

Industry 4.0 technologies and the servitization strategy: a good match?¹

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Abstract

Purpose of the paper: *The paper aims at investigating whether a relationship exists between the servitization strategy and the adoption of Industry 4.0 (I4.0) technologies in small and medium sized enterprises (SMEs) operating in a B2B context.*

Methodology: *Case study method based on in-depth interviews with the entrepreneurs and managers of 7 SMEs operating in the mechanical sector in Italy*

Findings: *The article provides some preliminary evidence on the interplay between some I4.0 technologies (Internet of Things, cloud computing, simulation, big data and analytics) and the servitization strategies of B2B SMEs, and highlights its performance implications. The authors propose three research propositions to be tested in future studies.*

Research limits: *Although the goal of the research is exploratory, it is worth mentioning that it considers a small sample of B2B SMEs operating in the metals and machinery sector. Future studies could investigate these relationships among larger samples of cross-sectional companies.*

Practical implications: *This work identifies a selection of technologies belonging to I4.0, that could be compatible with one another and functional to the implementation of a servitization strategy of SMEs.*

Originality of the paper: *This work contributes to servitization literature by investigating the role of I4.0 technologies. Also, it contributes to management literature by offering initial empirical evidence of Italian manufacturing SMEs that have adopted I4.0 technologies.*

Key words: Industry 4.0; digital technologies; servitization; performance; B2B; SME.

1. Introduction

Digitization connects people, companies, systems, products and services (Coreynen, Matthyssens and Van Bockhaven, 2017), thus creating opportunities for new ways of doing business with potential strong

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impact especially in the manufacturing sector (Rymaszewska *et al.*, 2017). Indeed, digital technologies can provide critical support to innovation and marketing strategies, but can also enable firms to organize and manage their business in a completely different way. In particular, in the digital era, scholars and practitioners have attributed a disruptive power to Industry 4.0 (I4.0) technologies that could dramatically impact on industries and competition on the one hand (Porter and Heppelmann, 2014; Vendrell-Herrero *et al.*, 2017), and on organizations themselves on the other hand (Porter and Heppelmann, 2015). Indeed, from this second point of view, I4.0 technologies may be implemented in different activities of the value chain, with potential impacts at different levels ranging from inbound logistics to post-sale assistance (Porter and Heppelmann, 2015).

I4.0 technologies are also expected to enable and/or support the servitization of manufacturers (Kamp and Parry, 2017). Such a relationship is drawing attention in the literature but remains largely under-explored from an empirical point of view (Kowalkowski *et al.*, 2017; Paiola, 2017a; Paiola 2017b). An exception, in relation to the manufacturing context, consists in the study by Coreynen, Matthyssens and Van Bockhaven, (2017) that shows that specific digital technologies can lead companies along different servitization pathways but require a dynamic configuration of the firm's resources. Despite such an attempt, to the best of our knowledge, no empirical studies have tried to investigate whether - and how - I4.0 technologies enable or support servitization strategies in manufacturing firms. Moreover, assuming that this relationship exists, it becomes crucial to understand to what extent firms really benefit from the synergies it can deploy in terms of performance (Paschou *et al.*, 2017; Rymaszewska *et al.*, 2017).

This paper aims to contribute to fill this gap and deepen the relationship among I4.0 technologies, servitization strategies and the performance of firms operating in the business-to-business (B2B) market context. In fact, I4.0 technologies are expected to pave the way for profound innovations in the way B2B firms organize their business (Paschou *et al.*, 2017). In particular, a transition from product-based to service-centric business models - or an acceleration of ongoing transitions - is expected (Vendrell-Herrero *et al.*, 2017; Kamp and Parry, 2017; Coreynen *et al.*, 2017).

Furthermore, considering just the issue of servitization, a multifaceted framework is emerging, in which the intensity of and the role played by services among sectors, and between firms belonging to the same sector, can vary greatly (Cusumano *et al.*, 2015; Rymaszewska *et al.*, 2017; Vendrell-Herrero *et al.*, 2017). Moreover, recent surveys have shown that the transition from product- to service-based business models can be more difficult than expected for the companies undertaking it (Baines *et al.*, 2017; Paiola, 2017a; Paiola, 2017b). In this respect, some studies have shown that servitization can be a profitable competitive strategy in particular conditions (Lee *et al.*, 2016), whereas other works have highlighted a negative relationship between servitization and performance (Saccani *et al.*, 2014), and other works have underlined that this relationship is moderated by other factors (Zhen, 2012). In this articulated framework, it becomes even more important to understand which role I4.0 technologies

could have in the servitization of manufacturing (Paschou *et al.*, 2017).

