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Research paper

Internet of things technologies, digital servitization and business model innovation in BtoB manufacturing firms

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ABSTRACT

Technologies like the Internet of Things (IoT) are offering new opportunities and posing serious challenges to firms, forcing them to create entirely new business models, migrating from the conventional product-centric approaches to (digitally-based) service-oriented ones. This paper – following a qualitative research method – aims at describing the service-oriented impact of IoT technologies on firms' business models, with a particular focus on opportunities and challenges for BtoB manufacturing firms.

Being the impact of IoT technologies on businesses a quite recent research stream, to date scarce attention has been devoted to the topic with specific attention to its impact on service-oriented business models in manufacturing firms. The paper contributes in this research stream in different ways. It proposes a map of digital servitization that helps in understanding firms' strategic transitions caused by technologies, making both theoretical and managerial contributions. Firstly, the research underlines the impact of the firms' sales model as a strategic factor in shaping firms' digital servitization strategies. In addition, three progressive levels of digital servitization complexity are identified, namely product- process- and outcome-oriented, that are based on an increasing use of IOT technologies and have specific challenges and opportunities.

1. Introduction

The IoT (Internet of Things), Cloud platforms, Big Data and Data Analysis are offer industrial firms the possibility to leverage technology to innovate their strategies, in particular in order to implement new service-oriented business models (Falkenreck & Wagner, 2017; Laudien & Daxböck, 2016).

The design and delivery of services are key capabilities to compete in complex manufacturing markets (Baines et al., 2017). Technology has always been considered a catalyst for a service business orientation (Kowalkowski, Kindström, & Gebauer, 2013), and a key resource in order to manage the different issues that arise from complex product-service systems (Neu & Brown, 2005).

The current technological scenario is opening opportunities for a service-oriented transformation of manufacturing firms' business models that are deemed important both by business-oriented (Noventum, 2016) and academic literature (Coreynen, Matthyssens, & Van Bockhaven, 2017).

However, that transformation is potentially disruptive both for companies and entire industries, calling for a thorough commitment (Porter & Heppelmann, 2014 and 2015): it may present enormous advantages but may also have potentially disruptive consequences for industrial services and manufacturers' strategies (Evans & Annunziata, 2012; Laudien & Daxböck, 2016).

Notwithstanding the managerial and scientific relevance of this line of research, little investigation has been done to date on these aspects: recent contributions underline how academic research on the relation between IoT technologies and service-based business models is in its infancy (Suppatvech, Godsell, & Day, 2019), especially as regards the most advanced use of digital technologies (Coreynen et al., 2017).

In light of this gap in the literature we designed a qualitative research involving Business to Business firms belonging to different manufacturing industries in Italy. The empirical research addresses the following research questions: what are the main opportunities that IoT technologies offer to BtoB manufacturing firms in order to expand their service-oriented offerings? What are the challenges that this digital servitization poses to traditional manufacturers' Business Models?

Our aim is to identify how manufacturing firms (belonging to

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different industries and with different value chain positions) can use IoT technologies in order to add services to their traditional product-focused offerings and enlarge their traditional value propositions with the offer of advanced customer-related services. The theoretical perspective adopted in the research is to use the Business Model Innovation lens to read the impact of IoT technologies on BtoB manufacturing firms' service-led growth strategies. Thus, we aim to describe the main opportunities and challenges that digital servitization poses to traditional manufacturers' Business Models, highlighting and characterizing the various strategic impacts that different uses of IoT technologies may have on firms' business model elements.

The paper is organized as follows: Section 1 presents a selected literature review on the subject, introducing the linkage between IoT technologies, business model innovation and servitization strategies; Section 2 describes the empirical investigation, detailing methodological aspects and presenting the main findings of the research. Section 3 discusses in more depth the findings and introduces a model that synthesizes the fundamental strategic moves facing BtoB manufacturing firms in the current technological scenario. Finally, conclusions, limitations and further research avenues are discussed.

2. Literature review

2.1. IoT technologies, business models and business model innovation

A group of nine technologies form the building blocks of the current technological scenario (the fourth industrial revolution, I4.0) and are the drivers of the consequent business transformation (Rüßmann et al., 2015). Among those technologies, the Internet of Things (IoT), and in particular the Industrial Internet of Things (IIoT), plays a primary role in helping manufacturers to unlock the value of their machines, and is involved in the development of service-based offerings in manufacturing firms (Ehret & Wirtz, 2017).

The IoT paradigm is based on the pervasive presence around us of a variety of devices which, through unique addressing schemes, are able to interact and cooperate with each other (Atzori, Iera, & Morabito, 2010). In fact, the IoT is the fundamental technological element for the transformation of stand-alone and isolated "things" into smart (with a local computational capability) and connected (able to transmit different types of data) products (Fleisch, Weinberger, & Wortmann, 2014). This new breed of smart and connected products is offering firms: the possibility to harness real-time data and to analytically process it, allowing customer information and data to be integrated within the firms' information systems and strategic planning (Dalenogare, Benitez, Ayala, & Frank, 2018); the possibility to monitor, optimize and automatize products' functions, remotely and globally (Porter & Heppelmann, 2014).

In this work, in accordance with emergent literature (Frank, Mendes, Ayala, & Ghezzi, 2019; Suppatvech et al., 2019), we will use the term "IoT technologies" referring to four front-end deeply interlinked technologies that support firms' service-oriented business model innovation: IoT, Cloud computing, Big Data and Data Analytics. The reasons for adopting such a perspective are the following. On the one hand, the massive amount of data generated by relatively inexpensive sensors and actuators embedded in products can be rather easily stored, accessed and processed thanks to the progress of cloud computing technologies (Hashem et al., 2015). On the other hand, big data is a complex set of extremely diverse information, in both structured and unstructured form (Demirkan et al., 2015). In order to be used to inform decisions, it needs a thorough analysis (Lee, Kao, & Yang, 2014; Santos et al., 2017), using specific techniques (Manyika et al., 2011). Therefore, big data and analytics can be considered key enablers to advanced applications of IoT and I4.0 (Frank et al., 2019).

Altogether, IoT technologies may present enormous advantages and have potentially disruptive consequences even for industrial services and manufacturers' strategies (Evans & Annunziata, 2012). They can leverage the design of innovative product-service systems (Belvedere, Grando, & Bielli, 2013), and may radically affect value propositions, upstream and downstream relations in the value systems, and the business models themselves (Laudien & Daxböck, 2016).

In fact, being able to connect hundreds of products directly within the end-user firms' premises all over the world can provide firms with information that may transform the business models in different ways: – enhance the product and or the system/solution; − develop new products and services; − optimize customer segmentation, positioning and pricing strategies; − develop the capability to dynamically modify business models' component configurations over time (Porter & Heppelmann, 2015).

Therefore, technology is only part of the picture: as previous research has clearly stated, the extent of value that firms can capture from technological innovation depends on their business model (Chesbrough & Rosenbloom, 2002), and the business model concept has increased its importance especially for technology and innovation management (Massa, Tucci, & Afuah, 2017). Indeed, technology may seriously affect firms' business models, posing significant challenges to its various interlinked elements (Amit & Zott, 2012), and it may also make the existing business models obsolete and uncompetitive (Bock, Opsahl, George, & Gann, 2012). This means that along with new opportunities, IoT technologies pose some threats that companies may not be able to address with their existing business models, calling for Business Model Innovation (Arnold, Kiel, & Voigt, 2016).

Even if a thorough review of BM literature is beyond the aim of this work, some considerations regarding the concept may be useful in order to properly introduce the importance of BMI and to better understand the scope of the ongoing transformation. Different interpretations of the meaning and the functions of "business models" emerge from the management literature, defining them either as (Massa et al., 2017): attributes of real firms; cognitive/linguistic schemas; formal representations of how a business works. Synthesizing that vast literature in order to provide a useful perspective for this research, we can essentially say that a BM summarizes the architecture and logic of a business (Baden-Fuller & Morgan, 2010), or the fundamental functions in the strategic life of a firm (Chesbrough & Rosenbloom, 2002); either explicitly or implicitly, it describes "the design or architecture of the value creation, delivery, and capture mechanisms it employs" (Teece, 2010, p. 172). Specifically, BM elements relevant for the present research refer to (Osterwalder & Pigneur, 2010): the position and role in the value system (value creation); the sales model, channels and customer relations (value delivery); the nature and features of product and services (value proposition); the revenue model and costs structure (value capture).

The Business Model Innovation (BMI) literature sees the BM concept in a transformational way as a tool to address change and innovation in the organization (Demil & Lecocq, 2010). This perspective has received a considerable amount of attention in the last few years. However, consensus on what it means is far from general, and to date there isn't a shared definition to build upon (Foss & Saebi, 2018). For the aim of this research we can say that BMI may occur whenever the company modifies or improves at least one of the value dimensions (Ritter & Lettl, 2018). It is a process through which firms accomplish deliberate changes in the activities and functions within their BMs and explore new architectural designs (Foss & Saebi, 2017): BMI means exploring new possibilities related to value creation, distribution and capture for customers, suppliers and partners (Gambardella & McGahan, 2010).

The concept of change in BM literature has been variously codified, referring to different perspectives that highlight the contrast between BM development and BM innovation (Schneider & Spieth, 2013), or between incremental and radical perspectives (Laudien & Daxböck, 2016).

On the one side, a more gradual and evolutive view is in place. Here changes in BMs are seen as projected and emergent fine-tuning adjustments, aimed at reaching dynamic consistency and allowing leverage on extant resources and competences (Demil & Lecocq, 2010). In this sense the concept itself of BM is a permanent evolution of the relations and feedbacks set among its constituents (Casadesus-Masanell & Ricart, 2010). On the other side, a more radical and disruptive view of BMI is in place, implying firms' reactions to changes in the sources of value creation that call for major entrepreneurial actions (Schneider & Spieth, 2013).

Apart from the theoretical value of such a dispute, the topic is particularly important here, since it refers directly to the question of whether IoT technologies call for an adjustment or a radical change in the business model. The literature seems to agree on the fact that IoT technology may have disruptive effects on BMs: it may affect firms' internal and external processes and interdependencies, involving reconfiguration of internal capabilities, value and pricing models, revenue and cost structures, and power and collaboration in the value system (Arnold et al., 2016; Vendrell-Herrero, Bustinza, Parry, & Georgantzis, 2017). From this perspective, Laudien and Daxböck (2016) describe how a “full utilization of IIoT” requires a radical innovation of the firms' business model.

Therefore, acknowledging the work by Berman (2012), we assume that the effects of IoT technologies on firms' business models can be put on a scale of increasing complexity as follows: BM enhancements are ordinary modifications that firms usually apply to their strategies in order to maintain their competitive advantage, such as augmenting traditional products with features and services that differentiate them from their competitors' ones; BM extensions deal with product or process developments that allow firms to streamline costs and increase their market share, like adding new revenue streams by extending traditional products and services through the use of digitally delivered services, content or information; finally, BM redefinitions lead to a profound reshaping of the value propositions (and the business model components) that transform the operations delivering the value.

As we will see in the next section, these considerations are particularly pertinent for the family of technologies we are addressing in this work, and the intrinsic and unescapable service-oriented transformation they instill in firms' strategies.

2.2. Servitization and digital servitization

The shift from product- to service-oriented business models in manufacturing industries is an important phenomenon characterizing manufacturers' strategies: the logic and implications of this shift have been studied since the ‘80s by a range of scholars from a variety of disciplines, producing different conceptualizations. Among them we find: servitization (Vandermerwe & Rada, 1988), going downstream (Wise & Baumgartner, 1999), services transition (Oliva & Kallenberg, 2003), product-services systems (PSS) (Tukker, 2004), moving from product to solutions (Gebauer et al., 2013), service business development (Gebauer, Paiola, & Edvardsson, 2010), service growth (Kowalkowski, Gebauer, & Oliva, 2017), service infusion (Brax, 2005), hybrid offerings (Ulaga & Reinartz, 2011).

Notwithstanding the differences in terminology, all these approaches may be reliably condensed in the concept of “servitization”, that is now widely recognized as the process of creating value by adding services to products (Baines, Lightfoot, Benedettini, & Kay, 2009) and developing service-based business models in manufacturing industries (Kindström, 2010; Raddats, Kowalkowski, Benedettini, Burton, & Gebauer, 2019). This transition – although necessitating the transformation of existing organizational structures and processes – can be started by manufacturing firms leveraging on their resources and capabilities. It may represent an opportunity for product-centric servitization, meaning a service growth directly coupled to a product offering (Baines, Lightfoot, Peppard, et al., 2009): thus, since manufacturers know their products intimately, they are well positioned to exploit many servitization opportunities (Wise & Baumgartner, 1999).

