Digital servitization as Business Model Innovation: an explorative study on the role of absorptive capacity

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Abstract

Frame of the research: *Firms often face the digitalization paradox. Digital servitization may be the key to unlocking the value of investing in digital technology. More research is needed on the enabling factors of such processes. Notably, the extant literature suggests that dynamic capabilities can play a role. Hence, we suggest that ACAP, as a particular type of dynamic capability, positively influences the relationship between Industry 4.0 adoption and digital servitization.*

Purpose of the paper: *The study investigates how the firm's absorptive capacity allows to appropriate value from Industry 4.0 by enabling digital servitization.*

Methodology*: A single case study based on semi-structured interviews with key informants.*

Findings*: The business model innovation process towards digital servitization started with the value proposition to affect the value creation and value capture dimensions. Significant changes exist in product/service development, human resources competencies, and business relationships with customers and suppliers. The firm's absorptive capacity represents a significant enabler of such a process.*

Research limits: *A single case study suffers from limitations related to the external validity of results, which may be overcome by a multiple case study. Besides, increasing the number of interviews and collecting data from other actors (e.g. customers, suppliers, etc.) would allow a broader view.*

Practical implications: *Developing absorptive capacity might help manufacturing firms in overcoming the digitalization paradox. Managers should encourage exploratory, transformative, and exploitative learning that can facilitate the provision of value-added services that allow the firm to appropriate value by enhancing its bargaining power and expanding its market.*

Originality of the paper*: The study primarily contributes to the digital servitization literature by providing empirical evidence on its enabling factors. It also contributes to the knowledge management field and the literature on absorptive capacity.*

Key words: industry 4.0; digitalization; digital servitization; business model innovation; absorptive capacity; single case study

1. Introduction

Industry 4.0 (I4.0) offers tremendous opportunities for manufacturing companies' growth and innovation given the ongoing paradigm shift from

an industrial to a more digital economy (Porter and Heppelmann, 2015). Yet, firms often experience the "digitalization paradox": despite significant investments in digitalization, they often fail to achieve the expected revenue enhancement (Gebauer *et al.*, 2020; Kohtamäki *et al.*, 2020). For instance, firms tend to invest in advanced digital technologies without a clear strategy for how customer-related data would be used to improve financial performance (Kohtamäki *et al.*, 2020).

To achieve the envisioned results, companies should not merely adopt I4.0, but rather leverage these technologies to innovate their business models (BMs) (Gebauer *et al.*, 2020; Müller *et al.*, 2021, 2018). Notably, deploying digital technologies to support the transition from a product-centric to a service-centric BM may be the key to unlocking the value of digitalization (i.e. digital servitization BMs) (Coreynen *et al.*, 2017; Kohtamäki *et al.*, 2020, 2019; Tronvoll *et al.*, 2020). Yet, although the concept of digital servitization (DS) has been gaining momentum, the empirical evidence on the relationship between digitalization and servitization in manufacturing companies is scant (Kohtamäki *et al.*, 2020; Tronvoll *et al.*, 2020). This far, the literature has focused on identifying specific DS pathways (Coreynen *et al.*, 2017) and understanding how DS affects financial performance (Kohtamäki *et al.*, 2020), whereas little is known about the factors that might help firms to innovate their BM towards DS (Coreynen *et al.*, 2020).

Scholars suggest that DS might depend on companies' resources and capabilities, experience, and organizational routines (e.g. Coreynen *et al.*, 2020, 2017; Paiola *et al.*, 2021). In this regard, previous studies showed that absorptive capacity (ACAP) is a fundamental capability to stimulate various forms of innovation, including business model innovation (BMI) (Ali *et al.*, 2016; Kostopoulos et al, 2011; Miroshnychenko *et al.* 2021). Hence, we suggest that the absorptive capacity (ACAP), which is commonly conceptualized as a particular type of dynamic capability (Zhara and George, 2002; Miroshnychenko *et al.* 2021) and specifically, the capability of identifying, assimilating, transforming, and applying external knowledge (Cohen and Levinthal, 1990), is a suitable theoretical lens to understand how companies can effectively reap the benefits of an I4.0-enabled transition (Ardito *et al.*, 2021).

Specifically, I4.0 leads to redesigning the BM of established companies by incorporating new external knowledge into internal activities (Müller *et al.*, 2020). As such, I4.0 requires firms to re-examine the ways they can effectively manage external and internal knowledge (Ardito *et al.*, 2021). Firms wanting to successfully leverage external sources need to develop internal capabilities to acquire, internalize, and exploit external knowledge (Cohen and Levinthal, 1990).

Therefore, this article employs a single case study to investigate the enabling factors of DS by emphasizing the role of ACAP. We aim to answer the following research question: how does the firm's ACAP allow appropriate value from I4.0 adoption by supporting DS? Put differently, is ACAP an enabling factor of DS? To the best of our knowledge, this is the first attempt to empirically show how ACAP facilitates DS. In doing so, the article provides a novel perspective to the literature on DS and knowledge management (KM) by linking ACAP to digital-driven BMI processes.

2. Literature background

2.1 Digital servitization as business model innovation to mitigate the digitalization paradox

Based on digitization, automation, and interconnection, I4.0 represents a paradigm shift in the manufacturing industry toward the next industrial revolution (Liao *et al.*, 2017; Müller *et al.*, 2018).

I4.0 leads to more efficient product development, more efficient and flexible manufacturing, more sophisticated products and services, more integrated value chains, higher customization (Müller *et al.*, 2018), improved customer participation in product design (Naeem and Di Maria, 2021).