Through qualitative methodology, the present study contributes to this discussion by analyzing a sample of SMEs operating in a B2B context. The purpose of the study is to answer the following research questions: Are I4.0 technologies enabling or accelerating the (ongoing) transition from product- to service-based business models in B2B firms? If so, could this have an impact on firm performance?

To this purpose, we adopt a case study method (Eisenhardt, 1989) based on in-depth interviews with the managers and entrepreneurs of 7 SMEs operating in the mechanical sector. In particular, this study seeks to understand whether I4.0 technologies - and which ones specifically - can boost the servitization strategies of SMEs, how such an interplay takes place and, finally, what the performance implications of this interaction are.

This work contributes to the literature on servitization strategy by clarifying the role played by I4.0 technologies in the deployment of servitization strategies and by discussing the outcomes of such a joint effect in terms of firm performance.

The article is structured as follows: the second section provides an overview of the literature, and the third one outlines the used methodology. Then, in the fourth, we present the cross-case analysis and, in the fifth section, we discuss its results. Research and managerial implications, as well as the limitations of the study, conclude this paper.

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Industry 4.0 technologies
and the servitization
strategy: a good match?

2. Literature overview

2.1 *The evolution of services in B2B contexts*

If we look at the evolution of managerial literature on buyer-supplier relationships, we will notice that such a debate has mostly assumed the perspective of client firms (e.g. Dwyer, Schurr and Oh, 1987; Zhao and Cavusgil, 2006). Such a vast literature had the merit of highlighting the many advantages stemming from the collaboration between clients and supplying firms operating in B2B, including speeding-up the clients' time-to-market, reducing errors and related costs, and increasing product quality (e.g. Sako and Helper, 1995; Dyer and Singh, 1998; Kotabe, Martin and Domoto, 2003). However, B2B companies have not been passive - or just reactive - throughout this process. On the contrary, a parallel but minority literature has highlighted the active role played by suppliers and subcontractors in supporting the many achievements - in terms of innovation, quality improvement, cost reduction, etc. - that have been obtained by client firms (e.g. Nassimbeni *et al.*, 1993; Kindström and Kowalkowski, 2014; Carbonell and Rodriguez-Escudero, 2014; Gremyr *et al.*, 2014; Von Koskull and Strandvik, 2014; Mustak, 2014). As Furlan *et al.* (2007) observe, firms operating in B2B have assumed more and more design responsibilities over time and have been substantially helping their clients in designing better and/or more efficient products and processes. More in general, over time, suppliers and subcontractors operating in

B2B have gradually abandoned a mere productive (and reactive) role and started being increasingly proactive in providing their customers with a wide array of extra services - including *just-in-time delivery*, total quality assurance, co-design, etc. - that complement the supply of components, semi-finished products or machinery (Grandinetti and Bortoluzzi, 2004; Chiarvesio and Di Maria, 2009). As a result, the distinction between products and services has progressively blurred in the B2B context.

Vandermerwe and Rada (1988) first described this phenomenon and coined it as the “servitization” of business. Since then, the literature on servitization has significantly grown, intersecting the literature on buyer-supplier dynamics (Lightfoot *et al.*, 2013; Baines *et al.*, 2017; Bustinza *et al.*, 2017). Servitization has been introduced into firms in different manners. Oliva and Kallenberg (2003) talk about a product-service continuum that ranges from traditional manufacturing companies that only offer services as add-ons to their products, to companies that are also service providers and offer services as the main part of their value creation process. Cusumano *et al.* (2015) highlight three service categories for a product firm: those that “smooth out” the product sale or usage without significantly altering the product’s functionality, those that enable the product to adapt to specific conditions by expanding its functions; services that replace and are therefore sold instead of the product. In the same vein, Kowalkowski *et al.* (2017: 9) recently distinguish between a “service infusion” strategy - defined as the “process whereby the relative importance of service offerings to a company or business unit increases, amplifying its service portfolio and augmenting its service business orientation” - and a strategy of pure servitization, corresponding to “transformational processes whereby a company shifts from a product-centric to a service-centric business model and logic”.