In this picture, the domains in which manufacturers may develop their service growth are both what the literature has described as product-oriented services and end-user's-process-oriented services (Mathieu, 2001; Oliva & Kallenberg, 2003). In other words, both the services directed to enhance the performances of installed products and the services aimed at helping the customers in reaching their operational performances may be targeted using existing capabilities (Ulaga & Reinartz, 2011). In both cases servitization has a fundamental resource to start from, a resource that most product-centric firms possess: the installed base. Since customers do not go straight from being strangers to asking for complex services, an existing customer base and the relative installed base can be used to ignite servitization and gradually shift to more advanced services (Kindström & Kowalkowski, 2014; Ulaga & Reinartz, 2011; Wise & Baumgartner, 1999).

In particular, access to data represents a unique asset that firms jealously protect to differentiate themselves from other manufacturers, a powerful resource in terms of product usage and process information (Wise & Baumgartner, 1999). Installed base product usage and process data are a central element for leveraging on manufacturers' resources and capabilities for servitization (Ulaga & Reinartz, 2011). Therefore, being the base for harnessing and leveraging customers' data, IoT technologies are the means for transforming the firm's installed base (IB) into a wealth of information regarding products use and processes.

In fact, IoT technologies can improve manufacturers' visibility of activities in customer-specific contexts, leading to a better understanding of users and improved strategies (Kamp & Parry, 2017). In particular, IoT technologies can help all those manufacturers (45% of the total) that struggle to develop the service business due to the difficulty in monitoring product usage conditions and related data (Adrodegari, Alghisi, Ardolino, & Saccani, 2015), and have a clear role in enabling service-oriented business models (Rymaszewska, Helo, & Gunasekaran, 2017).

A recent literature review by Suppatvech et al. (2019) identifies a series of benefits and inhibiting factors of IoT-enabled servitized business models. According to that study, advanced service-oriented business models based on IoT technologies allow firms to: reduce operating costs, generate additional revenue, maintain a long-term business relationship with customers, increase resource utilization, and assess the risks of current product or service provision. At the same time, advanced business models are inhibited by the fact that they: require close collaboration with different stakeholders, require new ways of customer interaction, require skills and expertise in data management and necessitate the development of innovative offerings that align with customers' needs.

Now, with their capability of managing information input and output at a distance, IoT technologies are allowing new (smart and digital) forms of services for manufacturers, boosting servitization through digitalization (Coreynen et al., 2017). Thus, the concept of “digital servitization” takes root and gives birth to a research stream focusing on how digital technology enables the supply of services in innovative ways (Cenamor, Rönnberg Sjödin, & Parida, 2017; Coreynen et al., 2017; Kohtamäki, Parida, Oghazi, Gebauer, & Baines, 2019; Sklyar, Kowalkowski, Tronvoll, & Sörhammar, 2019; Vendrell-Herrero et al., 2017).

While manufacturers have been so far slow in innovating their service business models, IoT technologies seem to be opening up important opportunities for a service-oriented transformation of their business models. Suppatvech et al. (2019) summarize different ways of using IoT technologies in enabling services at the operational level found in the extant literature: tracking and reporting real-time information remotely, monitoring customer's usage behavior, allowing responsive and proactive maintenance, promoting optimization and remote control of operations, as well as autonomous management. Field research on business use of IoT technologies shows that the majority of manufacturers use them to provide basic product-related services, such as time & material-based repair services and the required warranty services. However, leading manufacturers develop IoT-based processes and business optimization services (like innovative preventative maintenance and availability services) aimed at helping their customers reach optimal performance levels (Noventum, 2016).

In other words, technology may influence the way firms are providing a wide spectrum of services belonging both to the product-level and the customer-level. But the challenges firms are facing may be different depending on how they use the technology and on the subsequent impact on the current business model. On the one hand, IoT can make basic IB services (like documentation, inspection, diagnosis, basic maintenance repair and overhaul and spare parts management) more efficient, a perfect fit for the manufacturer classical repertoire. Here, digital technologies present a little menace to manufacturing firms' business-as-usual.

On the other hand, we are dealing with a different situation when customer-oriented services are involved, and major extensions and redefinitions of the firms' business models are requested (Berman, 2012). In the first place, that is because more advanced customer-oriented services (like preventative maintenance, remote condition monitoring, and performance-based operations management) imply a more intense use of technology, requiring a connected IB for remote monitoring of the product location, condition and use and a thorough knowledge and analysis of the data it provides (Grubic, 2014). Moreover, according to the literature, big data analysis is the major difference between the current technological scenario and the role of traditional ICT investments in servitization (Manyika et al., 2011; Opresnik & Taisch, 2015; Sklyar et al., 2019). Advanced services are directly connected to the firms' capability of leveraging the data created by IoT, and in particular the ability to use customers' Big Data to design better-tailored products and services in order to create and capture value (Urbinati, Bogers, Chiesa, & Frattini, 2019).

In fact, data gathering and analysis allow firms to imagine a number of IoT-enabled servitized value propositions that are at the base of business model redefinitions (Suppatvech et al., 2019): digital servitization may be the trigger of a transition from ownership-based business models to non-ownership-based ones (Ehret & Wirtz, 2017), boosting advanced revenue models like pay-per-use, subscription or sharing, introducing a completely new value-capture mechanism (Adrodegari et al., 2015; Bonnemeier, Burianek, & Reichwald, 2010). Thus, the transition from a transactional view of the customer to a relational one is complete (Ehret & Wirtz, 2017): the product ceases to be the only reason for the business relation and becomes instead just an element of that relation; the revenues are exclusively or mainly connected to the actual value that the product creates in the customers' processes.

Altogether, advanced forms of digital servitization challenge traditional manufacturing strategic culture, impacting heavily on business models in their value distribution, creation and capture mechanisms: the shift of uncertainty and risk from the end-user firm to the manufacturer, which unburdens customers from specific value activities, impacts heavily on transaction cost structures (Coreynen et al., 2017; Ehret & Wirtz, 2017); the extent to which personalized services can be employed and delivered enables new and deeper forms of relations with key clients (Suppatvech et al., 2019); the amount of resources and capabilities necessary is so vast that a firm rarely can make such steps on its own, requiring the competences to manage an ecosystem of suppliers, complementors, and stakeholders (Kohtamäki et al., 2019).

3. The empirical research

3.1. Methodology and sample description

Since academic research on the relation between IoT technologies and service-based business models is in its infancy (Suppatvech et al., 2019), we managed to design an inductive research approach, that is especially appropriate to deal with the new topics that call for further attention (Bluhm, Harman, Lee, & Mitchell, 2011) and an effort of contextualization (Welch, Piekkari, Plakoyiannaki, & Paavilainen-Mäntymäki, 2011). The inductive research method is founded on a qualitative exploratory research design based on a multiple case study (Bryman & Bell, 2011). Case studies are recommended in exploratory research, as they provide detailed data and allow for the investigation of current managerial challenges (Yin, 2009). This setting is congruous with prescriptions coming from well-known specific literature on qualitative research when dealing with exploratory investigations (Voss, Tsikriktsis, & Frohlich, 2002). Multiple case study research has been used as methodology by a number of recent empirical works investigating how emerging technologies impact business models (Laudien & Daxböck, 2016; Müller, Buliga, & Voigt, 2018), since it gives more robust results than the single case study (Eisenhardt & Graebner, 2007).

Given the aim of the research and its exploratory nature, our empirical setting followed conceptual considerations (Silverman, 2005), and in line with Bryman (2003) our qualitative research follows a theoretical rather than a statistical sampling logic, adopting a non-probability sampling technique. Accordingly, cases were selected on the basis of their relevance for our research questions, their convenient accessibility and proximity to the researcher (Mason, 2002). In particular, instead of building a statistically representative sample, we aimed at depicting the variety of situations and challenges posed to firms by the above-described transformation, and the sampling process ceased at theoretical saturation (Glaser & Strauss, 1967), as indicated by information redundancy (Miles & Huberman, 1994).

In order to consistently arrange a selection criterion for cross-case analysis and a proper set of questions, we managed to gather and use information coming from a preliminary investigation phase. In line with other similar investigations (Laudien & Daxböck, 2016), we interviewed 10 industry experts. Sharing in-depth details about their work experience and professional point of view, they gave us some orientation in the field of research (Littig & Pöchhacker, 2014).

Indications and suggestions coming from this phase have proven precious in order to have an initial view of the approach of Italian manufacturing firms to digital servitization, to test the interview template and to select an initial set of firms that presented interesting empirical evidence for our research. Further cases were retrieved during the investigation process, also using indications and names provided by the interviewees during the research meetings and gradually pursuing subjects emerging from the interviews to date (Gioia, Corley, & Hamilton, 2013), following a process of theoretical sampling (Glaser & Strauss, 1967).

Altogether, the following criteria were used to select the companies for the research project. Firms had to: be BtoB manufacturing companies headquartered in Italy; have at least one project related to IoT technologies related to their installed base; be willing to recognize the importance of the research work and commit to it; provide congruous access to information and knowledgeable informants.

Between the end of 2016 and the end-2017, we collected data coming from key informants in 25 manufacturing companies, located in the north of Italy and belonging to different industries in order to maximize diversity among the participants. The number of investigated firms is consistent with the sample sizes recommended for exploratory research and used in research protocols for investigation in similar contexts (Kindström, 2010: 7 cases; Ulaga & Reinartz, 2011: 22 cases; Laudien & Daxböck, 2016: 11 cases; Müller et al., 2018: 68 cases). Consistently with other researches on similar topics (Müller et al., 2018), the relatively high number of cases contributes to lower the sample bias, reducing the risk of selecting companies that have unique abilities or inabilities to use technology for servitization.

The aim of the field research was to get detailed information on the type of IoT technologies used by the firms, the current and potential use of those technologies (with particular attention to services) and the resulting changes in the BM. In line with Gioia et al. (2013), the interview guideline was designed to be flexible enough to avoid imposing an academic terminology or a preordained understanding, and to limit the danger of missing key aspects of the respondents' sense-making. A semi-structured set of questions was adopted, open to the emersion of further questions during the interview and also to slight modifications as research progressed. The interview guideline (Appendix A) is composed of three sections: firstly, the respondent was asked to clarify his/her professional role in the company. In the second section the interviewee(s) detailed the IoT technologies used by the company and their operative utility. Finally, the effects of IoT technologies on the way of doing business were discussed, both from a current and perspective viewpoint. As regards the last point, in line with our overall research design we decided not to employ the a priori constructs suggested by Eisenhardt (1999) and employed by Laudien and Daxböck (2016). Information emerging from the interview was attributed to the pertaining business model component in the analysis and codification phase.

Consistent with acknowledged best practice in research in management, a further survey questionnaire (see Appendix B) was distributed in order to gather a set of detailed information (Voss et al., 2002), with the purpose of having a clearer understanding of the interview and a common set of detailed information of the firms. When more than one interview was permitted to the researchers, the following ones were frequently focused on specific areas of inquiry listed in the survey.

We performed in-depth face-to-face semi-structured interviews with firms' key-informants and top managers in charge of general managing, service-related or technological activities, specifically related to IoT technologies, like Chief Executive Officers, Service Managers, Chief Marketing Managers, Sales Managers, Chief Technology Officers, Chief Information Officers, Chief Operating Officers and Chief Human Resources Officers. In many cases, 2 or more people were involved in the interviews, for a total of approximately 57 h of interviews (see Table 1 for a report of the total number of interview sessions, roles of the interviewees, total duration of the interviews).

Data gathering and reduction followed methodological rigor. Interviews were registered, transcribed, categorized and coded in order to be able to better understand differences and similarities among different companies (see Appendix C for representative quotations). We followed the coding scheme suggested by (Strauss & Corbin, 1990) and reconceptualized in Gioia et al. (2013): as shown in Fig. 1, a first open coding, aimed at identifying concepts and their properties and dimensions (1st Order Concepts), grouping individual observations, sentences and events into sub-categories and categories; then axial coding regrouping categories and linking them to each other in a reasonable way (2nd Order Themes); last, selecting a core category and relating it to other categories (selective coding, Aggregate Dimensions).