Yet, although companies face complex processes and high budgets, they fail to achieve the expected revenue growth (i.e. digitalization paradox) (Gebauer *et al.*, 2020). In other words, when cumulative investments in digitalization are relatively small, revenue enhancement remains in line with expectations. However, as cumulative investments increase, companies increasingly face the digitalization paradox and do not obtain the projected revenue enhancement. Following another perspective, a large majority of firms remain stuck in the so-called "pilot purgatory" (Gregolinska *et al.*, 2022), experiencing several difficulties in capturing the full potential of their investments.

A possible reason could be that companies find difficulties in successfully leveraging digital technologies to change their BMs (Gebauer *et al.*, 2020; Paiola, 2018). Interestingly, Kohtamäki *et al.* (2020) find that the decreasing returns from digitalization to firm performance are mitigated by higher levels of servitization, which could be an effective path for creating and appropriating value from digitalization in manufacturing companies.

The concept of "servitization" is largely acknowledged as a transformation journey of product-centered firms that manifests in advanced services and integrated solutions (Baines *et al.*, 2009; Ulaga and Reinartz, 2011). A cornerstone of servitization is strong customer centricity (Baines *et al.*, 2009). Such orientation consists in the shift from product-oriented services to user processes-oriented services as well as in the shift from selling to cultivating customer relationships (Oliva and Kallenberg, 2003).

The literature acknowledges different servitization types that can be positioned on a product-service continuum, whereby services might complement products or entirely substitute them (Baines *et al.*, 2009; Tukker, 2004). Overall, servitization seems to offer several opportunities for manufacturers, such as strategic differentiation and competitive advantage (Gebauer *et al.*, 2011), high-profit margins (Baines *et al.*, 2009), and building unique and long-term customer relationships (Tukker, 2004).

Servitization is largely considered a way to innovate the BM of product firms (Casprini, 2015; Frank *et al.*, 2019; Paiola and Gebauer, 2020), affecting the product firms' value proposition, value creation, and value capture mechanisms (Ayala *et al.*, 2017; Frank *et al.*, 2019). Through

servitization, BMI follows a demand-pull innovation trajectory, where the value proposition is focused on the customers (Frank *et al.*, 2019). Turning into a service provider represents a shift in focus since the firm intends to generate higher revenues from the service part of the business. Besides, service strategies entail building an ability to deliver services, changing long-standing practices, training personnel to become service-oriented, as well as developing a new organizational culture (Baines *et al.*, 2009).

Nowadays, digital technologies are deemed to enable servitization in the manufacturing industry (Kohtamäki *et al.*, 2019; Paiola and Gebauer, 2020) and the term "digital servitization" appeared to describe the convergence of servitization and digitalization (Gebauer *et al.*, 2021). Various definitions of DS exist in literature; we refer to Paschou *et al.*'s (2020) conceptualization as "the development of new services and/or the improvement of existing ones using digital technologies. These can be exploited to enable new (digital) business models, to find novel ways of (co)creating value, as well as to generate knowledge from data, improve the firm's operational and environmental performance, and gain a competitive advantage" (p. 284).

DS might occur through different pathways which demand different resources and capabilities and lead to different benefits (Coreynen *et al.*, 2017; Paiola and Gebauer, 2020). It not only brings value to customers but rather data and information gathering might also improve internal processes (Frank *et al.*, 2019). Moreover, DS is likely to affect the bargaining power in different sections of the value systems and how manufacturers increase their power using digitalization (Kohtamäki *et al.*, 2020). For instance, DS generates closer provider-customer relationships characterized by co-creation logic, long-term commitment, and greater investment in the relationship (Coreynen *et al.*, 2017).

Scholars suggest that a successful DS depends on companies' resources and dynamic capabilities (e.g. Coreynen *et al.*, 2020, 2017; Paiola *et al.*, 2021). Design-to-service capability, service sales capability, user involvement capability, as well as dynamic capabilities, such as customer needing interpretation capability, and data processing capabilities, allow manufacturers to overcome DS challenges (Coreynen *et al.*, 2017; Ulaga and Reinartz, 2011). According to Paiola and Gebauer (2020), extant manufacturing resources and capabilities (such as a firm's in-depth product knowledge) need to be complemented with new ones and firms need to possess the ability to constantly reconfigure their strategic capabilities to meet continuously evolving customer needs (Bustinza *et al.*, 2018).

Hence, it is likely that dynamic capabilities, and particularly the capabilities of combining external and internal knowledge, are significant enablers of DS as BMI, in the context of I4.0.

2.2 Absorptive capacity

ACAP was defined by Cohen and Levinthal (1990, p. 128) as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends". Such concept spans beyond the resource-based view (Barney, 1991) by contending that differences in organizational

performance and competitive advantage can be explained by companies' different abilities to explore, assimilate, and exploit new knowledge over time (Schlagwein and Hu, 2016; Zahra and George, 2002). Therefore, even though a firm's ACAP is dependent upon prior related knowledge (Cohen and Levinthal, 1990), the predominant theoretical view is that it is not an asset, but rather a particular type of organizational dynamic capability (Chichkanov, 2021; Hussain *et al.*, 2022; Zahra and George, 2002).

It is well known that ACAP influences innovation and firms' performance (Gebauer *et al.*, 2012; Miroshnychenko *et al.*, 2021; Todorova and Durisin, 2007; Zahra and George, 2002) and also the innovation of a business model (e.g. Bhatti *et al.*, 2021; Kranz *et al.*, 2016; Miroshnychenko *et al.*, 2021; Müller *et al.*, 2020). The recombination and integration of internal and external knowledge play a crucial role in renewing or reinventing the fundamental components of BMs. In addition, the ability to acquire and use external knowledge can provide firms with new ideas on how to change the current BM to extract and capture more value. In the I4.0 scenario, the assimilation of external knowledge is even more critical for the successful transformation of processes and products, especially for traditional and incumbent organizations (Ricci *et al.*, 2021; Siachou *et al.*, 2021)

Significantly, not only technological knowledge is relevant, but also market knowledge (Kranz *et al.*, 2016; Lane *et al.*, 2006) and this could be especially important in servitization because it often entails targeting new customer segments.