The recent interest of academia towards services and servitization strategies in B2B is mainly due to the belief that through services firms can defend themselves from competing companies based in lower cost economies because services are more difficult to imitate and have increasingly become the source of competitive advantage for companies (Kamp and Parry, 2017). Indeed, service-based strategies are “distinctive, long-lived, and easier to defend” (Baines *et al.*, 2009, p. 547). Therefore, services can be used to strengthen business relationships with main clients by creating lock-in effects, hence laying the grounds for (greater) sustainable competitive advantage in the long run.

The advantages and drawbacks of service-based strategies have also been discussed in the literature (Baines *et al.*, 2009; Neely, 2008) and include financial benefits (such as more stable revenue streams and higher profits), strategic benefits (the provided services are tailored around the specific needs of business clients and hence difficult to imitate), marketing benefits (higher client retention is achieved) as well as environmental benefits (less waste is produced since production activities are streamlined along the supply chain). Of course, there are also costs and drawbacks, particularly for SMEs (Coreynen *et al.*, 2017) and mainly include the difficulties in managing the transition from products to services and in exploiting their full potential (Mathieu, 2001; Neely, 2008; Baines *et*

al., 2009; Paiola *et al.*, 2013; Zhang and Banerji, 2017). In this regard, Gebauer *et al.* (2005) present a potential “service paradox” that happens when firms invest heavily in extending the service business according to which increasing services creates additional costs without generating the (expected) corresponding higher returns.

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Industry 4.0 technologies
and the servitization
strategy: a good match?

2.2 Industry 4.0 technologies, digitization and servitization

Since digital transformation has recently become a hot topic in relation to manufacturing activities and B2B firms, academics have shed light on new potential connections between service-based strategies and the digital transformation of businesses (Porter and Heppelmann, 2014; 2015; Rymaszewska *et al.*, 2017). As Neil Gershenfeld said in 2012, “A new digital revolution is coming, this time in fabrication”. A revolution that is headed by specific technologies, like additive manufacturing, big data and analytics, collaborative robots, advanced simulation, augmented reality, the Internet of Things (IoT), cybersecurity, and cloud computing (Rüßmann *et al.*, 2015) are all grouped under the definition of “Industry 4.0”. We use this term to refer to a series of heterogeneous technologies that are associated with the ability to enable and accelerate the digital connection between products, processes, activities, and firms and that should lead manufacturing towards the so-called Fourth Industrial Revolution.

In Europe, Germany has been the leading country in supporting investments by private firms in such technologies. Since then, the term “Industrie 4.0” (in German) - or “Industry 4.0” (in English) - has become commonly used to identify a wide array of enabling technologies that are expected to radically change the processes of value creation in intermediate markets (Kagermann, 2015) and, as a consequence, the business model of firms (Burmeister *et al.*, 2016; Westerlund *et al.* 2014), not to mention the entire competitive environment and economic rules (Weller *et al.*, 2015).

Recent studies have started to address the managerial side of the adoption of these new digital technologies (Liao *et al.*, 2017; Lu, 2017). In particular, Bauer *et al.* (2016) identified several possible impacts including the increase in productivity, the rise in product quality and process efficiency, superior flexibility, the reduction in time-to-market, environmental sustainability, the new role of the consumer and, last but not least, a profound impact at the business model level (Lacy and Rutqvist, 2015; de Sousa *et al.*, 2018). Another expected impact of I4.0 is the increase of servitization strategies that are implemented by firms (Rymaszewska *et al.*, 2017). In fact, suppliers can leverage certain I4.0 technologies to improve their existing service offering, while other technologies may be used to deliver new services (Rüßmann *et al.*, 2015). This might be the case of big data analytics, for instance, which could represent a new tool in support of decision making (Rüßmann *et al.*, 2015). Another example regards the inclusion of advanced sensors in products - the Internet of Things (IoT): it can allow suppliers to manufacture smart and connected products that are expected to have a strong impact not only at the product level, but also in terms of the system of services (e.g. remote assistance, predictive maintenance, data production and storage, etc.) (Porter and

Heppelmann, 2014; 2015). Moreover, the combination of specific I4.0 technologies, such as IoT and cloud computing, can allow manufacturers to draw on real-time data deriving from the use of products and to provide new value-added services for their customers, with strong impacts on after-sales services (Bauer *et al.*, 2016).