Since a good documentation of observations and multiple sources of evidence allow for a chain of evidence to be established (Voss et al., 2002), analysis of within-case data was made before cross-case comparisons, and triangulation was adopted in order to increase internal validity (Yin, 2009): information coming from face-to-face interviews was integrated and compared with companies' internal documents (presentations, official documentation, websites) and external sources (local and national economic magazines, industry-specific information platforms, other online business-related sources). Respondents were recontacted in order to discuss preliminary results, and any incomplete information and incongruence detected in relation to the triangulation activity was the object of a specific consideration. Within-case and cross-case data analysis followed the method of visual representation suggested by Miles and Huberman (1994). Information and data regarding each case were displayed with arrays and event listings, and then a large spreadsheet was built embodying the summarized case data. The analysis was then deepened starting from single categories and searching for cross-case similarities or differences.

Table 1 portraits an outline of the sample: the 25 firms in our sample operate in industries seriously affected by IoT technologies, and in various degrees involved in digital servitization processes. All the firms in the sample are product-based manufacturing companies (no pure-service player is present in the sample). The sample encompasses a broad range of firm sizes: considering the number of employees, one firm is very small, 11 firms are small- to medium-sized (from 20 to 250 employees), and 13 are medium- to large enterprises, with above 250 employees. In line with previous research in similar topics (Laudien & Daxböck, 2016), very large corporations were excluded from our sample.

Regarding their current business models, Table 1 reports basic information regarding the firms' position in the value system (OEM or OES), the adopted sales model (direct or indirect), and the prevalent

Table 1
Empirical cases: outline of firms' characteristics.

Company	Industry	Rev.	Emp.	Product type (prevalent)	Digital technologies	Retrofit	Value system	Sales model	Interviews, roles, total duration
1	Professional equipment	3	8	Standard	IOT, Cloud	No	OEM	Indirect	1, SM, 2 h
2	Machine tools	8	24	Custom	IOT	Yes	OEM	Direct	1, CEO, 1,5 h
3	Professional equipment	5	28	Standard	IOT, Cloud, DA	No	OEM	Indirect	1, CIO, 2 h
4	Mechanical components	6	28	Standard	IOT, Cloud	No	OES	Indirect	2, CEO, 2,5 h
5	Packaging machines	17	79	Custom	IOT	No	OEM	Direct	2, CEO, CMM, 2 h
6	Retail Equipment	22	84	Standard	IOT, Cloud, BD, DA	Yes	OEM	Direct	1, CMM, 2 h
7	Professional equipment	73	95	Standard	IOT, Cloud	No	OEM	Indirect	2, CEO, 2,5 h
8	Packaging machines	55	119	Custom	IOT, Cloud, DA	Yes	OEM	Direct	2, SM, 3,5 h
9	Inspection machines	29	131	Custom	IOT	No	OEM	Indirect	1, CTO, COO, 2 h
10	Heating control systems	43	182	Standard	IOT, Cloud	N.A.	OES	Indirect	2, CTO, CMO, 2 h
11	Food machines	145	240	Standard	IOT, Cloud, BD, DA	No	OEM	Indirect	2, SM, CTO, 3 h
12	Heating devices	60	250	Standard	IOT, Cloud, DA	Yes	OEM	Indirect	2, CEO, 2 h
13	Diagnosis machinery	54	394	Standard	IOT, Cloud, BD, DA	N.A.	OEM	Indirect	1, CMM, CTO, 2 h
14	Home automation	137	396	Standard	IOT, Cloud	No	OEM	Indirect	2, CTO, 2 h
15	Heating control systems	137	561	Standard	IOT, Cloud	N.A.	OES	Indirect	2, CTO, CIO, 2,5 h
16	Machine tools and plants	187	627	Custom	IOT, DA	No	OEM	Direct	1, CTO, CHRO, 2 h
17	Retail Equipment	203	708	Standard	IOT, DA	Yes	OEM	Direct	2, CTO, 3 h
18	Off-road automation	129	713	Standard	IOT, Cloud, DA	Yes	OES	Indirect	2, CEO, CTO, 2,5 h
19	Heating components	254	725	Standard	IOT, Cloud	Yes	OES	Indirect	1, CEO, CTO, 1,5 h
20	Water management devices	249	780	Standard	IOT, Cloud	Yes	OEM	Indirect	1, SM, CTO, 3 h
21	Packaging machines	166	804	Custom	IOT, Cloud, DA	No	OEM	Direct	2, CEO, 3 h
22	Heating equipment	212	817	Standard	IOT, Cloud	Yes	OES	Indirect	2, CEO, SM, CTO, 3 h
23	Packaging machines	216	956	Custom	IOT	No	OEM	Direct	1, CTO, 1,5 h
24	Home automation	188	1089	Standard	IOT, Cloud	No	OEM	Indirect	2, CMM, 2 h
25	Coffee and coffee machines	360	1130	Standard	IOT, Cloud, BD	No	OEM	Direct	1, CTO, 2 h

Companies' facts and figures refer to f.y. 2015.

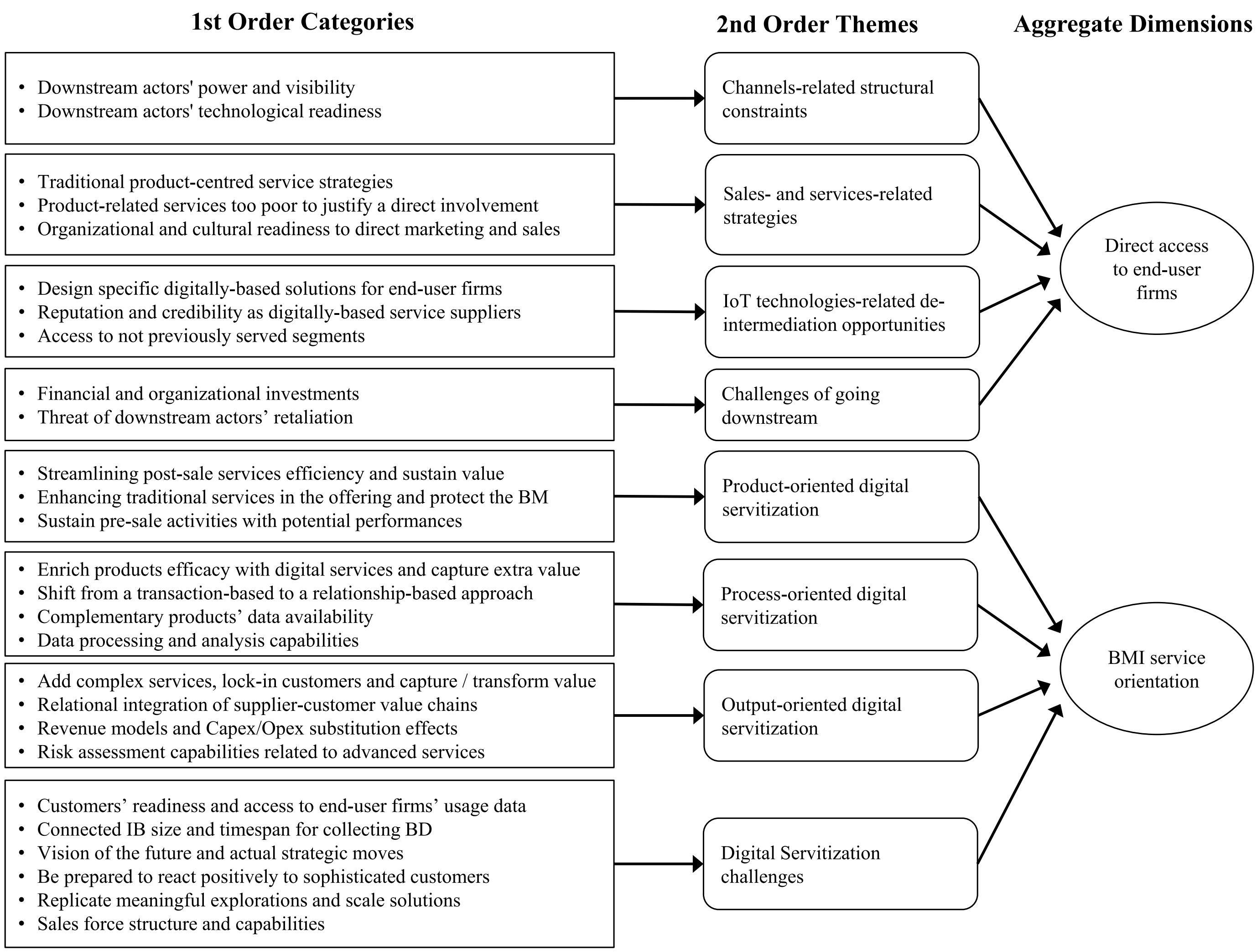

Fig. 1. Data structure.

type of product (standardized/customized). Business models of the sampled firms are currently prevalently product-centered: the value proposition of the firms is founded on the provision of quality products; services are included in the offer with the fundamental aim of fulfilling products' differentiation or complementing product customization strategies. Overall, they play a secondary role, with some specific distinctions that will be detailed later on. Selected firms have different value chain positions: along with 19 OEMs – firms that manufacture BtoB end-user products (machinery or equipment) – the sample contains and considers also the instances of 6 OESs that manufacture core functional components sold to OEMs, frequently underrepresented in samples of similar investigations (Storbacka, Windahl, Nenonen, & Salonen, 2013). Altogether, their goods (products and components) are important assets in end-user firms' processes, being systems or subsystems in other firms' products; components are frequently core functional elements of other complex products (e.g.: automation systems and devices, heating control systems, PLCs).

Regarding the sales models 9 firms sell in prevalence directly to their end-user firms, while 16 have a mainly indirect access to their customers through external channels of various length (depending also on the market).

Firms' competitive strategies are very frequently characterized by segment or niche focalization, with a consequent specialization of resources, capabilities, products and services: 7 firms prevalently customize their products and solutions on customer's needs (also through some form of modularization), while 18 firms manufacture prevalently standardized products.

With regard to technologies, Table 1 shows that all firms' products and components deploy IoT sensors, communication devices and WIFI gateways in order to gain access to local servers or cloud repositories: in reason of this, firms' installed bases can be subjected to 24/7 remote-monitoring on a real-time basis, potentially allowing to collect a wide array of data. It is worth noticing that 9 firms offer their customers a "retrofitting kit" that allows to connect also previously-sold products.

More than half of the sample (14 firms) has a rather simple technological outfit: 4 firms have IoT devices installed in their IB but are not using them at the moment, 10 firms are using IoT and Cloud for some basic level of digital servitization. The other half of the sample (12 cases) is composed by firms with a more complete technological equipment and/or having more experience in using them. Two firms are doing data analysis without a cloud platform, whereas the remaining 10 firms are using a rather complete set of IoT technologies (including DA and/or BD), and have started to harvest data coming from the installed base (apart from one case whose plans in that direction have undergone a slight delay). Either way, only 4 firms can leverage on large amount of data.

3.2. Main findings

On the whole we can say that the level of experimentation in digital servitization varies a lot from firm to firm. On the one hand, every company has invested in basic IoT technologies in order to make its

Table 2
Digital servitization and business model innovation in the sample: details.

