the IoT more generally contains various business-related factors that can enable or restrain the use of technologies in service business. The business aspects of RMS need to be considered in firms to achieve the benefits of the IoT in a full-scale service business. The findings have shown that RMS can be a useful channel for collecting and using customer information efficiently and, thereby, developing and delivering new services. Managers need to enhance the use of customer information in service design and delivery, and the effective use of RMS-based customer information will require new routines and processes. Converting the collected data into suitable formats, integrating multiple data sources, and analysing them are critical areas that need to be covered effectively in the service business. Manufacturing firms also need to understand how RMS will change their customer relationships. In an automated supplier-customer cooperative setting, manufacturers need to become more open to the different ways of doing business with customers. Depending on how they utilise RMS in their operations, it may change the companies' business models.

Limitations and future research direction

The study was conducted in six companies in the engineering industries, which limits the generalisability of the findings to similar contexts. Further, the number of interviewees was rather limited in each case company. To improve the validity, informants were selected based on their first-hand experience in the use of RMS; thus, they were expected to offer topical and accurate knowledge on the issues in their firms. Reviews and workshops with company representatives were included to validate the findings both at the company level and across companies. The interviews were mostly conducted with managers in product development and service units, and the experiences and opinions of service design and delivery employees and supporting business functions, such as sales and marketing units, remain topics for future study.

This study has presented some possible uses of RMS as one of the relevant technologies in the IoT. The IoT encompasses other technologies such as RFID and M2M communication. Further studies are needed to analyse the potential of these technologies for use in manufacturing firms and to evaluate their possible effects on service business, product development, and operations. Also, the findings showed that manufacturing firms use multiple channels for customer information collection. It would be interesting to study the multi-channel customer information approaches and platforms further to identify their success factors and contextual alignment across different types of companies.

The present research focused on one core aspect of IoT technologies, i.e. data utilisation. Other related topics that can affect data utilisation, such as data security, were not covered. Different aspects of data security and possible approaches to eliminate or mitigate these risks must be explored in the future.

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