However, I4.0 technologies are diverse and can be implemented in different business functions with different impacts. In particular, an incremental and synergic use of these technologies can empower the achieved outcomes because the factor that really lays the foundations for the Fourth Industrial Revolution following the third one driven by ICT and the internet, is connectivity among actors, objects, companies, systems, products and services (Coreynen *et al.*, 2017; Porter and Heppelmann, 2014). This, however, could become more difficult for established manufacturers than for start-ups and niche players because digital skills and smart value propositions have become more important in obtaining profits through an increase of offered services (Bechtold *et al.*, 2014). Indeed, most studies and reports suggest that the actual disruptive effect of I4.0 may be obtained through the simultaneous use of several technologies that could allow companies to deliver smart, complex services and, later, move towards a pay-per-use servitization strategy with a clear value-proposition that captures the offered value by providing additional and smart services (Bechtold *et al.*, 2014). In some cases, the use of I4.0 technologies may entail the possibility of generating new business models where users have no need to buy a product but can simply access and use it - for instance, through access to digital platforms (Bauer *et al.*, 2016). At the same time, each I4.0 technology does not necessarily lead to an increase in the service offering or enable a servitization strategy. For this reason, it becomes important to explore and understand which I4.0 technologies could be adopted to this purpose.

3. Research method

The purpose of this study is to investigate the existing interplay among I4.0 technologies, the servitization strategy and the performance of B2B firms. To this purpose, we developed a multiple case study method (Eisenhardt, 1989). The nature of this study is exploratory. We obtained qualitative data through in-depth interviews with the entrepreneurs and managers of 7 SMEs. Data were collected between September 2017 and June 2018. We adopted a purposive sampling approach to select B2B SMEs in the North-East of Italy operating in the mechanical sector. The selection process benefited from the assistance of experts working in local technology transfers and the mechanical cluster, who helped investigators in the identification of SMEs that had adopted at least one I4.0 technology. The selected companies were in line with the European definition of SME (European Commission Recommendation 96/280/EC: <250 employees and turnover <50 million Euro).

We collected in-depth interviews with entrepreneurs and managers based on a semi-structured questionnaire, with questions regarding the

adopted I4.0 technologies, firm and servitization strategies, products, and sectors. Each interview lasted between 1 and 2.5 hours and involved at least two investigators. We decided to involve multiple investigators because the reliability of findings generally increases when the observations of multiple investigators converge, (Eisenhardt, 1989). We collected the transcription of follow-up telephonic interviews, as well as press and archival documents for triangulation purposes. The interviews were taped and transcribed, producing a total of 12.5 hours of tape recordings and 30 pages of transcripts. The archival data were used for triangulation purposes. Table 1 illustrates the number and type of interviews per company, whereas Table 2 provides information about the selected cases.

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 Industry 4.0 technologies
 and the servitization
 strategy: a good match?

Tab 1: Data collection process

Case	C1	C2	C3	C4	C5	C6	C7
Respondents	Founder-entrepreneur	Founder-entrepreneur & Operations Manager	Founder-entrepreneur	Founder-entrepreneur	Entrepreneur & Board Member	CEO	Founder-entrepreneur
Data collection process	Interview lasted 2.5 hours + production site visit	Interview lasted 1.5 hour + production site visit	Interviews (2) lasted 2 hours and 1.5 hours + client's production site visit	Interview lasted 1.5 hour + production site visit	Interview lasted 1.5 hour + production site visit	Interview lasted 2 hours + production site visit	Interview lasted 1.5 hour

Source: Our elaboration

Tab. 2: Case description

Case	C1	C2	C3	C4	C5	C6	C7
Age	40	22	32	22	58	8	10
Turnover in 2016 (M Euro)	18	17	10	7	20	6	2.5
Employees	80	45	30	32	50	30	10
Foreign sales on total sales (%)	80	90	40	50	90	75	85
Product	Saws	Wire Rolling Technology	Beverage machines / plants	Mechanical machinery	Coating equipment	Programmable ovens	Machines

Source: Our elaboration

4. Cross-case analysis

As illustrated in Table 3, the manufacturing companies in our sample have selected specific I4.0 technologies in accordance with their overall strategy, their resources, and product and process attributes. The firms generally adopted such I4.0 technologies to be more competitive within an environment that they perceived as dynamic and challenging. I4.0 technologies led them to obtain different outcomes (e.g. automation in processes led to an increase of efficiency and productivity; IoT and cloud technologies led to product innovations).