Company	Technologies adopted	Functionalities (*potential*)	Actual use and utility	Current impact on BM	Envisioned opportunities	Challenges/obstacles
1	IOT, Cloud	Remote condition monitoring, updating and parametrizing	Updating and parameterization is used by large customers	Sustain product-orientation	Add new service streams, lock the customer in	Customers' readiness
2	IOT	*Remote condition monitoring, updating and parametrizing*	Connectability helps pre-sales activities	Sustain product-orientation (initial transition to process oriented services)	Add new service streams, lock the customer in	Customers' readiness; compatibility issues with other suppliers' machines
3	IOT, Cloud, DA	Remote condition monitoring, updating and parametrizing, initial DA	Updating and parameterization is used by larger customers	Sustain product-orientation	Sustain new product and service development	Visibility in the value system; channels' readiness
4	IOT, Cloud	*Remote condition monitoring, updating and parametrizing*	Connectability helps pre-sales activities	Sustain product-orientation	Add new segments or value spaces in the current value chain.	Complex channels and powerful OEMs
5	IOT	*Remote condition monitoring, updating and parametrizing*	Connectability helps pre-sales activities	Sustain product-orientation (initial transition to process oriented services)	Add new service streams, lock the customer in	Customers' readiness
6	IOT, Cloud, BD, DA	Remote condition monitoring, updating and parametrizing, data analysis and BI	Asset Efficiency Services for main customers	Extend the BM with process-oriented services (initial transition to outcome-oriented services)	Approach performance-based contracting with selected key customers	Financial and operative risks assessment and mitigation
7	IOT, Cloud	Remote condition monitoring, updating and parametrizing	Updating and parameterization is used by larger customers	Sustain product-orientation (initial transition to process oriented services)	Streamline post-sales services and add process-oriented services for selected customers	Customers' readiness
8	IOT, Cloud, DA	Remote condition monitoring, updating and parametrizing, data analysis and BI	Asset Efficiency Services for main customers	Extend the BM with process-oriented services (initial transition to outcome-oriented services)	Adding new process- and outcome-oriented services through scalable solutions	Services sale capabilities, data interpretation capabilities
9	IOT	*Remote condition monitoring, updating and parametrizing*	Connectability helps pre-sales activities	Sustain product-orientation (initial transition to process oriented services)	Adding new process-oriented services	Visibility in the value system; customers' readiness
10	IOT, Cloud	*Remote condition monitoring, updating and parametrizing*	Connectability helps pre-sales activities	Sustain product-orientation	Adding new segments or value spaces in the current value chain	Complex channels with integrators and system vendors.
11	IOT, Cloud, BD, DA	Remote condition monitoring, updating and parametrizing, data analysis and BI	Updating and parameterization is used by larger customers	Sustain product-orientation	Streamline post-sales and field services; add process-oriented services for selected customers	Organizational complexity and investments
12	IOT, Cloud, DA	Remote condition monitoring, updating and parametrizing	Remote operativity via a dedicated app is appreciated and sustains brand value and sales	Sustain product-orientation (initial transition to process oriented services)	Interact with final customers and learn about their needs; vehiculate directly some new value propositions.	Extant channels' actors retaliation
13	IOT, Cloud, BD, DA	Remote condition monitoring, updating and parametrizing, data analysis and BI	RCM, updating and parameterization is used by larger customers	Sustain product-orientation (initial transition to process oriented services)	Build a direct contact with end-user firms; create new (niche) markets and revenue streams	Channels resistance, investments
14	IOT, Cloud	*Remote condition monitoring, updating and parametrizing*	Connectability helps pre-sales activities	Sustain product-orientation	Cultural transformation of the channel, starting from the most receptive partners.	Channels readiness; aggressive platform innovations from big tech
15	IOT, Cloud	*Remote condition monitoring, updating and parametrizing*	Connectability helps pre-sales activities	Sustain product-orientation	Adding new segments or value spaces in the current value chain.	Complex channels with integrators and system vendors.
16	IOT, DA	Remote condition monitoring, updating and parametrizing, data analysis	Remote condition monitoring and operativity of the machines used by larger customers	Sustain product-orientation (initial transition to process oriented services)	Adding new service streams, lock the customer in with more services	Services sale capabilities, integration with value system partners
17	IOT, DA	Remote condition monitoring, updating and parametrizing, data analysis and BI	Asset Efficiency Services for main customers	Extend the BM with process-oriented services (initial transition to outcome-oriented services)	Approach performance-based contracting with selected key customers	BD and ML for cost-intensive activities automation
18	IOT, Cloud, DA	Remote condition monitoring, updating and parametrizing, data analysis and BI	Remote condition monitoring and operativity of the machines used by larger customers	Sustain product-orientation (initial transition to process oriented services)	Add new process-oriented services through scalable solutions	Channels readiness; investments
19	IOT, Cloud	*Remote condition monitoring, updating and parametrizing*	Connectability helps pre-sales activities	Sustain product-orientation (initial transition to process oriented services)	Sustain brand value and sales; create new market opportunities bypassing OEMs and distributors	Extant channels' actors retaliation; uncertain vision of the future
20	IOT, Cloud		Connectability helps pre-sales activities	Sustain product-orientation		Channels' readiness

(*continued on next page*)

Table 2 (*continued*)

Company	Technologies adopted	Functionalities (*potential*)	Actual use and utility	Current impact on BM	Envisioned opportunities	Challenges/obstacles
		Remote condition monitoring, updating and parametrizing			Cultural transformation of the channel, starting from the most receptive partners	
21	IOT, Cloud, DA	Remote condition monitoring, updating and parametrizing, data analysis and BI	Asset Efficiency Services for main customers	Extend the BM with process-oriented services (initial transition to outcome-oriented services)	Approach performance-based contracting with selected key customers	Services sale capabilities; risk assessment capabilities; BD and ML for cost-intensive activities automation
22	IOT, Cloud	*Remote condition monitoring, updating and parametrizing*	Connectability helps pre-sales activities	Sustain product-orientation (initial transition to process oriented services)	Sustain brand value and sales; create new market opportunities bypassing OEMs and distributors	Extant channels' actors retaliation; uncertainty of the future role played
23	IOT	*Remote condition monitoring, updating and parametrizing*	Connectability helps pre-sales activities	Sustain product-orientation	Specialize in information integration and sell the firm's organizational experience.	Customers' readiness
24	IOT, Cloud	*Remote condition monitoring, updating and parametrizing*	Connectability helps pre-sales activities	Sustain product-orientation	Cultural transformation of the channel, starting from the most receptive partners.	Channels readiness; aggressive platform innovations from big tech
25	IOT, Cloud, BD	Remote condition monitoring, updating and parametrizing, data analysis and BI	Updating and parameterization is used by larger customers	Sustain product-orientation	Streamline post-sales and field services; protect current revenue sources of the business.	Organizational complexity and investments

products smart and connected, and has a clear idea of what could be the impact of IoT technologies on basic and traditional services that are usually offered by BtoB manufacturers (such as spare parts and traditional MRO). On the other hand, major experimentations on advanced end-user's process-oriented services are less frequent.

Table 2 represents the different situations registered in the sample as regards the use of IoT technologies (digital servitization), and its effects on business models.

3.2.1. *Digital servitization and business model innovation*

Overall, we register that 6 firms (cases 8, 13, 16, 18, 21, 23) are currently using IoT technologies in order to transition from product-oriented to end-user's process-oriented services. In 2 cases, both belonging to the packaging industry, firms are currently involved in sophisticated digital servitization strategies that encompass performance-based contracting with key-clients with remote equipment management, able to grant remarkable productivity gains.

In the case of company 21, the management has been involved in studying possible applications of IoT technologies for servitization for some time. Then, a specific request coming by a key customer triggered the digital servitization project in the firm. Here a complete IoT infrastructure is at the base of advanced services, in which specific efficiency levels are guaranteed by complex service contracts. Company 21's aim is to consider this specific solution as the "beta version" of a new business model that could be extended also to other customers and has worked in order to increase the solution's scalability, stability and generalizability. A similar perspective can be detected in company 8. Here the technological solution and the innovative business model have been designed from scratch in a proactive way by the company's Service Manager: in the last years she and her team have been working on various technical and functional aspects of the solution in order to be able to offer it at first to key customers, and then to the customer base at large.

In other cases, firms leverage on IoT technologies in less sophisticated ways, trying to help customers to gain productivity increases. For instance, company 16, that has been exploring IoT technologies since 2012, has recently designed a solution for one of its four product lines to remotely control process operations with web- and smartphone-based applications. It also offers retrofitting for older machines and envisions a first form of predictive maintenance. But "*for the moment connected IB and running applications are few and we cannot leverage big data yet*" says the company's CTO.

A group of 9 other firms (cases 2, 5, 6, 7, 9, 12, 17, 19, 22) has been investing in IoT technologies, and is planning to use them in order to transition from product-oriented to end-user's process-oriented services in the near future. In particular, 2 firms with prior experience in using remote connection technology with key customers are planning to leverage IoT technologies in order to deliver end-user's process-oriented services to the same customers.

Company 6, has a multi-year experience in telemonitoring key customers' installed base and processes, using dedicated control rooms and advanced technological solutions: some of these customers have expressed their interest for more comprehensive value propositions and more advanced contracts with a full-service approach and efficiency levels guarantees. The new business model is currently at study in the company, that is carefully evaluating risks and opportunities, in order to present it to the market. A similar technological and knowledge patrimony can be detected in company 17, that however has a more proactive approach in the management of technological opportunities. Specific external partnerships have been initiated in order to develop an outcome-oriented subscription-based multi-level service package. A particular attention has been devoted to the completeness, robustness and scalability of the solution, with the aim of using up-to-date machine learning technologies to automate different cost-intensive maintenance activities, to be integrated in an overall building automation approach.

In other cases, leveraging on IoT to deliver advanced services is hindered by a number of structural, organizational or environmental factors, such as: Customers are not prepared for digital servitization and offer resistance to the new technologies (i.e. they don't connect the machines); channels are not prepared and/or interested in digital servitization and are too complex and/or powerful to be bypassed; firms' sales force is not culturally prepared to sell advanced services and digital solutions. For instance, company 2, while having approached IoT technologies many years ago, is struggling to effectively exploit the end-user's process-oriented services envisioned (among which a retrofitting kit), because of both the firm resistance of the customers to use the new technologies and some complications arising in process services when machines from other suppliers are involved. For company 7 end-user's process-oriented services are prevented by the low average rate of utilization of the products by the end users: "*analyzing the data, we have discovered that owner-operated businesses have such a low rate of utilization of our products that discourages us to invest in any solution aimed at supporting their processes or introducing use-based contracting*" says the CEO.

Looking at Table 2, we realize that in 9 cases no significant attempt at changing the current strategic approach is ongoing, since the firms are using IoT technologies in order to sustain and enhance the BM. It is not correct to say that all of them are not leveraging on technology at all, since there are basic ways to use IoT technologies (like initiating maintenance ticketing and warranty management support) that are comfortably rooted in the current product orientation of manufacturing firms and are quite easy to implement since they call for little changes in the extant business models. For some companies, in fact, not trespassing product-oriented service levels is the result of a strategic decision, aimed mainly at using digital technologies for protecting the current business model and its fundamental mechanisms.

Company 25, for example, has a long history in connecting its professional machines. It decided to invest in IoT technologies in 2012, in order to renovate the previous infrastructure, with the creation of a complex database hosted in a cloud architecture. The solution allows the firm, the dealers and the distributors to constantly control the real usage of the (thousands of) machines, promptly detecting incorrect or illegal use of the products. This comes with evident advantages for the post-sale service division, in terms of control of costs in the warranty period, and protection against free riding behavior regarding the use of consumables. "*A post-sales service that knows in real time what's going wrong with the machine is a powerful tool to sustain the business and strengthen the relation with the customer, who knows that we can intervene rapidly and reduce his money loss*" says the CTO.

However, as we mentioned, there are cases in which firms are struggling to embrace advanced forms of digital servitization due to obstacles related to the distribution channels. Given the particular importance of these situations, we'll describe them in more detail in the next section.

3.2.2. Moves toward the end-user firm

Table 1 shows us that more than half of the firms of our sample (16) have an indirect sales model, meaning that they cannot boast a direct relation with their end-user firms (hybrid forms are traced back to the prevalent): all OESs (6) are in this group, with the addition of 10 (out of 19) OEMs. We focus on these firms in Table 3 in order to make some further observations. Only 2 of the firms listed in Table 3 (cases 13 and 18, 1 OEM and 1 OES) are currently involved in digital servitization strategies that regard end-user's process-oriented services (as described in the preceding paragraph). However, we have to observe that 5 more firms within this group (cases 7, 9, 12, 19, 22) are trying to implement some initial form of such a transition. A closer look to Table 3 allows us to observe that overall we are dealing with 7 firms (4 OEMs and 3 OESs) that are taking or planning to take steps to have a direct contact with the end-user firm of their product. These moves have a crucial role in the digital servitization of manufacturing firms with an indirect sales model, and have to be analyzed in depth.

Successful attempts at bypassing the downstream channels can in some cases be related to an extension of the product – service line: in this case firms turn to horizontally-correlated businesses for building a direct relation (via technology) with the end-user firms and leverage on the installed base without conflicting with the current distribution channels.

Company 13 has for instance succeeded in using IoT technologies to overcome the power of large international independent distributors. These distributors have huge portfolios and cannot focus on single opportunities related to a specific business. Thanks to IoT technologies, company 13 directly interacts with its end-user firms, proposing them brand-new services aimed at supporting and solving different process activities (like automated malfunction detection and resolution). It also applies a business model that is based on a subscription solution with two technical levels (base and advanced) in relation to the needs of the user. "*We aim at being a sort of 'Apple Store' for our final customers: in our platform they can find every up-to-date information and problem solution they may need*" says the Sales Manager.