Following this line of reasoning, we may suggest that ACAP is a fundamental capacity in the transition towards servitization because it allows firms to use external knowledge - for example, the "knowledge from customer" - more efficiently, to easily sense new opportunities and to enhance the service value proposition offered. In the KM field, the acquisition of client knowledge through the wide number of digital channels and the assimilation of such knowledge across different functional areas are positively associated with both product and business process innovations in knowledge-intensive business services (Chichkanov, 2021). Moreover, Coreynen *et al.* (2020) found that both exploitation and exploration are associated with digital servitization and ACAP is positively related to such activities (Escribano *et al.*, 2009; Müller *et al.*, 2021). It is worth noting that DS calls for collaboration across firm boundaries within ecosystems (Tronvoll *et al.*, 2020; Kohtamaki *et al.*, 2019), and, therefore, ACAP is likely to play a pivotal role in leveraging knowledge within such networks. Finally, ACAP may facilitate the embedding of digital technologies needed for service transition. Hence, we posit that ACAP could be a fruitful theoretical lens for understanding the enabling factors of DS in an I4.0 context.

The literature conceptualizes ACAP as a group of intangible capabilities to manage knowledge (e.g., Saiz *et al.*, 2018) or as several distinct but complementary dimensions, namely acquisition, assimilation, transformation, and exploitation of external knowledge (Ardito *et al.*, 2021; Zahra and George, 2002). According to the second perspective, Lane *et al.* (2006) propose a learning process-oriented definition by arguing that ACAP is a firm's ability to utilize external knowledge through three

sequential processes: (1) recognizing and understanding potentially valuable new knowledge outside the firm through exploratory learning, (2) assimilating valuable new knowledge through transformative learning, and (3) using the assimilated knowledge to create new knowledge and commercial outputs through exploitative learning. We adopt this perspective in interpreting the empirical findings of our research and suggest that ACAP may influence the relationship between the I4.0 investment and the business model transformation toward DS.

3. Research method

3.1 Single case study

Since research on DS is still in its infancy (see Kohtamäki *et al.*, 2020; Tronvoll *et al.*, 2020), we adopt a single case study to investigate the driving factors of DS in an I4.0 context. A single case study does not aim at statistical generalization, but rather its objective is a thorough analysis and understanding of a single subject. The case study method is best suited to properly answer 'how' and 'why' questions, thus supporting the analysis of complex phenomena in which many elements, processes, and actors must be considered as they interact with one another. As such, this method appears particularly useful to provide in-depth information and allow for a comprehensive and realistic understanding of the phenomenon under investigation (Yin, 2014), to fully grasp the dynamics and complexities of DS which are linked to the specific context of the analysis.

The case company (Alpha) is a family-owned small and medium-sized (SME) footwear manufacturer, working as a sub-supplier for high-luxury fashion brands. The reason for selecting this firm is twofold. First, since 2014 it has progressively invested in I4.0 to support a transition process from being a mere supplier of products (sub-supplier) to becoming an advisor and consultant by providing value-added services relating to the customers' product design process. Hence, servitization spans beyond the scope of supporting the functioning of the product or the creation of additional cash flows due to customer's purchase of new services to encompass a path that adopts a customer-centric perspective to enhance customer satisfaction and loyalty in the long run (Raimondi, 2011).

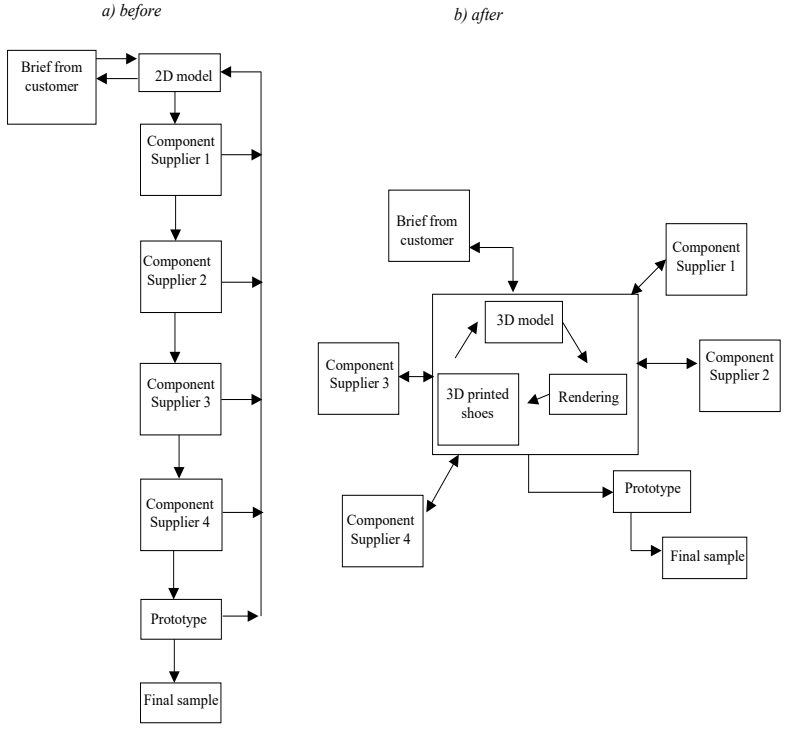
Notably, Alpha has significantly invested in I4.0 by focusing on two major technological areas:

- 3D technologies (i.e. 3D rendering, 3D printing, 3D configurators). Such technologies are customer-centric innovations that entail significant implications even for companies in the most traditional industries (Martinelli, 2018). Specifically, 3D rendering and 3D printing are aimed at changing the product development process (Fig. 1). The previous model was based on a sequential and iterative process involving footwear samples, fittings, and design-related changes to transform the initial customer's idea into the final product. It was a very expensive and time-consuming process, also entailing communication problems between the parties. Digital technologies allow a circular and

iterative model to design a detailed 3D rendering which is then printed in artificial resin. Moreover, the firm invested in 3D configurators for physical stores owned by B2B customers as well as for the e-commerce website for the B2C market.