The adoption of some I4.0 technologies is associated with service growth, as companies have started to offer new or additional services (e.g. simulation in pre- and post-sales; IoT for specific remote post-sales assistance). However, in most cases, these technologies have further boosted a pre-existing trend of service growth. The established manufacturers of the sample started to increase their service components in the Nineties, long before adopting recent I4.0 technologies. In contrast, the business idea of younger companies (C6, C7) was based on selling innovative products that - through the use of specific technologies such as IoT and the cloud computing - could offer additional, complex, smart services.

All manufacturing firms considered service growth as a key element of their competitive strategy in response to growing competition from - among others - low-cost countries. Indeed, additional services were the key attributes of their differentiation strategy.

In recent years, service growth related to I4.0 technologies have generally helped firms increase their overall value on the market because they started to offer new value-added services. This led to different outcomes: for instance, C1 noted that the additional services that could be offered thanks to these technologies have strengthened their relationship with some customers.

“Simulation services have helped us increase customer loyalty. Some clients (e.g. machine manufacturers) started to involve us in the design of their new products following a co-design logic”. - the founder of C1.

The level of service growth is heterogeneous (stronger or weaker) among the sampled companies. Whereas most companies have translated service growth in service infusion, two companies (C3, C7) have been experimenting a complex evolution of their business model towards a servitization logic. As one entrepreneur noted, C3 enacted a shift towards a service-centric business model about 10 years ago, but the change is still not concluded:

“Over the years, the company has evolved by adding more and more types of machines to its offering. We have always invested in technology. About ten years ago, we started including sensors in our products and - thanks to this - offering remote assistance services. Now, we commercialize turnkey plants that are vertically and horizontally integrated. In this case, the plant consists of interconnected machines that are connected to the manufacturer’s cloud and the customer. Now, thanks to IoT, cloud computing and big data collection, we now perform a real-time remote monitoring and management of plants. For a selection of customers, we have implemented/introduced servitization: they buy service packages while we maintain the ownership of plants. At this stage, our business model is moving towards a servitization logic, but it has not been a linear process so far”. - The founder of C3.

In all cases, the manufacturing companies have certainly used some I4.0 technologies-namely IoT, simulation technologies, cloud computing and big data collection and analytics, to offer new or additional services.

For instance, simulation has been used to offer pre-sales services (e.g. more accurate cost estimates, waste reduction, problem solving in prototyping...) (C1, C2, C4, C5) and even for post-sales assistance (e.g. to monitor machinery performance, to simulate use in different conditions or with different tools, etc.) (C2). IoT built the foundations for creating smart products that could potentially and later be connected to the manufacturer (C2, C3, C4), the cloud (C3, C5, C6, C7), or to customers via app (C6, C7) or to platforms (C7). Cloud computing was widely adopted to share a virtual storage space with customers in order to offer new post-sales services (e.g. remote monitoring, storage of certifications and information about finished products, direct download of clients' orders through Electronic Data Interchange (EDI) systems, etc.). Cloud computing was often associated with the adoption of IoT in the case of manufacturers of machinery or smart connected products. The companies encountered more problems in implementing big data collection and analytics technology, which is often aimed at analyzing data on products' usage or features in order to respond to product innovation purposes (C1) or enrich the company's service portfolio (C3, C6, C7). An exception is represented by the young company C7, because at the beginning the founder identified a group of technologies that could jointly enable new, smart services. In this case, along with IoT and cloud technology, the founder already had a clear idea on how to develop big data and analytics. Since the beginning, C7 conceived a smart product that was supposed to be connected to the manufacturer's cloud and customers via app in order to let them collect and monitor data on energy consumption and related costs. Now, the company is developing a pay-per-use strategy, where customers can share the product with other people according to a sharing economy logic.

More interestingly, among the companies that have already developed a servitization strategy, the adoption of I4.0 technologies was finalized towards a planned increase of services for customers. In most cases, the adoption process reflected an incremental approach following a rapid evolution. As a result, after implementing one form of technology to offer a specific service, most companies rapidly understood the potentialities of other related I4.0 technologies that could enhance or enrich the service offering. From this perspective, through a simultaneous and combined adoption of I4.0 technologies that were aligned with the firm's strategy, the companies were able to obtain positive returns from the servitization strategy, like in the case of C3 and C7.