Something similar has been accomplished by company 18: leveraging on specific requests coming from new niche segments (not previously served) – activated by a specifically appointed business developer – it has designed a platform of digitally-based solutions flexible enough to be potentially suitable also to other customers. Experimentations outside the mainstream markets gives the company the freedom to test innovative technological solutions oriented at end-users' processes and adopt new revenue models that could be easily transferred to the main markets in the near future.

Whenever these types of options are not viable or irrelevant, and the role of downstream activities is critical for future's development strategies, firms may decide to make a mere vertical integration move. In one of our cases (company 7), building a direct distribution structure, also in view of the international markets expansion, has been identified as "*the only viable remedy to our supply chain poor positioning, and valuable enough to make us face the financial effort and the potential retaliation of previous partners*" says the CEO. In company 9, we have a similar strategy, in which the direct investment in the distribution channel has involved in the first place less risky situations: replacing small dealers, preferably without a post-sale service structure, in secondary markets, has been the first move.

Similar tentative efforts in the same direction are being played by other firms that, however, are comparatively more troublesome. Company 19 and Company 22 well represent the impasse that even medium- to large-sized manufacturing OESs are experiencing when trying to find a way of exploiting IoT technologies in order to change their strategy and improve their business models. Even if they are solid and wealthy at the moment, they perceive the technological evolution as potentially risky, and have invested in IoT technologies in order to "be ready" for the future change, both in relation with OEMs and the rest of the articulated distribution channels (made of direct branches, small dealers, big distributors, installers, post-sale service organizations, system integrators). Nonetheless, the change is anything but clear at the moment: "*our strategic vision is partial, we do not have a clear idea of the role we could play in the future in the value system yet*", says company 22's CEO.

Turning our attention to Table 3 again, we see that the 9 firms that are not exploring user-oriented process services all belong to this group of firms having an indirect sales model (see companies 1, 3, 4, 10, 11, 14, 15, 20, 24). They all are firms that supply prevalently standard products and components, 3 of which are small- to medium-sized enterprises that have positioned in very articulated BtoB value systems, where various and multiple intermediate subjects take charge of different critical downstream tasks (such as handling, distribution, installation, maintenance and technological integration).

Some companies lament they are too small to be visible within the supply chain. Small-sized firms like company 1, 3 and 4 are using digital servitization capabilities basically in order to sustain pre-sales

Table 3
Digital servitization and moves toward end-user firms.

Company	Value system	Sales model	Sales model shift	BM service orientation shift	Moves toward end-user firms *(obstacles)*
1	OEM	Indirect	=	=	*(Channels too large to bypass or to buy)*
3	OEM	Indirect	=	=	*(Channels too large to bypass or to buy)*
4	OES	Indirect	=	=	*(Channels too large to bypass or to buy)*
7	OEM	Indirect	To direct	To process (planned)	Direct investment in distribution network (international expansion)
9	OEM	Indirect	To direct	To process (planned)	Direct investment in the distribution network, involving less risky situations.
10	OES	Indirect	=	=	(Channels too articulated and powerful to get some visibility or bypass)
11	OEM	Indirect	=	=	(Not planned at the moment)
12	OEM	Indirect	To direct	To process (planned)	Use of IOT technologies to interact directly with customers and vehiculate new value propositions in correlated businesses
13	OEM	Indirect	To direct	To process	Use of IOT technologies to bypass obstructive distribution channels and propose new services
14	OEM	Indirect	=	=	*(Channels too fragmented and product ranges too large to move downstream)*
15	OES	Indirect	=	=	*(Channels too articulated and powerful to get some visibility or bypass)*
18	OES	Indirect	To direct	To process	Use IOT technologies to leverage on specific requests coming from new niche segments
19	OES	Indirect	To direct (planned)	To process (planned)	Investments in IOT technologies in order to "be ready" to leverage on specific requests coming from new segments
20	OEM	Indirect	=	=	*(Channels too powerful and doing costly services, unconvenient to move downstream)*
22	OES	Indirect	To direct (planned)	To process (planned)	Investments in IOT technologies in order to "be ready" to leverage on specific requests coming from new segments
24	OEM	Indirect	=	=	*(Channels too fragmented and product ranges too large to move downstream)*

activities. They have IoT devices and Cloud applications that could supply efficient product-oriented services, but advanced solutions that may interest large end-user firms are out of reach for them. As company 3 CTO says: "*our visibility on the final customer is very small, they are huge firms and our machine is just a small part of the overall purchase they do*". "*We sell our products to organizations that are capable of doing the installation and post-sale assistance, we simply cannot afford to manage sales and services directly, especially in foreign markets*" says company 1 CEO.

Elsewhere, the problem is the critical role played by downstream channels (in terms of adding services and composing a complex offer for the end-user firm) and their unpreparedness for IoT technologies. Company 14, 20 and 24, whose product line covers different markets and segments, all have extremely variegated and complex distribution channels, and all suffer from extremely aggressive platform innovations coming from big tech global leaders that have also innovated the sales process with the e-commerce. Their product is traditionally complex and needs professional installers and careful maintenance with post-sales services that can hardly be provided without the collaboration of the current supply chain. "*Due to value chain structure and costs levels, our direct customers have little interest in advanced service extensions*" says company 24 Marketing officer. Therefore, those companies are involved in a project of cultural transformation of the channel, starting from the most receptive partners, but that will take some time to complete.

Finally, we register that these obstacles are particularly evident in case of OESs, like company 10 and company 15. Here international supply chains with specific actors that act as integrators or system vendors are particularly high obstacles to overcome, and firms struggle to find spaces of digital servitization both in the current value chain and in new markets and segments.

4. Discussion of the research's findings and outcomes

The analysis of digital servitization strategies of the firms in our sample allows us in the first place to underline the importance of a resource that previous studies considered central in servitization, namely the installed base (Storbacka et al., 2013).

In particular, the firms in the sample recognize the crucial role of the installed base in the rush to harvest big data as soon as possible: not by chance 9 companies – when technologically and economically feasible – offer their customers a "retrofitting kit" that enables the connection of traditional products previously sold. Indeed, leveraging on the "conventional" installed base to gather data regarding customers can be critical for digital servitization. A minority of firms has actually begun to gather and analyze data, but only 4 of them can leverage on big data.

As we have seen, manufacturing firms with direct contact with end customers (all OEMs), are in a privileged position for using their Installed Base to unleash the potential of digital servitization: having a direct relationship with their customers, they don't need to worry about conflicts with distribution channels and neither to strive to improve their positioning strategy within the value system. Moreover, they have a clear opportunity to implement complex service-based business model innovations that introduce advanced services directly related to the customers' needs instead of the mere product-based ones.

With regards to the transition toward advanced service-oriented business models, we can now enhance the analysis of the research findings described in the previous section. Building on the research on Product-Service System (Adrodegari et al., 2015; Coreynen et al., 2017; Tukker, 2004), Hybrid offerings (Ulaga & Reinartz, 2011), service transitioning (Oliva & Kallenberg, 2003), and service complexity levels (Baines, Lightfoot, Peppard, et al., 2009), we identify three different areas of impact of IoT technologies in our sampled firms' Business Models. They represent different orientations in digital servitization strategies and correspond to three different types of service-based business models in manufacturing firms: we name them product-, process- and outcome-oriented digital servitization. Table 4 shows the main features of product, process- and outcome-oriented service business models as regards the type of services, the service orientation and the technological infrastructures. As far as the strategic role of technology is concerned, our cases testify how it varies depending on the complexity of the services: for basic product-oriented services, IoT technologies act as streamlining and enhancing tools, while they are game changers for intermediate and advanced services (Baines, Lightfoot, Peppard, et al., 2009), where they act as strategic enablers of process- and outcome-oriented digital servitization business models.

Product-oriented digital servitization involves the use of IoT technologies for services oriented to the supplier's products, or what the literature refers to as Product Life-Cycle Services (PLS) (Oliva & Kallenberg, 2003; Ulaga & Reinartz, 2011). PLS are services designed for ensuring the proper functioning of products during all stages of their life cycle, like: delivery, documentation, installation, setting, calibration, basic maintenance repairing and overhaul (MRO), warranty, spare parts, refurbishing and modifications.

Table 4
Main features of the different Business Model service orientation.

	Product	Process	Outcome
Services type	PLS	AES PSS	PDS
Examples	Maintenance ticketing Warranty management Spare parts management	Spare parts optimization Process/line optimization Preventive maintenance	Line's performances guaranteed (like uptime, OEE) with bonus/malus logic
Service orientation toward	The firm's product	The customer's process (products in the line)	The customer's business
Technology	IoT	IoT Cloud (DA)	IoT Cloud BD DA

The next level, process-oriented digital servitization, regards the use of IoT for delivering services oriented to increase the efficiency of customers' products and processes, assisting, auditing and consulting them in order to improve their own business processes. Here we can refer to Asset Efficiency Services (AES) and Process Support Services (PSS) as services aimed at helping customers in achieving productivity gains from their assets (Ulaga & Reinartz, 2011), like: process-oriented training and consulting, process-oriented engineering (R&D, tests, optimization, simulation), remote condition monitoring and preventative maintenance. In these services, the transactional approach is replaced by a more relationship-based attitude where the end-user's services are process-oriented (Oliva & Kallenberg, 2003).

In outcome-oriented digital servitization, the supplier's value proposition is centered on using IoT technologies to reach a given business outcome that is relevant to the customer (e.g. a certain operation's Overall Equipment Efficiency) and to provide resources and capabilities in order to reach that result. Agreements are usually based on complex contracts with bonus/malus mechanisms. We can find examples of outcome services within Process Delegation Services (PDS), where the supplier takes charge of performing processes on behalf of the customer on the base of performance-based contracts, like in the management of packaging operations, maintenance function, spare parts management, fleet management, or plant procurement activities.

For firms that are far away from the end-user firms, the scenario may be very different: their options of leveraging IoT technologies to access advanced digital servitization strategies are fewer. Ultimately, all the digital servitization strategies enacted by the firms in our sample have a common requirement: to get access to end-user firms' data. In digital servitization, the companies that succeed in obtaining comprehensive information on their customers' needs will (sooner or later) be able to use IoT technologies in order to reshape their strategy expanding their service offer.

That explains the reason why, although all the firms of our sample are conscious of the importance of leveraging on their installed base data in order to digitally servitize their offer, experimentation deployed by OEMs and OESs with no or episodic contact with end-user firms entails minor business model changes (enhancements), unless they embark in downstream vertical moves to get access to end-user firms.

Table 4 presents the overall situation of the sample in view of the preceding considerations. Digital servitization and business model innovations in manufacturing firms are strictly related to the sales model adopted and to the moves that firms make in order to get access to end-user firms' data. Thus Table 5 shows strategies related both to the sales model and the business model service orientation. It also gives a preliminary grade of the BM innovation magnitude, that will be detailed below.

4.1. A map of digital servitization strategies

Building on Table 4, if we were to represent the digital servitization strategies implemented by the firms in our sample in a map, two main aspects would have to be taken into consideration: on the one side, the direct or indirect nature of the sales model (the access to end-user firms data); on the other, the different level of service orientation of the business model. These two variables have been used to build the map of digital servitization shown in Fig. 2 (digits are related to the number of companies that are making or planning each specific transition).

Overall, vertical and horizontal moves in the map offer different opportunities (related to new sales/higher market shares, more profits/higher efficiency, or future strategic options), and pose specific challenges (in terms of risk levels, amount and type of resources and capabilities requested, technological and organizational complexity). Each of these moves impacts differently on firms' BMs.

4.2. Vertical moves: disintermediate or buy the distribution

The strategic decisions underlined by the vertical axis of our map have had an important role in servitization ever since, and they are referred to by the literature as "downstream moves" (Wise & Baumgartner, 1999). Altogether, only a few selected manufacturers have successfully made downstream moves and thus transitioned to services (Auramo & Ala-risku, 2005; Gebauer, Fleisch, & Friedli, 2005): these strategic moves have proved to be complex and risky, and their persistent shortcomings have seriously limited their diffusion. This is connected to the circumstance – recurrent also in our cases – that supply chains may be very complex and populated by powerful actors, thus making vertical moves very demanding. As other scholars have underlined (Gebauer et al., 2010), especially in international markets firms may have to confront with long distribution channels with different intermediate actors (like distributors, system integrators, contractors and sellers) that might not be inclined to change their business behavior in order to welcome service extensions delivered by any single manufacturers.