- Two robotic machines aimed at replacing human interventions in the production process to relieve workers of dangerous processing tasks (e.g. due to unhealthy powders and glues) and alienating activities.

Fig. 1: The product development process before and after the adoption of 3D technologies



Source: authors' elaboration

Thus, the case is especially relevant due to the use of digital technologies geared toward the shift from product-centric to service-centric business logic. Moreover, for such a commitment to the implementation of I4.0, the firm was awarded the Innovative SME and SMAU Innovation prizes. Second, Alpha provided a very high level of access to the firm (De Massis and Kotlar, 2014) as researchers were able to interview key informants (i.e. the company's owner, the marketing consultant, and the project manager) on multiple occasions during the period of the study.

3.2 Data collection and analysis

Study data were collected between May 2018 and November 2020 by using multiple sources to guarantee triangulation and provide stronger

empirical evidence (Eisenhardt, 1989) (Table 1). Semi-structured face-to-face interviews represent the primary source to ensure uniform coverage of the research themes as well as the right flexibility in gathering key informants' free descriptions and opinions. Direct observation and archival data analysis were employed to provide additional information, verify, and increase evidence (Eisenhardt, 1989). For instance, the firm's website and presentation about I4.0 were used to assess the investment in such digital technologies, whereas on-site visits allowed to see how the I4.0 technologies are employed in the firm.

Tab. 1: Data collection

Data source	Date	Key informants	Duration
Interview	11/05/2018	Owner and Marketing Consultant	1.30 hours
On-site visit	11/05/2018	-	-
Interview	7/12/2018	Marketing Consultant	2 hours
Interview	20/11/2019	Marketing consultant and Project Manager	2 hours
On-site visit	20/11/2019	-	-
Interview	28/01/2020	Marketing Consultant	2 hours
Interview	13/11/2020	Owner and Marketing Consultant	1 hour
Archival data Website, presentations in workshops and conferences about Industry 4.0, meeting reports, articles on specialized magazines			

Source: authors' elaboration

We conducted five interviews with key informants involved in the DS process and two on-site visits. The interviews lasted between one and two hours, they were conducted in Italian, audio recorded, and transcribed verbatim. The interview track was based on open-ended questions within a standardized protocol to ensure both guidance and consistency in the interviewing style as well as an adequate level of freedom in answering.

The interview guideline is structured into four sections (Table 2). First, the respondents were asked to describe the firm's business and clarify their professional role in the company. The second section aims to shed light on the I4.0 technologies used and their application, by highlighting benefits and challenges. The third section is devoted to investigating the effects of such technologies on the way of doing business. Finally, the fourth section consists of follow-up questions to better understand the role of absorptive capacity understood as the ability to assimilate, transform, and exploit external knowledge to support DS.

We performed a manual coding aggregating the data into categories that facilitate the analysis (De Massis and Kotlar, 2014; Miles and Huberman, 1994). Before being analyzed, the information gathered was manipulated by applying data reduction and condensation to ease the analysis and focus on which data best answers the research question. Then, we labeled interview pieces that have the same message or are connected in some way and added an accompanying explanation of what the selected excerpts have in common. Such coding process employed an abductive approach (e.g. Dubois and Gadde, 2002) . By doing so we used case study data to

illustrate how the firms' ACAP may represent the key to unlocking the potential value of digital technologies (specifically I4.0 technologies) in DS.

Tab. 2 Interview guideline

1st section - Background information
Could you give us some general information about the company (e.g., industry, turnover, employee number, etc.)? Could you briefly describe the company's historical background? Please describe shortly the current company's business. What are the company's main products, activities, and markets? What is your professional role in the company?
2nd section - Leveraging I4.0
Can you point out the key ways you use I4.0 technologies and in which fields? What are the key benefits of using I4.0? What are the main challenges of using I4.0 in your business?
3rd section - Digital servitization
What products and services are provided to the customer *(ask for concrete examples of basic - e.g. warranty - intermediate - maintenance, training - advance - support agreements outsourcing - services)?* What are the main opportunities that I4.0 provides to expand your service-oriented offerings? How do I4.0 technologies impact your way of doing business? *Follow-up questions on DS as BMI (if not mentioned by the respondent)* - *What are the main changes in customer segments related to the implementation of I4.0?* - *What are the main changes in customer relationships related to the implementation of I4.0?* - *What are the main changes in distribution channels and activities related to the implementation of I4.0?* - *What are the main changes in supplier/partner relationships related to the implementation of I4.0?* - *What are the main changes in the firm's key resources and activities related to the implementation of I.40?* - *What are the main changes in the revenue streams and payment methods related to the implementation of I4.0?* - *What are the main changes in cost structure due to the implementation of I4.0?*
4th section - Absorptive capacity
What is the role of I4.0 in acquiring new external knowledge? What is the role of I4.0 in enhancing customer understanding? Who oversees collecting and using the acquired external knowledge? How is external knowledge employed? What is the relationship between the newly acquired knowledge and the firms' existing knowledge and expertise on products and customers? Which tools are employed to spread knowledge in the firm? How does the use of external knowledge contribute to the development of new services? Are there any challenges related to the acquisition and use of external knowledge?