Overall, firms generally underlined their difficulties in exploiting the full potential of service growth. Customers frequently do not recognize the value of additional innovative services connected with smart products, incapable of exploiting the advantages of remote assistance, or are simply unwilling to pay more for these services.

As C6 noted:

"The company is developing a smart oven that can be remotely monitored and managed by us and connected to our cloud. The connection to the cloud was planned in order to increase the service offering embedded in the product. However, service growth entails many challenges, such as critical

aspects on how to manage data, privacy issues and cybersecurity. Once these issues will be solved, we expect that the creation of smart, connected products will give us the opportunity to offer a wide range of after-sales services that will be added to the product itself. For instance, this technology will allow the company to understand the users' habits through the collection and analysis of usage data". - The founder of C6

Remaining in the context of machinery, C4 underlined other difficulties in exploiting the full potential of innovative services:

"Customers frequently do not recognize the value of additional services such as remote assistance, or are unable to exploit the potentialities of smart products. In other cases, customers are not ready to share sensitive data such as those related to their production processes, but this is absolutely necessary to exploit the advantages of remote assistance". - The founder of C4.

Another challenge relates to customers' unwillingness to buy innovative services integrating I4.0 technologies as a separate offering or simply by paying additional costs for them. Some firms have tested commercial solutions to help customers understand the value of services, thus reducing customer's reluctance to use and pay for them. For instance, C5 is evaluating the possibility of selling remote assistance as an independent service that the customer could decide to buy (or not) when purchasing the coating equipment. C2 is also defining a solution to sell its simulation software:

"After purchasing our machinery, our customers can use our simulation software for free for one year. Then, the customer can decide to buy the license to keep on using the software". - The founder of C2.

Instead, C3, which has adopted I4.0 technologies in accordance with its servitization strategy, is the only company that has defined an explicit pricing strategy to sell its services.

"To some MNEs and large clients, we give machines on a gratuitous loan, but require a fee to use them. In these cases, we maintain the ownership of the plant and remotely manage it from our headquarters, while the customer only has the right to use it based on a usage fee. This represents a complete shift in business model compared to the past. Now, we offer useful, innovative services, and profitability largely depends on them". - The founder of C3.

The exploitation of innovative services seems to entail a need of learning and experimentation that should involve not only the manufacturing firm but also its customers. In contrast, C7 is developing a digital platform on which the firm could base the development of a servitization strategy responding to a sharing economy logic. This young company was set on the idea of selling products that could offer complex services on which the competitive advantage of the firm is based, through a combination of I4.0 technologies. Although this combination of I4.0 and servitization allowed the firm's growth, the implementation of a comprehensive servitization

strategy still requires an entire reconception of the firm's positioning and an accurate identification of the segments that could be served.

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 Valerio Veglio
 Industry 4.0 technologies
 and the servitization
 strategy: a good match?