In this situation, accessing end-user firms' data can be troublesome. Companies that sell exclusively through a captive set of distributors will likely face conflicts and retaliation if they try to reach the end-user firms directly, and this may be a huge hurdle for their digital servitization strategies.

It comes as no surprise that in our sample moves aimed at trying to get in contact with the end-user firms are scant. Such vertical moves can be of two basic types: the disintermediation of the downstream channels via IoT technologies; the control of the distributor. In 7 of our cases (companies 7, 9, 12, 13, 18, 19, 22), those moves are the starting point of a subsequent step toward advanced forms of Digital Servitization, in the form of process-oriented services.

4.2.1. Digital disintermediation

For many firms in our sample "going downstream" is hardly an option. Nonetheless, several companies are trying to find a way to use digital technologies to disintermediate their distribution channels (at least as regards information and service flows). Digital disintermediation is based on the electronic deliverability and customizability of services (Andal-Ancion, Cartwright, & Yip, 2003): the internet enables firms to mitigate buyers' bargaining power or disintermediate distribution and service partners (Porter & Heppelmann, 2014), impacting directly and significantly on digital servitization strategies (Vendrell-Herrero et al., 2017).

In our sample, this move is being taken under consideration in

Table 5
Business Model Innovations in the selected cases.

Company	Digital technologies	Retrofit	Value system	Sales model	Sales model shift	BM service orientation shift	BM modification scope
1	IOT, Cloud	No	OEM	Indirect	=	=	Enhancement
2	IOT	Yes	OEM	Direct	=	To process (planned)	Enhancement
3	IOT, Cloud, DA	No	OEM	Indirect	=	=	Enhancement
4	IOT, Cloud	No	OES	Indirect	=	=	Enhancement
5	IOT	No	OEM	Direct	=	To process (planned)	Enhancement
6	IOT, Cloud, BD, DA	Yes	OEM	Direct	=	To outcome (planned)	Extension/Redefinition
7	IOT, Cloud	No	OEM	Indirect	To direct	To process (planned)	Redefinition
8	IOT, Cloud, DA	Yes	OEM	Direct	=	To outcome	Redefinition
9	IOT	No	OEM	Indirect	To direct	To process (planned)	Redefinition
10	IOT, Cloud	N.A.	OES	Indirect	=	=	Enhancement
11	IOT, Cloud, BD, DA	No	OEM	Indirect	=	=	Enhancement
12	IOT, Cloud, DA	Yes	OEM	Indirect	To direct	To process (planned)	Redefinition
13	IOT, Cloud, BD, DA	N.A.	OEM	Indirect	To direct	To process	Redefinition
14	IOT, Cloud	No	OEM	Indirect	=	=	Enhancement
15	IOT, Cloud	N.A.	OES	Indirect	=	=	Enhancement
16	IOT, DA	No	OEM	Direct	=	To process	Extension
17	IOT, DA	Yes	OEM	Direct	=	To outcome (planned)	Extension/Redefinition
18	IOT, Cloud, DA	Yes	OES	Indirect	To direct	To process	Redefinition
19	IOT, Cloud	Yes	OES	Indirect	To direct (planned)	To process (planned)	Enhancement/Extension
20	IOT, Cloud	Yes	OEM	Indirect	=	=	Enhancement
21	IOT, Cloud, DA	No	OEM	Direct	=	To outcome	Redefinition
22	IOT, Cloud	Yes	OES	Indirect	To direct (planned)	To process (planned)	Enhancement/Extension
23	IOT	No	OEM	Direct	=	To process	Extension
24	IOT, Cloud	No	OEM	Indirect	=	=	Enhancement
25	IOT, Cloud, BD	No	OEM	Direct	=	=	Enhancement

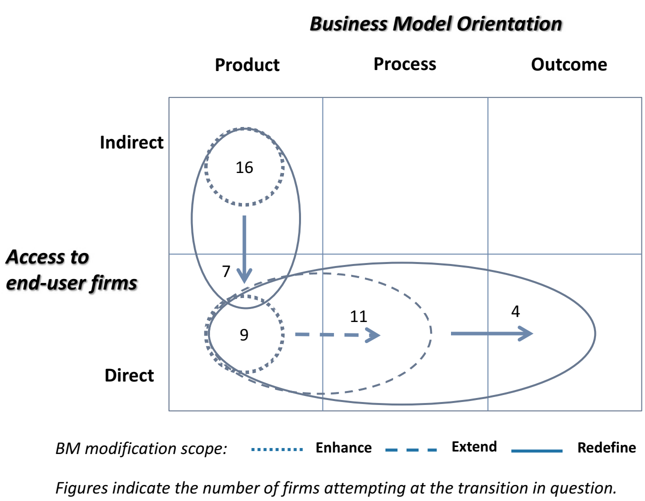

Fig. 2. The map of digital servitization strategies in the selected cases.

particular by medium- to large-sized OEMs (and large OESs) with indirect sale models, that are conscious of their uncomfortable position in the digital servitization scenario. They aim at seizing the opportunity to open new businesses, and begin to learn how to interact with the final customers, accumulating an experience that may be valuable for the future. For these firms, the move may succeed only under specific conditions, connected to the structure of downstream channels. For instance, downstream actors might lack the competences to sense the changes in the environment as well as the resources to seize and exploit them, or yet they might be too small to react. In other cases, they might not even feel endangered by the move, since the disintermediation strategy performed by the upstream firm could be related to a less relevant part of their offer, or to a new value proposition that regards a niche market.

One successful strategy adopted by our firms is linking vertical moves to the introduction of new components into the Product-Services System: focusing the vertical move to new offerings may limit the cannibalization with the extant value proposition, therefore reducing the menace of retaliation by the distribution system. This is the case of non-core complementary products (like accessories, consumables, etc.) that don't conflict with distributors' offerings (companies 12, 13, and 18 show a similar strategy).

However, such opportunities are counterbalanced by a series of strategic challenges, that regard firstly the plausible retaliation of the current distributors or sales network; in addition, gaining a direct relationship with customers may be a tough organizational and cultural challenge for those manufacturers whose marketing resources and capabilities may not be prepared to extend their activities beyond the classical intermediate supply chain relationships (Coreynen et al., 2017), and have little faith in complementary service-based business compared to traditional goods-based ones (Gebauer et al., 2005). Challenges are also linked to the range of capabilities required by digital disintermediation: the exploitation of direct access to end-user customers requires good service deployment capabilities as well as sales and marketing capabilities (Alghisi & Saccani, 2015), that may be well sustained by manufacturing development resources and the availability of IB usage data.

Overall, as far as Business Model innovation is concerned, digital disintermediation impacts on:

Value Distribution elements, since customer segments, customer relations and channels are directly involved; in turn, the new market segments ask for new Value Propositions that leverage on IoT technologies and may involve incremental activities and resources (Value Creation). Its strategic impact could be classified as an extension: through the use of digitally delivered services, content or information, the firm extends traditional products and services adding new revenue streams.

4.2.2. *Distribution control*

In order to gain control over activities that have become strategic, some firms may decide to take control of the distributor moving downward in the value chain (Wise & Baumgartner, 1999).

Obviously this move may not be within the reach of every firm, since it brings a whole new set of challenges: 'If the manufacturers attempt to bypass channels' actors and sell directly to consumers, the resellers can respond by cutting off the manufacturers' access to a large portion of buyers…' (Wise & Baumgartner, 1999, p. 137). In fact, only 2

Table 6
Reaching the end-user firm: opportunities and challenges.

	Digital Disintermediation	Distribution control
Opportunities	By-pass obstructive distributors Open new niche markets Build a direct relationship with the end-user firms Progressively reach the Installed Base	Take control of the sales and its profit contribution Directly manage and control the installed base Potential full access to data
Challenges	Reaction of the current distributors (retaliation) Direct relationship with customers as a cultural and organizational challenge Business growth may be slow	Reaction of the current distributors (retaliation) Development of value distribution resources and capabilities Rapidity depends on financial resources
IoT technologies	IoT, Cloud	?
BMI (elements, magnitude)	Value Distribution, Value Creation, Costs?, Revenues? Extension	Value Distribution, Value Creation, Costs +, Revenues Redefinition
Conflicts	?	High
Case #	12, 13, 18	7, 9

firms in our sample are actually involved – with different intensities – in such a move (company 7 and 9).

The main challenges underlying this strategic move are of financial and organizational nature. They relate to the substantial investment necessary for: building the new sales and distribution force, acquiring the knowledge and expertise necessary to manage the downstream activities and attracting the human resources essential to success. Moreover, as other researchers have pinpointed, this transition may also encounter significant internal organizational resistance to extend activities beyond the current point-of-sale (Mont, 2002).

As far as Business Model innovation is regarded, this move has a main impact on costs and revenues, together with Value Creation (new activities and resources) and Value Distribution (channels and customer relations): the latter two elements of the BM change significantly, adding a series of operations that were beforehand outsourced. The change may be very challenging and may lead to a profound reshaping of both value proposition and value-delivering operations. The change can be classified as a BM redefinition, especially in case the firm implements new advanced services. Table 6 summarizes the main strategic aspects of vertical moves emerging from our sample.

4.3. Horizontal moves toward process- and outcome-oriented BM

Horizontal moves (acted or planned) count for the main part of the business model innovations in our sample (15 out of 22 strategic moves regard the service orientation of the BM). These digital servitization strategies require using IoT technologies in order to supply services oriented to the customer' processes and outcomes. These strategies are a prerogative of firms with a direct access to the end-user firms of their products.

Before dealing with opportunities and challenges of the transition toward advanced forms of digital servitization, some aspects of Product orientation have to be clarified. In this case, IoT technologies are at the base of a service growth that entails comparatively few changes in the extant business model. This circumstance is not necessarily negative, and it may also prove to be a correct deliberate strategy when market opportunities and competitive pressures don't encourage firms to explore more advanced solutions. In fact, product-oriented digital servitization allows manufacturing firms to significantly increase the efficiency of traditional post-sales services: as we have seen (companies 11 and 25), in some cases that result is well worth the investment in technology.

Otherwise, advanced forms of digital servitization in our sample present specific challenges (along with opportunities) for manufacturing firms. It is worth underlining that service growth poses cultural and corporate challenges (Alghisi & Saccani, 2015; Brax, 2005) due to the fact that it implies a shift from a transaction-based to a relationship-based approach to customers (Gaiardelli, Resta, Martinez, Pinto, & Albores, 2014): along with technical and operational needs, relationship-based services require a customer-based perspective and an increasing integration of supplier-customer value chains with process- and outcome services (Coreynen et al., 2017). Moreover, firms have to be able to use IoT technologies and ICT in order to successfully develop and deliver service offerings (digitalization capabilities) (Kohtamäki et al., 2019; Rönnberg Sjödin, Parida, & Kohtamäki, 2016). Therefore, as underlined also elsewhere (Kindström, 2010), a shift toward advanced service-based business models potentially implies changes in all areas of the business model.

4.3.1. Moving toward process-oriented services

Most of the moves beyond product services in our sample are extensions of the firms' business models toward process-oriented services (11 firms). Moving from basic product-oriented services to this intermediate level presents peculiar opportunities and challenges, for firms' BMs undergo significant modifications.

As regards challenges, in process orientation firms have to build competences in order to service also competitors' products, a phenomenon named “Horizontalisation” (Bundschuh & Dezvane, 2003). In particular, capabilities related to data processing and interpretation have to be extended to all the machines and the equipment that are in the same production line (see for example companies 2, 9, 16, 21, 23). In addition, in order to be effective, process services may involve the control of services provided by other parties, that may impact directly on the machine and the line's productivity (see in part. Company 16, 21).

As highlighted elsewhere (Kohtamäki et al., 2019), the extension of the monitoring and control activities horizontally requires an active technological integration across different ICT platforms and solutions. This is therefore the context in which digitalization capabilities, or the ability of using digital technologies to sustain the development and delivering of customer-oriented service offerings, begins to assume a critical role for the success of digital servitization (Rönnberg Sjödin et al., 2016). In order to be successful, firms need to integrate the knowledge regarding specific customers' needs in order to target a large variety of customers (Matthyssens & Vandenbempt, 2010): in digital servitization, this means to be able to efficiently deploy and sell scalable product-services solutions for global markets via standardization and modularization (Burton, Story, Raddats, & Zolkiewski, 2017), a capability that has been referred to as mass service customization capability (Zhang, Zhao, Lyles, & Guo, 2015).

As far as the technological outfit is concerned, in process-oriented digital servitization, Data Analysis technologies are essential in order to gain access to valuable installed base product usage and process data and be able to deliver effective services oriented to the customer's process (such as remote monitoring and optimization of production lines, logistical optimization audits, and preventive maintenance solutions).