Source: authors' elaboration

4. Findings: innovating the business model toward digital servitization

Alpha is shifting from a product-centric to a service-centric BM. This DS process started in the product design and development area to affect the entire firm's business logic by requiring significant transformations in organizational competencies as well as business relationships with customers and suppliers. This section describes the firm's DS by highlighting

how the implementation of I4.0 technologies changes the three main BM areas: value proposition, value creation, and value capture. To support the study findings, illustrative quotes relating to changes in each BM area are provided in Table 3.

a) Value proposition

I4.0 technologies allowed Alpha to transform its value proposition from idea generation to prototyping and the following production of the footwear sample.

The implementation of 3D technologies improves Alpha's capability of identifying and acquiring externally generated knowledge (cf. acquisition and assimilation of external knowledge) on customers' needs. Before the investment in such technologies, understanding customers' requirements was rather difficult due to the vagueness of the designer's idea of the final product (in terms of materials, shapes, accessories, etc.); hence, customer knowledge was only available upon realizing footwear physical samples. On the contrary, 3D rendering allows to work on products' digital images, instead of directly creating a prototype or a sample. Moreover, Alpha offers a virtual fitting service which appears extremely helpful for customers' product configuration. Enhanced customer knowledge can be used to fine-tune the model in real-time based on its needs as well as create tailor-made products. This has significantly streamlined the entire product design and production process.

Hence, Alpha shifts its value proposition from producing the final product (i.e. shoes) and being a mere sub-supplier toward integrating value-added services throughout the entire design process, thus becoming an advisor and consultant. In this regard, the firm plays a pivotal role in translating the customer's idea (generally a sketch or a brief) into a real product. Alpha's customers are luxury fashion houses, lacking an internal division dedicated to accessories (i.e. shoes and bags), thus needing a sub-supplier that can interpret and convert the designer's idea into products. Overall, this allowed the firm to become highly specialized, while offering an innovative service and becoming a partner for the client instead of a mere manufacturer.

Customization is another dimension of the company's digitally enabled service-oriented value proposition. The firm guarantees the ability to fully customize the product for the business customer. Changes to the product forerun the prototype and the final sample to significantly reduce design errors and increase product quality.

Leveraging 3D technology to design products makes variability, which is usually costly as it requires changing physical parts, far cheaper. Moreover, the company aims to seize the opportunity to access the end consumers by investing in digital product configurators to offer a customization service both in third-party stores and through the firm's e-commerce website.

b) Value creation

Business model changes affecting the value creation mechanisms relate to three specific aspects: organizational competencies, production efficiency, and supplier and partner relationships.

Firstly, the adoption of I4.0 technologies requires Alpha to complement its traditional technical expertise on shoe making (i.e. prior knowledge) with the newly acquired knowledge and develop additional capabilities. As the customer does not have the technical know-how to design and create the product, Alpha's long-standing technical skills are pivotal. Alongside this, the firm displays the development of unique customers needing interpretation capabilities to integrate its prior knowledge of products with the new knowledge regarding customers' needs and requirements for providing value-added services. Moreover, Alpha is consistently enhancing the employee's digital-related capabilities to manage 3D technologies and use digital technical data sheets, which specify the prototype and product details (e.g. leather, lining, etc.).

All this information represents a valuable knowledge asset that Alpha is nowadays able to code and share in real-time between the departments involved in the design and production processes to support the development of value-added services. In this regard, the interviewees highlighted that if all the models created in the last twenty-five years had been recorded, as they are now, today Alpha would have an incredible amount of knowledge. Moreover, the possibility to share and internalize data across departments via digital channels significantly reduces errors.

The implementation of I4.0 also required a generational change, especially at the production level, as the workforce needs to use digital technologies (e.g. tablets, robotic machines, etc.) to acquire customer data and information to correctly fulfill their tasks.

Secondly, value creation-related changes entail greater efficiency in the design and production processes. Thanks to 3D technology and its capability of collecting and assimilating valuable knowledge, Alpha cuts errors and costs for physical prototypes by avoiding unnecessary expenses for molds and real accessories. Moreover, this also shortens the timeframe for their development as the entire process can be executed in a shorter time without waiting for its suppliers to make the molds before showing a prototype to the customer.

Thirdly, Alpha's value creation changes also relate to relationships with suppliers and partners. Alpha can show the prototype through 3D technologies to its customers, without waiting for the shape or the mold to be made, thus becoming less reliant on suppliers, and acquiring more power in the relationship.

Moreover, sharing 3D files among all the parties involved in the design and production processes (i.e. customer and component suppliers, such as heel and sole factories) fosters a more intense collaboration along the entire supply chain and a significant reduction of the time-to-market. Interviewees also noted that such knowledge-sharing mechanisms with suppliers streamline the communication flow and ease the job.

Alpha is also increasingly involved in strengthening collaborations with external actors, mainly schools and universities, that provide technical support for ensuring the customization service. Moreover, since Alpha has invested in developing its brand, it relies on university collaborations to develop marketing-related knowledge and competencies. The interviewees also emphasized that training individuals to perform new professional roles

is pivotal for the entire supply chain. In this regard, universities become a valuable source of specialized expertise.

c) Value capture

Although Alpha has not yet experienced changes in its revenue model, a shift towards DS enhanced the value capture mechanisms by improving existing customer relationships and acquiring new customers.

First, business relationships of mere shoe sub-suppliers are usually extremely biased in favor of the customers. Alpha's capability to combine its technical expertise in footwear with new knowledge to develop customer-needing interpretation capabilities, allows it to successfully develop co-design activities with its customers, thus becoming a consultant throughout the entire design process - from the prototyping to the final product. The creation of such a partnership allows Alpha to acquire greater bargaining power in the relationship.