Tab. 3: Cross-case analysis in terms of I4.0 technologies and service processes

Case	Service path	Adopted I4.0 technologies	I4.0 technologies enabling firms to offer new or additional services
C1	Over the last decades, the firm has developed a service infusion strategy that has strengthened the firm's competitive advantage.	Advanced robotics, cobots, and interconnected machines aimed at achieving vertical integration to increase the plant's efficiency, reduce costs, improve lead times and increase production flexibility; simulation used in prototyping to improve the production process and offered as a service in pre/post-sales; big data collection and analytics in progress - related to the utilization of the tool - with the purpose of further improving product performance.	Simulation, Cloud, Big data collection and analytics: the adoption of simulation has reinforced the pre-existing trend to service growth. Simulation service has been particularly appreciated by some customers that have started to collaborate more intensely with the firm. The firm aims to further exploit the potentialities of this service; this service is now offered as an add-on to physical products, rather than a separate expense.
C2	Since the establishment of the company, services have represented key components of its offering.	Simulation used at the design stage and offered to customers as a post-sales service; IoT applied to smart products.	IoT, Simulation: I4.0 technologies were adopted to introduce product innovations. A simulation software is offered to customers. The firm is exploring commercial solutions to exploit the commercial value of the simulation service.
C3	Since the beginning, service infusion has characterized the evolution of the firm's offering. About 10 years ago, the firm began to shift its business model towards a servitization strategy.	Robots in production to reduce production costs. Fully implemented IoT to create smart and connected plants that are vertically and horizontally integrated. The former one entails that the whole production process is made up of interconnected machines that are connected to the various value chain activities of the company (from orders to post-sales). Also, plants are horizontally integrated as the manufacturer remotely controls, monitors and manages the plants for its customers.	IoT, Cloud, Big data collection and analytics: the adoption of I4.0 technologies is associated with service growth not only through "service infusion" but also an explicit "servitization" strategy. In this case, I4.0 technologies have enabled new services (e.g. remote control), thus driving the firm to experiment a business model evolution towards "servitization".
C4	Since the company's foundation, service infusion has characterized the evolution of firm's offering. Over the last years, the firm has increased the service component in response to growing competition.	Simulation used at the design stage to improve the subsequent production process; IoT applied to the product; smart and connected products, where connectivity is mainly offered as a service of remote diagnostics to international customers.	IoT, Simulation: I4.0 technologies (e.g. simulation, smart products) are boosting the process of "service infusion". The adoption of I4.0 technologies represented a means to improve products and increase sales. Customers very frequently underestimated and underused the potentialities of smart products. The firm considers the production and adoption of I4.0 technologies as a "learning process" that involves both the firm and the clients.
C5	Service infusion has gradually increased over last 20 years. The firm has been gradually developing new, complex services that could be the base on which to transform their business model according to a servitization logic.	Simulation used in the designing phase to improve both the product and the production process; smart and connected products that make remote diagnostics available; cloud computing used to offer remote software management to customers.	IoT, Simulation: some smart products' potentialities are not fully exploited. For example, remote assistance is available in smart equipment, but is not requested by customers. The firm is looking for a "commercial formula" to obtain higher returns from smart products. It is evaluating the possibility to sell remote assistance as an independent service that the customer can decide to buy (or not) when buying the coating equipment.

C6	Since the company's establishment, complex services have been key components of the firm's differentiation strategy.	IoT related to the creation of smart and connected products that are sold globally. Products include sensors and are connected to the manufacturer, the app (international costumers) and cloud technology/computing.	IoT, Cloud, BD collection (WIP): Smart products could increase the service offering embedded in the product. However, service growth entails challenges that the firm is trying to overcome.
C7	Since the company's establishment, products have been developed to exploit and offer complex services, which are key the components of the firm's offering. The firm has shifted towards a servitization strategy that should let most of its profits be obtained through post-sale services.	Product embedding sensors and cyber physical systems (IoT) that are connected to the cloud and allow big data collection and analytics. A further connection will be developed to connect products with a digital platform.	IoT, Cloud, BD collection and analytics: Smart connected products embed a key service component into the offering. The firm has developed a product that already embedded high technological components and targeted selected technologies since the beginning in order to increase the offered service component. The adoption of IoT, Cloud, Big data collection and analytics was rapid and in line with the company's servitization strategy. Further potentialities in terms of increasing the technological boost of service offering were discovered later.

Source: Our elaboration

5. Discussion

The cross-case analysis has provided some preliminary evidence on the interplay between I4.0 technologies and the servitization strategies of B2B SMEs and highlighted some performance implications. We see three main results that can be translated in research propositions to be further tested empirically after enlarging the sample of involved firms.

First, our results suggest that the adoption of I4.0 technologies - namely those concerning the Internet of Things, simulation, cloud computing and big data collection (and analytics) - specifically aimed to increase the service offering of the firms. In particular, as regards the interviewed companies (that were already offering their clients a combination between products and services), we noticed that I4.0 technologies allowed many of them to provide new or additional services (e.g. remote maintenance, big data analytics on usage performance). Based on this, we propose the following research proposition:

Research proposition 1: Investments in I4.0 technologies - namely the Internet of Things, simulation, cloud computing, big data and analytics - enable the further infusion of services in B2B SMEs.

Based on our evidence, we cannot conclude that the adoption of these technologies could automatically and unavoidably lead to radical servitization. This can be related to a number of reasons and challenges that are connected with the implementation of a servitization strategy. Indeed, translating a product-based into a service-centered business model is not an obstacle-free process, as has already been discussed in the literature (e.g. Gebauer *et al.*, 2005). Moreover, all the interviewed companies had already implemented a service-centered growth strategy well before the adoption of I4.0 technologies. However, the cross-case analysis showed that through

the adoption of specific I4.0 technologies (e.g. simulation offered in pre- and post-sales; IoT in remote post-sales assistance), several companies were able to shift their service-infusion strategy towards a more radical servitization by enhancing the existing one. Thus, I4.0 technologies acted as “enablers”. In other cases, I4.0 technologies empowered an established servitization strategy. Hence our second research proposition:

Guido Bortoluzzi
Maria Chiarvesio
Rubina Romanello
Raffaella Tabacco
Valerio Veglio
Industry 4.0 technologies
and the servitization
strategy: a good match?