In relation to the deployment and sales capabilities related to advanced services, our cases (companies 2, 3, 7, 16, 20, 25) underline the misalignment of the sales force, whose traditional focus on goods is inadequate to sell advanced digitally-based services. This problem is even more critical in view of the fact that digital servitization value propositions can be complex and may not be fully understood by customers, who might not perceive their real usefulness and ultimately neglect them.

Overall, new knowledge is deemed crucial in order to succeed in process-oriented digital servitization: networking with external partners (among which Universities and Knowledge Intensive Business Services) is fundamental, especially in the first phases of the business model innovation. Finally, attracting the right human resources that are able to imagine and design tomorrow's services is critical: the final aim is to become autonomous on that respect on the long run.

As regards the BM, the main elements involved in the change are: Value Distribution, since the deeper interaction with the customers changes the relations; Value Creation, since new Activities have to be added to the firm's operations, and Revenues, since those new activities generate new income streams. Connected to the abovementioned, there is the choice of the revenue model to be proposed to customers' for accessing the digital service: up-front, annual fee and for-free (temporary) access are alternatives to be considered in the overall data accumulation strategy (also in combination with retrofitting capabilities).

Process-oriented service capabilities also present opportunities for firms to: support product sales, especially in international markets; ease customers' purchase decisions; create additional revenue streams based on services related to the installed base; exploit and leverage the firm's knowledge regarding product and manufacturing development.

4.3.2. Moving toward outcome-oriented services

In outcome-oriented digital servitization, firms have the opportunity to create new revenue streams selling advanced services whose value is parametrized on the performances they are able to guarantee to customers.

As we have seen, only 4 firms are exploring the right side of the map: 2 firms (company 8 and 21) are currently involved in offering advanced outcome services and contracts based on performances, while 2 other firms (companies 6 and 17) are planning to do it in the next future. Quantitatively and qualitatively these results are in line with those reported in other investigations: in Müller et al. (2018) only few “prepared” companies are at the moment able to face the level of complexity implied by advanced uses of IoT technologies; furthermore, in Laudien and Daxböck (2016) “full IIoT” business models are rare (2 case firms). Literature considers outcome-based business models the most advanced form of servitization (Hypko, Tilebein, & Gleich, 2010; Visnjic, Jovanovic, Neely, & Engwall, 2017), but the very high-capability requirements they set may explain why their diffusion – at least in capital equipment manufacturers – is still limited (Grubic & Jennions, 2018).

The move to outcome services presents specific challenges for firms. The technological outfit is similar to the one displaced in process-oriented business models, with one important difference: the key role of gathering and analysis of data, especially in continuous forms and in large quantities (Big Data). In line with previous research (Laudien & Daxböck, 2016), our results show that Data Analysis (DA) is in fact critical in allowing firms to access the full potential of installed base product usage and process data, which is the crucial element for enabling outcome-oriented BM. In addition, using Cloud computing platforms is also a must-have feature.

In line with other studies (Coreynen et al., 2017) our cases show that outcome-oriented business models ask firms to meet the same requirements as process-oriented BM. Consistently, companies now targeting outcome services may have been previously involved in process services (like companies 6 and 17) and, as a result, they have to be able to effectively master horizontalization (products and services provided by other parties). Moreover, outcome-oriented services add further complexity, since relating revenues to customers' performances not only requires data processing and interpretation capabilities, but also asks for strong risk assessment and mitigation capabilities.

A previously underlined misalignment plays a major role also in this context: companies 8 and 21 testify how the traditional goods-oriented culture of the sales force may be inappropriate for effectively infuse the customer with the value proposition, and to overcome the resistance in sharing valuable information outside the firm (Matthyssens & Vandenbempt, 2010): sales force transformation is at the moment one of the top priority strategic changes.

As far as Business Model innovation is regarded, embracing an outcome-orientation can be considered a Business Model redefinition. Consistently with previous research (Storbacka, 2011), our cases show that outcome-oriented digital servitization induce a completely new relation with key clients. Here the product is a means to supply a service (the benefit for the customer) and technology is the means to gather and analyze customers' behavior data in order to be able to reach the contractually guaranteed service level agreements. Value Distribution elements are therefore significantly affected.

In particular, our most advanced cases (company 8 and 21) stress the importance of some under investigated topics such as the role of building learning relationships with key customers (Neu & Brown, 2005), as well as the role of key-account managers (Gebauer, Paiola, & Edvardsson, 2012). In fact, these companies perform a value research on lead customers, regularly interacting in a cross-functional way in order to assess needs, actively searching for what is valuable. They willingly involve lead customers in innovation projects and craft specific contract models in order to smoothly manage those relations and codify the experience.

Value Creation elements are also profoundly involved, since Activities, Resources, and Partners may change. In fact, a firm is rarely in the position to exploit IoT technologies on its own, thus requiring an ecosystem of suppliers, complementors, and stakeholders that calls for additional new competences for successfully managing networks (Dahlström, Desmet, & Singer, 2017). The critical importance of both human resources and new knowledge is confirmed also in outcome-orientation, where firms need to network with external partners in order to gather the appropriate knowledge for future developments, with the aim of becoming autonomous on that respect in the long run (all the firms involved in this type of BMI assert this). For instance, big data analysis calls for specific knowledge profiles related to data interpretation capabilities and digital capabilities: data scientists (in part company 8), and business intelligence analysts (in part company 6) are critical for future replications and scalability of the current projects. Finally, main capabilities are to be managed in coordination with each other: for instance, digitalization capabilities – such as data processing and interpretation capability – are positively supporting risk assessment and mitigation capability, that in turn may enhance the effectiveness of value propositions and sustain the work of the sales representatives.

Regarding the revenue model, our cases confirm that “the more challenging the revenue architecture, the greater the changes likely to be required to traditional business models” (Teece, 2010, p. 186). It is extremely risky to promise specific performance levels to the customers in advance, especially, as in cases 8 and 21, if SLAs are linked to increases and decreases in compensation (bonus-malus logic). Our cases testify that here data are already helpful and will be even more critical when BD will be available in the future.

Finally, as highlighted also elsewhere (Ehret & Wirtz, 2017), in respect to non-ownership business models, our cases show that their potential disruptiveness suggests firms to approach the topic very carefully. This is true in particular for those industries – like capital equipment or machinery production – in which the amount of capital expenditure necessary to obtain the product is significant. In those cases, a critical task the firm has to master is the management of the conflicts that may arise from the duality of the traditional and the emergent business models (Markides, 2013).

Table 7 summarizes the main relevant aspects of process and outcome-oriented service business models.

Table 7
Process- and Outcome-oriented digital servitization: opportunities and challenges.

	Process-orientation	Outcome-orientation
Opportunities	Creating new revenue streams selling additional services Exploiting and leveraging knowledge regarding product and manufacturing development	Creating new revenue streams selling additional services Exploiting and leveraging knowledge regarding product and manufacturing development Leveraging on key customers' sophisticated needs
Challenges	Service-related data processing and interpretation capabilities; Misalignment of the sales force's capabilities BtoB Customer Relationship management Manage external partners and competitors' products Individuate and attract the right Human Resources	Service-related data processing and interpretation capabilities; Execution risk assessment and mitigation capabilities Misalignment of the sales force's capabilities BtoB Customer Relationship management Manage external partners and competitors' products Attract the necessary capabilities to become autonomous in the future Advanced product – service Deployment
Triggers	Customer request Proactive strategy	Customer request Proactive strategy
BMI (main impacts)	Value Distribution (relations) Value Creation (Activities) Revenues (new streams)	Value Distribution (Relations) Value Creation (Activities, Resources, Partners) Revenue model (Risk)
Conflicts	?	+
BMI magnitude	Extension	Redefinition
Case #	11 firms	4 firms

5. Conclusions: implications and limitations

The recent rapid development in technology and in particular in IoT technologies is opening up important opportunities for a service-oriented transformation in manufacturing firms, affecting the urgency and speed of a relentless but undoubtedly fragmentary ongoing transition to service-based business models. This study investigates how firms approach the increasing pressure for both customization and operational efficiency urged by the current rapid technological developments of IoT technologies. It describes and analyses how BtoB manufacturing firms are adapting their strategies and their business models (both reactively and proactively) to the technological scenario, aware of the fact that failing to adapt will likely compromise future's value creation opportunities.

Specifically, the study aims at investigating how BtoB manufacturing firms are leveraging IoT technologies to expand their service-oriented offerings and change their business models, further enhancing the stream of research related to digital servitization (Cenamor et al., 2017; Coreynen et al., 2017; Kohtamäki et al., 2019; Sklyar et al., 2019). The study contributes to expand the scientific evidence and to enhance the research on digital servitization, investigating different important subjects related to benefits and inhibiting factors (Suppatvech et al., 2019), opportunities, challenges and impacts on business models posed by IoT-enabled servitization strategies in BtoB manufacturing firms.

Based on qualitative data from a cross-case analysis of 25 BtoB manufacturing firms, the findings underline that digital servitization opens up significant service-based spaces of growth for manufacturing firms, but also prefigure threatening scenarios.

The study confirms that digital servitization doesn't nullify the manufacturers' resource and capability base useful for the service business development (Kindström & Kowalkowski, 2014), and that manufacturing firms possess valuable assets in order to face the challenges posed by digital servitization. Confirming previous study (Wallin, Parida, & Isaksson, 2015), our cases show that manufacturing firms' in-depth product knowledge can be a unique starting point for maximizing the leverage of proprietary and partners' resources and capabilities, and generating value through the design and deployment of new services.

Nonetheless, extant manufacturing resources and capabilities – although critical – have to be complemented with new ones in order to successfully leverage on the possibilities offered by IoT technologies and to develop advanced service-oriented business models (Rönnberg Sjödin et al., 2016; Sklyar et al., 2019). Although our findings don't permit substantial generalization, we think that they have a valuable impact both on theory and practice and contribute to shed some light on a complex and increasingly important research stream.

5.1. Theoretical contributions

As far as theoretical implications are involved, we have presented a focused literature review that acknowledges the centrality of services in the new scenario of IoT technologies, leveraging and expanding the extant literature connecting the research streams of servitization, digital servitization and business model innovation. The study contributes in the progress of the literature in different specific ways.

First, we provide a sketch of the state of adoption of IOT technologies in small and medium-to large-sized manufacturers in Italy, showing the functionalities being implemented and the actual use of digital technologies currently adopted by firms. The strategic impact of technology is represented via a business model innovation map that summarizes the articulated empirical evidence of the research. It also helps to visually codify fundamental strategic moves and to better understand the different strategic situations firms are facing currently.

Second, the study highlights that the latency of some manufacturing firms digital servitization strategies is directly related to their value system position and sales model, extending the influence of some previous literature to the current technological scenario (Mont, 2002; Wise & Baumgartner, 1999). Direct access to final-user firms is in fact critical in leveraging IOT technologies for a service-based business model innovation, a condition that scientific literature has neglected so far.

Third, the study extends and re-contextualizes previous literature related to the need of widening the value proposition horizontality in service-oriented business relationships (Bundschuh & Dezvane, 2003). As highlighted elsewhere (Kohtamäki et al., 2019; Rönnberg Sjödin et al., 2016), the empirical evidence underlines how the more the service is aimed at customers' performances, the more it needs a challenging (in technological and cultural terms) extension of the monitoring and control activities over different customers' products and operating processes, whose visibility is enabled and sustained by IoT technologies (Kamp & Parry, 2017).

Fourth, the evidence allows us – also capitalizing on previous literature (Oliva & Kallenberg, 2003; Baines, Lightfoot, Peppard, et al., 2009; Ulaga & Reinartz, 2011; Baines, Lightfoot, Peppard, et al., 2009) – to identify three basic orientation that may be pursued in innovating the business model with the use of technology. They are product-, process- and outcome-oriented service business model innovation, based on a progressively intensive use of IoT technologies. They also have specific opportunities and pose specific challenges. Evidence allows to observe that different technological outfits may have different impact on business model innovation, since more advanced services imply a use of technology that is different both in quantity and quality from simpler service solutions. This is particularly true for data analysis and big data, that are not of widespread use in our sample, but are deemed to have a great impact in the near future both by the sampled firms and by scholars (Grubic, 2014; Opresnik & Taisch, 2015; Urbinati et al., 2019).