Moreover, the use of 3D technologies and increased knowledge sharing enhances customer contact, hence allowing them to overcome the physical distance, which was one of the main problems in the customer relationship. In this regard, Alpha employs new mechanisms for customer interaction through digital communication. Alpha can share 3D files with customers which significantly eases real-time interactions and understanding of customers' needs. Similarly, interviewees emphasize the tremendous advantage of using a virtual fitting room which allows the customers to reduce the number of business trips and expedite the entire design and production process.

Finally, the shift toward DS also allows the acquisition of new customers. Notably, alongside traditional B2B customers (i.e. luxury fashion houses), Alpha is now reaching new startups owned by young designers eager to emerge in the luxury industry. Moreover, the firm is also approaching the B2C market by moving toward the end consumer through investments in 3D configurators and individually tailored value offers.

Tab. 3: Illustrative quotes

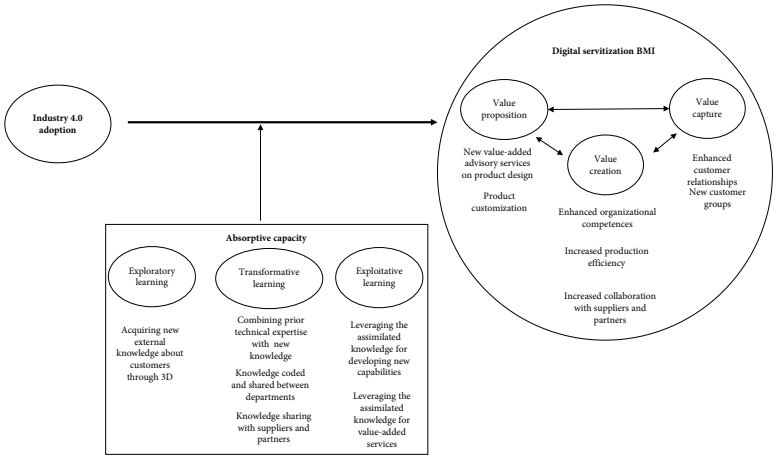
Illustrative quotes	Digital servitization
	Value proposition-related changes
Marketing consultant: "Once the prototype, the mold, the heel, etc. are created, traditional sub-suppliers can verify if the results are what the customer had in mind […] Customers in the luxury sector need to be taken by their hand. The supplier should take their idea and make it come true. None can guarantee this kind of service in Italy. This allowed us to become partners."	Alpha shifts its value proposition from producing final products (i.e. shoes) to providing digitally-enabled value-added services (i.e. consultancy) throughout the entire design and production process
Project manager: "We created a virtual fitting room, where we set up a projector and worked with the model wearing the shoes. In this way, the customer can see what we're working on in real-time, and we can design together the product remotely."	
Marketing consultant: "The customer's designer may imagine a given height for the heel, you ask for a mold, then they want to change the height, which requires changing everything and results in additional time and costs. […] Digital technologies provide us with information to refine the product in the design phase before making the footwear sample. We first design in 3D and create a high-quality rendering to understand if we are on the right path or not."	
Project manager: "We provide services from the initial design, as we realize a detailed rendering of the product. Thanks to 3D technologies, we can limit the costs of prototypes by receiving immediate feedback from the customer. Then, we can make a 3D resin shoe a few days after rendering. The designer is usually a clothing specialist who can get the shoe's idea by seeing a rendering or by holding a 3D shoe in his hand."	