Research proposition 2: Investments in I4.0 technologies - namely the Internet of Things, simulation, cloud computing, big data and analytics - can enable B2B SMEs to move from a service infusion towards a servitization strategy, or to empower the pre-existing servitization strategy.

Since the beginning, Investments in I4.0 technologies were coupled with specific business opportunities related to new or additional services that could be offered in the market. Investing in I4.0 could sometimes be functional to reduce costs and survive competition, but it is not enough to generate new streams of revenues related to these new services.

Companies that have simultaneously adopted a combination of I4.0 technologies in line with their servitization strategy were better able to exploit the value of the investment. Hence, I4.0 technologies can boost the effect that servitization strategies have on the performance of the firm, but they are not sufficient *per se* to generate better performance. They can bring positive returns in terms of customer loyalty and product positioning upgrading, among others.

Based on this, we advance our last research proposition:

Research proposition 3: The combined adoption of I4.0 technologies - namely the Internet of Things, simulation, cloud computing, big data and analytics - leads to positive performance outcomes when coupled with a clear servitization strategy.

6. Conclusions

This study contributes to servitization literature, by providing initial empirical evidence of the interactions between I4.0 digital technologies and servitization, and their impact on firm performance in a B2B manufacturing context. Also, it contributes to management literature by offering preliminary empirical evidence of Italian manufacturing SMEs that have adopted I4.0 technologies.

Investments in new technologies are sometimes needed to remain competitive, but technologies *per se* do not automatically provide additional revenue streams or higher profitability. The cases we analyzed in this paper well highlight the fact that the competitiveness of B2B firms in particularly challenging sectors (such as the mechanical sector) requires strategic proactiveness, technological evolution, and customer orientation. In this sense, investments in I4.0 technologies can boost the current evolutionary process and ongoing strategies, and even pave the way to new business strategies, but do not offer sufficient conditions to increase the competitiveness of firms.

Servitization strategies, in turn, are resource-demanding and imply specific strategic, marketing and financial challenges: the organization must be prepared for such a change; revenue models must be revised and may not be easy to define; customers should be “educated” in relation to new services to understand the concrete benefits and be willing to pay a premium or extra fee for them. Last but not least, most services require new data and privacy management policies. All these phases require financial resources. Hence, it is more likely for firms operating in B2Bs to adopt a step-by-step process in the transition from product-based to service-based business models, rather than radical moves. Such a transition may be boosted by the adoption of certain I4.0 technologies that act as accelerators, rather than enablers, of the transition. We refer, in particular, to IoT, simulation, cloud computing and big data collection (and analytics).

As regards the impact of servitization strategies and I4.0 technologies on firm performance, our results are not conclusive but offer interesting insights for further studies. Overall, the key to success seems to lie in the coherence between technology and strategy. However, there might be different nuances in this landscape. Some companies can invest in a few selected technologies to infuse services in their offering, while other firms adopt a group of technologies in accordance with a radical servitization strategy. Both situations can lead to positive impacts, but we might expect a greater effect in the case of higher levels of digital technologies and higher levels of servitization, as underlined by Frank *et al.* (2019), as long as there is coherence between them. In this sense, more in-depth studies will be needed.

The managerial implications of our study are straightforward: investments in (selected) I4.0 technologies should be carried out with the aim of empowering existing (or adopting new, but specific) servitization strategies. Otherwise, the firm’s returns will be unclear.

Our study comes with several limitations, mainly due to the limited number of analyzed cases. Further studies involving larger samples will be needed to empirically test the strength of our research propositions.

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Guido Bortoluzzi
 Maria Chiarvesio
 Rubina Romanello
 Raffaella Tabacco
 Valerio Veglio
 Industry 4.0 technologies
 and the servitization
 strategy: a good match?

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Guido Bortoluzzi
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 and the servitization
 strategy: a good match?

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