5.2. Managerial implications

Regarding managerial implications, our study widens the spectrum of analysis of opportunities and challenges brought about by IoT technologies and underlines how digital servitization calls for complex and challenging strategies that have to be handled by manufacturing firms.

First, the study helps firms to focus firms' internal debate and decision-making regarding technology-related business model innovation, in order to identify and prepare to face relevant and obstructing factors on the way to digital servitization. In particular, the study's original digital servitization map describes possible strategic shifts aimed at changing poor value system positioning or unfavorable sales models, and highlights opportunities and challenges of disintermediating extant channels (also via the use of digital technologies), and their relative impact on firms' business models.

Second, in line with other studies (Müller et al., 2018; Laudien and Daxböck (2016), we observe that only few “prepared” companies are at the moment able to meet the challenge of a “full” leverage of IoT technologies for digital servitization and conduct disrupting experimentations on it. Our evidence shows that, in order to be at the forefront, firms have to: be “prepared”, in the sense of being involved in studying and exploring technology use for their business; pragmatically and thoroughly exploit any useful resources and capabilities they already have access to (such as: their multi-year manufacturing capabilities, their reputation of reliable and high-quality OEMs and suppliers in their industry); leverage extant relationships with sophisticated and demanding end-user firms, and transform them into veritable learning relationships in which they are willing to invest with dedicated resources; be capable of questioning their past choices and reinventing their role in the value chain in order to find new ways to create value for current or new customers; be capable to deploy strategic and organizational change in order to exploit the opportunities.

Third, in line with other investigations (Burton et al., 2017; Matthyssens & Vandenbempt, 2010; Rönnberg Sjödin et al., 2016), our empirical work underlines that digital servitization may lead to a risky process of extension and redefinition of various elements of the business model. Since opting for the most advanced outcome-oriented solutions enabled by technology may not be the best option for every firm (Grubic & Jennions, 2018; Hypko et al., 2010; Kowalkowski, Gebauer, Kamp, & Parry, 2017; Visnjic et al., 2017), our study identifies three levels of digital servitization orientation, sequentially ordered in relation to technological, organizational and managerial complexity. By recognizing opportunities and challenges of each level (e.g. new revenue streams generation, digital capabilities development and acquisition, specific relational investments), the study helps managers to set priorities and focus on the orientation that fits best to the firm's specific competitive situation, resource slack and organizational structure.

5.3. Limitations and further research

We acknowledge that this study has also limitations, that restrict its generalizability. First, digital servitization strategies may be affected by industry-specific factors that can act as triggers or obstacles that have not been adequately considered in this research. We believe that the topic would benefit by extended quantitative investigations, that will be feasible as the research stream consolidates.

Moreover, the paper is focused on the main stream of digital servitization addressing end-user firms and doesn't explore the service space that OEMs and suppliers can find within their direct downstream markets: IoT technologies may be used to develop solutions for different categories of intermediate actors in the channel (OEMs, dealers and integrators), in order to modify firm's positioning even in cases where channel disintermediation is not viable.

This research is still in its first phases and plenty of under-investigated areas and research streams could be highlighted. Among these, we think that the most promising further research areas could be: the role of key business customers in shaping digital servitization strategies; the role of big data and artificial intelligence in shaping manufacturers' business models and in sustaining the scalability of advanced services' operating model; the role of ecosystems and partners orchestration within the transformation journey; the role of firms' ability to cope exploration and exploitation in digital servitization, where dual or multiple business model may imply different and conflicting objectives.

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Declaration of competing interest

None.

Appendix A. Semi-structured interview framework

What is your professional role in the company?
What are the company's main products and markets?
What are the services that you offer to your customers?
Which IoT technologies are you currently using, and in which field/operative application?
What are the main strategic opportunities that IoT technologies offer you in order to expand your service-oriented offerings?
How are IoT technologies impacting your business models and what are the challenges you have to face (now and in the future)?
(Final considerations)

Appendix B. Survey questionnaire

IoT, business models and digital servitization in manufacturing firms

1) The core product-(component) line:
   a. Revenues (in % on total)
   b. Unit price (€)

c. Customization level (H/M/L)
d. Digital technologies employed in the product/installed base (IoT, Cloud, BD, DA)
e. Average lifecycle of the product (Years)

2) Product-oriented services (list of the provided services):
   a. Pre-sale (list)
   b. Post-sale (list)
   c. Internal vs externalized (%)
   d. Are there internal service-focused organizational units? (Y/N)
   e. Total revenue of services (€)
   f. Non-ownership services (check if provided)
      i. Pay-per-use
      ii. Renting
   g. Strategic importance of services (H/M/L)
3) Market and clients
   a. Installed base size (#)
   b. Installed base ratio (%)
   c. Number of customers (#)
   d. Typology (OEMs, installers, distributors (direct and indirect), integrators, end-user firms, other) (% importance)
   e. Key account (# Italy, abroad)
   f. Average duration of customer relationships (years)
4) Competition
   a. Competitive position (leader, follower)
   b. Average size in relation to competitors (smaller, larger)
   c. Strengths and weaknesses in relation to competitors (list)
   d. Average relevance of services for competitors (H/M/L)
5) Channels
   a. Direct sales (% of revenues)
   b. Types of channels (list)
   c. Average size of distributors (# people)
   d. Internal organization for channel management (# people, #offices)
6) Suppliers and partners
   a. Strategic suppliers (#, type)
   b. Technological suppliers (IoT technologies, software) (local, national, international)
7) Sales force
   a. Internal organization for sales management (# people, #offices)
   b. Prevalent culture/mindset (product, service)
   c. Training (# annual programs, € annual expenses)
8) Skills
   a. New capabilities needed for IoT (H/M/L) (list of the capabilities)
   b. Specific training for IoT technologies-related capabilities (Y/N)
   c. External partnerships for IoT technologies (#, localization, importance)
9) Business model:
   a. Impact of IoT technologies on the business today – in 3 years on (H/M/L):
      i. Activities, resources and capabilities
      ii. Partnerships and supply relations
      iii. Product and value proposition
      iv. Markets and customer relations
      v. Costs and revenues
      vi. Other (specify)

Appendix C. Representative quotations

Aggregate dimensions	Second order themes	First order concepts	Representative quotations (company)
Direct access to end-user firms	Channels structure	Downstream actors' power and visibility	"We have IOT devices and Cloud platforms, but we strive for making our final customer firms see that… our visibility on the final customer is very little, they are huge firms, very far from us, and our machine is just a small part of the overall purchase they do" (3).
		Downstream actors' technological readiness	"The fact is that in our main market segments we need the collaboration of the current distributors and service providers; unfortunately they are not so ready yet for the digital transformation that is needed in order to include digital services in the offer"(24)
	Sales- and services-related strategies	Traditional product-centred service strategies	"Our focus has always been on products, on their quality and reliability, we always thought that the service part of the job had to be done by some other firms…" (14).
		Costs and value of product-related services	"We sell our products to organizations that are capable of doing the installation and post-sale assistance, we simply cannot afford to manage sales and services directly, especially in foreign markets" (1).
		Organizational and cultural readiness to direct marketing and sales	

			“Once we started to have a direct contact with the final user we realized that we had no idea of what we should do to manage that relation and who should have done it… that challenged our identity as manufacturers…” (12)
	IoT technologies-related de-intermediation	Design specific digitally-based olutions for end-user firms	“Those technologies [IOT technologies] allow us to design software and digital solutions that are intended not for our direct customer [the OEM] but for the end-user firm, that is the actual user of our equipment…” (15)
		Reputation and credibility as digitally-based service suppliers	“Given the schepticism that is so spread in the market concerning data privacy and security, if you want to embrace digital technologies for streamline your post-sales services you have first of all to be credible as a supplier not only of iron [the product], but also of something immaterial like a software, an app…” (11)
		Access to not previously served segments	“We have made interesting experiences with some customers that don't belong to our traditional markets. This is the oucome of continuously work toward the development of the business that I and some colleagues have done, and that led to the demand of specific solutions by these new customers that allowed us to use our capabilities and technologies to design a platform of digitally-based solutions flexible enough to be potentially suitable also to other customers” (18)
	Challenges of going downstream	Financial and organizaitonal investments	“Directly distribute our products, not only in Italy but especially abroad, is the only viable remedy to our poor positioning in the supply chain… valuable enough to make us face the financial effort and the potential retaliation of previous partners” (7)
		Threat of downstream actors' retaliation	“We have begun to change this situation [the indirect sales model], but we have to be careful to not upset our current channels. That's why we have started with replacing small dealers, preferably without a post-sale service structure, in secondary markets” (9)
BMI Service orientation	Product-oriented digital servitization	Streamlining post-sale services efficiency and sustain value	“For suppliers like us, that have thousands of machines installed all over the world, IOT technologies represent a formidable weapon for increasing the efficiency of the post-sales services, and this regards us as producers but also our main distribution partners” (11)
		Enhancing traditional services in the offering and protect the BM	“Digital solutions based on IOT have interesting applications for protecting our revenues, as happens in the warranty period, and in other phases as regards the use of the correct consumables. Moreover they help us controlling costs and refine the business model, since a post-sales service that knows in real time what's going wrong with the machine is a powerful tool to sustain the business and strengthen the relation with the customer, who knows that we can intervene rapidly and reduce his money loss” (25)
		Sustain pre-sale activities with potential performances	“Currently we aren't fully leveraging IOT technologies, but being compliant to Piano Industria 4.0 [special taxation related to IOT in Italy] is undoubtedly a ‘must have’ in our industry” (2)
	Process-oriented digital servitization	Enrich products efficacy with digital services and capture extra value	“With the IOT and the cloud we can provide automated malfunction detection and resolution for our equipment to our customers, together with a two-level technical repository and automated troubleshooting offered on a subscription basis” (13)
		Shift from a transaction-based to a relationship-based approach	“The challenge of adding advanced services oriented to the customers' process is not merely technological… on the contrary it is the fundamental change in the relation with the customer: we normally were used to hear from them once a while, now we have daily contacts” (23)
		Complementary products' data availability	“Of course, in order to make our machine work efficiently within our customers' processes we need to have access to other suppliers machines' data… boostering productivity of our machines makes no sense if the line is not under control…”(21)
		Data processing and analysis capabilities	“It soon became clear that one of the capabilities we missed was that of analyzing and extracting valuable and usable information from the data…” (8)
	Output-oriented digital servitization	Add complex services, lock-in customers and capture/transform value	“Not every competitor is capable of providing complex services, especially based on digital technologies, that the customers deem important… if you are able to do it, this is a formidable way of keeping the customer linked to you and also to increment its profitability” (17)
		Relational integration of supplier-customer value chains	“Services aimed at mitigating customers' risks are very complex, they cannot be managed without a proper technological outfit and an in-depth integration of supplier-customer activities” (21)
		Revenue models and Capex/Opex substitution effects	“In our industry it is very difficult at the moment to think of a real transition to non-ownership revenue models… the level of Capex connected to our machines and the level of customization and specificity of the systems we sell impose further reflections on the topic” (8)
		Risk assessment capabilities related to advanced services	“We have a valuable experience in helping our customers to manage their processes, also with technologies different than IOT; our customers are asking more of us, demanding that we guarantee efficiency levels, a real full service approach… we know that this may be the next future, and we are currently making all the evaluations of risks and opportunities linked to it” (6)
	Digital Servitization challenges	Customers' readiness and access to end-user firms' usage data	“One of the problems that we have in leveraging on IOT is that our customers haven't realized yet the utility of it… when there is a problem and we try to check it out, we realize that they never use the connection” (2)
		Connected IB size and timespan for collecting BD	“We have a product that allows to remotely control process operations with web- and smartphone-based applications, also with the possibility to retrofit older machines. We could think to supply predictive maintenance, but for the moment connected IB and running applications are few and we cannot leverage on big data yet” (16)
		Vision of the future and actual strategic moves	“Our strategic vision is partial, we do not have yet a clear idea of the role we could play in the value system in the future” (22)
		Be prepared to react positively to sophisticated customers	“We have been studying possible applications of IOT technologies for us for a while… but the fact that made everything start for real was a compelling request from one of our most important customers” (21)
		Replicate meaningful explorations and scale solutions	“We are now putting some effort in thinking how to use the experience we made in these experiments [with key customers] in order to develop complete, robust and scalable digitally-based solutions for the rest of our market” (17)
		Sales force structure and capabilities	“Sometimes I think that the biggest problem we have is our sales force… they are used to be focused on selling costly machines, and they strive to understand the sense of these new breed of digital services that create little revenues…” (8)

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