Marketing consultant: "Each line they need to make has a given shape, a heel, on which you can create many models. We receive the collection plan for the upcoming season and discuss the details with the customer. For example, 99% of the time they want a customized heel, for which we need to create a specific mold. Even the sole is usually made exclusively for the customer. Likewise, accessories are all customized; a buckle, a button, everything must be made with a special mold."	Alpha provides customization services to B2B customers and seizes the opportunity to directly access the end consumers with customized offerings through product configurators
Project manager: "We worked together with a software house for a year and a half to create a configurator that allows the consumer to personalize shoes. Either we place the configurator in outstanding third-party stores for the consumer who physically visits them, or the consumer can do it at home through the e-commerce platform."	
	Value creation-related changes
Marketing consultant: "The customer lacks knowledge in footwear and recognizes that Alpha holds the technical skills to manage the entire design and production process. They just decide the material and price ranges […] [Moreover] you need to change your attitude towards each customer; it's a matter of cultural interpretation. This is the difference between a mere third-party sub-supplier and Alpha which is a partner of major luxury fashion houses."	Organizational competencies: Alpha complements the new knowledge and prior knowledge and develops new capabilities, namely customer needing interpretation capabilities and digital technology-related capabilities
Project manager: "The style is important, yet when it comes to shoes the technical part is pivotal. […] We needed to change the workforce's mindset. Today we have a very low average age, and even those working manually use a tablet in their job. These guys are familiar and willing to use digital technology; if we had asked their fathers, they would have never done it."	
Marketing consultant: "The digital data sheet indicates the required changes which are shared among the departments in real time. Errors can be significantly reduced. […] Each change is directly communicated to those in charge of buying the raw materials, developing the model, etc. Years ago, removing an eyelet, adding an accessory, required a written communication, then an email, and if something went wrong, the entire production of the shoes failed."	
Marketing consultant: "We used to invest a lot to create a shoe sample in a short time, by making molds for the shape, heels, accessories, and so on. […] The risk is incurring higher costs to do the same thing ten times over, to customer's second thoughts, and longer timeframes to manage an entire supply chain. […]. Using the 3D and a rendering, I don't waste twenty days waiting for our suppliers. A mold costs € 500-1000, while a 3D heel costs only € 3. You save two-thirds of the time, with much higher quality and cost savings."	Greater efficiency of the design and production processes: Alpha cuts errors and costs for physical prototypes and shortens timeframes
Marketing consultant: "You no longer wait for the supplier to make the shape, rather we send the supplier the 3D project by directly sharing all the needed information and reducing the timing. Someone gets angry because they used to earn a lot before. […] Someone reluctantly accepts the change as 'earning a half is better than nothing', while others have shown interest in these technologies and think about investing in 3D in their business." Project manager: "Some of our suppliers have adapted to our needs and we now communicate with them in 3D. When the order is loaded, it is immediately ready."	Supplier and partner relationships: Alpha increases its power over the suppliers and enhances collaboration along the entire supply chain. Alpha strengthens partnerships with external actors that provide technical support for ensuring the customization service
Project manager: "We asked several universities to find a mechatronic engineer. […] Customization is how we envision the future, and we are collaborating with some universities supporting us on the technical side to offer a tailor-made service. […] [Moreover] since we invested in developing our brand, it is also important to work with universities on the marketing strategy."	
Owner: "We need to collaborate with universities. The tendency is a generational turnover in manufacturing. However, even young people are reluctant to be trained. I am fascinated by the university and how young people experience this cultural change. The relationship with the University is pivotal."	
	Value capture-related changes
Marketing consultant: "Traditional sub-suppliers are artisans that cannot succeed with their products. If a company can do the same job at a slightly lower price, the customer might change overnight. […] We overturned the balance of power by offering a unique service and becoming partners. A mere manufacturer will never be essential. […] Fashion houses only recommend the style, even the choice of materials is often shared. They acknowledge our expertise and ask us to organize the work."	Alpha acquires power over its customers by developing co-design activities and becoming a consultant throughout the design and production process
Marketing consultant: "We had a problem with one of our major customers: business trips from Paris to Le Marche are complicated. By using a virtual fitting, we can work in real-time and remotely. In this way, the customer is more focused, the interaction is fast and intense. This helps a lot when trying to translate customers' needs into a prototype and a product."	Alpha enhanced customer contacts and interactions
Owner: "We needed to invest in new digital technologies also to improve the customer relationship. Travelling from Paris is complicated. Our geographical location became a risk.[…] With virtual fitting, they need two business trips per year instead of six, saving both time and mental stress."	
Marketing consultant: "Our B2B customers are well-known brands with a long history as well as new startups of emerging designers. For example, we worked with a young Nigerian girl whose successful business addresses the African luxury market. A young Tunisian customer carried out a similar project in the United States."	Alpha acquires new customers alongside traditional B2B customers

5. Discussion and proposition development

Study findings show how the ACAP enables a DS process driven by the adoption of I4.0 technologies (Fig. 2). Hence, the more effectively the firm can explore, transform, and exploit external valuable knowledge (Lane *et al.*, 2006), the higher the likelihood to leverage I40 technology to its fullest potential, thus overcoming the digitalization paradox through DS. Accordingly, drawing on the identification of such a role, the study offers propositions to guide future research.

Fig. 2: The role of absorptive capacity in digital servitization



Source: authors' elaboration

P1. The firm's ACAP appears to strengthen the relationship between I.40 adoption and DS.

Although external knowledge searches have become increasingly important for firms, knowledge transformation, and exploitation are also vital to effectively embarking on a DS process and unlocking the value of digital technologies to innovate the BM. It is not just the potential ACAP (i.e. acquisition and assimilation of knowledge) that drives BMI (Miroshnychenko *et al.*, 2021). Still, all three learning processes (i.e. acquisition, transformation, and exploitation of knowledge) contribute to DS.

Notably, the firm performs exploratory learning by identifying and gathering new external knowledge regarding customers' needs and requirements through 3D technology as it steadily interacts and exchanges information with them. In this regard, increased contacts enhance access to customer's knowledge (Chichkanov, 2021). However, 3D technologies not only improve the intensity and the speed of the firms' efforts to identify and collect knowledge which determines the quality of a firm's acquisition capacity (Zahara and George, 2002), but the firm shows a capability to recognize the value of new external knowledge which represents an

important component of ACAP because "seeing" or "understanding" the potential of the new external knowledge is not automatic (Todorova and Durisin, 2007). In this regard, the 3D rendering itself is acknowledged and used as key information on customers' needs, to guide the product design and production process effectively and efficiently. Thus, we propose the following:

P1a. Exploratory learning by identifying, gathering, and recognizing the value of external knowledge is likely to enhance the relationship between I4.0 adoption and DS.

An embedded knowledge base and existing capabilities often prevent firms from identifying and absorbing valuable external knowledge (Kraz *et al.*, 2016; Todorova and Durisin, 2007). In this regard, we show that the firm has developed routines and processes to assimilate and interpret this valuable information (i.e. transformative learning) (Gebauer *et al.*, 2012; Lane *et al.*, 2006). Specifically, the firm combines prior knowledge (Paiola *et al.*, 2021), namely established knowledge and expertise about products and customers, with the newly acquired knowledge about customers' needs. This is valuable to assist the customer during the design process and translate its requirements into concrete product features, thus providing value-added consultancy services. Hence, firms need to look beyond their boundaries for external sources of knowledge to renew their knowledge, but most importantly they need to complement it with internal experience and resources to be able to develop more innovation (Saiz *et al.*, 2018). Such transformative learning also occurs through the development of knowledge-sharing mechanisms between organizational departments by coding relevant information into digital format. These organizational mechanisms associated with cross-functional interfaces and cooperation activities are central to the firm's ACAP (Jansen *et al.*, 2005; Saiz *et al.*, 2018). Notably, digital data that indicate prototypes and product features that fit the customers' requirements represent formal social integration mechanisms that facilitate the distribution of information within the firm as well as gathering interpretations (Zahara and George, 2002). This allows the assimilation of valuable knowledge that would not be otherwise stored and internalized. In doing so, the organization converts the acquired external knowledge into organization-specific knowledge (Lane *et al.*, 2006; Schlagwein and Hu, 2016; Yaun *et al.*, 2022). Hence, the ease with which information can now be edited, updated, and searched supports the assimilation, analysis, and reactivation of relevant knowledge in the organization.

In addition, such transformation of the acquired external knowledge into actionable knowledge for the organization's operations relates to a more intense collaboration and knowledge flow with external firms such as suppliers and partners. In fact, through such strengthened relationships, the firm refines and complements the acquired knowledge to develop marketing-related knowledge about product customization.

Study findings show that firms without the capability to combine and share internal and external knowledge into actionable knowledge can only

be product manufacturers and sub-suppliers, completely dependent upon customers. In this scenario, the adoption of I4.0 technologies can simply result in the so-called digitalization paradox. Thus, transformative learning processes are pivotal for strategic innovation (Gebauer *et al.*, 2012). Notably, the following proposition can be developed on these grounds:

P1b. Transformative learning through combining prior knowledge and new external knowledge, and sharing such knowledge between departments and across firms, is likely to enhance the relationship between I4.0 adoption and DS.

Finally, the firm effectively employs the assimilated knowledge to develop new capabilities (knowledge output) (Lane *et al.*, 2006; Zahara and George, 2002). In this regard, customer-needing interpretation capabilities (Coreynen *et al.*, 2017) appear pivotal to developing and offering a bundle of value-added advisory services regarding product design (commercial output) (Lane *et al.*, 2006; Zahara and George, 2002). In doing so, exploitative learning mechanisms are triggered (Lane *et al.*, 2006) as the assimilated and shared knowledge is successfully leveraged toward a useful end. Considering this, we can develop the following proposition:

P1c: Exploitative learning through leveraging the assimilated knowledge for developing new capabilities and offering value-added services is likely to enhance the relationship between I4.0 adoption and DS.

6. Implications

6.1 Theoretical implications

The study primarily contributes to the DS literature by shedding light on the factors that enable such processes in an I4.0 context. Such a contribution is formulated as propositions for further academic and managerial consideration Specifically, innovating the BM from product-centric to service-centric may help companies to overcome the so-called "digitalization paradox" and unlock the value of digital technologies (Coreynen *et al.*, 2017; Tronvoll *et al.*, 2020). Yet, studies on DS are largely conceptual (Tronvoll *et al.*, 2020; see also Kohtamäki *et al.*, 2019), and there is a lack of thorough understanding of its enabling factors (Coreynen *et al.*, 2020). Thus, we provide empirical evidence on the mechanisms through which the deployment of I4.0 fosters DS by arguing that the mere adoption of digital technologies is not sufficient for such a transformation (Bortoluzzi *et al.*, 2020). Organizational ACAP, namely a particular type of dynamic capability (Zhara and George, 2002; Miroshnychenko *et al.* 2021) of exploring, transforming, and exploiting new knowledge (Lane *et al.*, 2006), is needed to leverage the potential of these technologies.

Hence, by showing that ACAP may positively affect the relationship between I4.0 and DS, we extend the evidence of the influence of organizational dynamic capabilities (Coreynen *et al.*, 2017; Paiola *et al.*,

2021), thus answering previous calls on the role of such capabilities in DS (see Kohtamäki *et al.*, 2019). Recently, Paiola *et al.* (2021) shed light on the role of prior knowledge in DS. We add to these findings by showing that ACAP, including both prior knowledge and new knowledge, might help DS. Furthermore, this study adds to the extant empirical knowledge by extending the DS research focus to under-investigated digital technologies, such as 3D technologies (see Paschou *et al.*, 2020), other than the largely examined IoT (Paiola, 2018).

Additionally, we contribute to the KM literature calling for empirical research on the concept of ACAP (Ardito *et al.*, 2021; Chichkanov, 2021). Notably, the extant KM literature has focused on understanding the relationship between ACAP and innovation (e.g. Chichkanov, 2021; Tseng *et al.*, 2011; Xie *et al.*, 2018) and knowledge transfer processes (e.g. Dell'Anno and Del Giudice, 2015). We adopt an original perspective by investigating the role of ACAP in DS and show the relevance of managing prior knowledge and new customer knowledge for this type of BMI. In doing so, we also offer empirical support to extend prior research suggesting that ACAP is valuable to learn, develop, and assimilate new I4.0-related knowledge (Ardito *et al.*, 2021). Hence, we answer calls for studies regarding BMI from a KM perspective (Chen *et al.*, 2021). By employing Lane *et al.*'s (2006) conceptualization of exploratory, transformative, and exploitative learning, we provide conceptual clarity to show how ACAP might support DS and help in overcoming the digitalization paradox. We decompose the process of knowledge ACAP and identify the role of each dimension in facilitating DS.

Finally, the study findings also provide contributions to the literature on ACAP which lacks empirical evidence and mostly identifies ACAP with knowledge content (e.g. patents, R&D expenditures, etc.) (Zahara and George, 2002). We provide empirical support for the relationship between knowledge ACAP and organizational innovation and further develop the research by embracing an updated conceptualization of ACAP as exploratory, transformative, and exploitative learning. Moreover, studies on ACAP have largely focused on R&D contexts (Cohen and Levinthal, 1990). By linking the concepts of ACAP and BMI, we extend the current perspective beyond the R&D department to encompass the overall organization and its business logic.

6.2 Managerial implications

Traditional manufacturing companies can better understand how to overcome the digitalization paradox in I4.0 contexts. To this end, servitization and digitalization appear to be mutually beneficial. Servitization is indeed a feasible path for creating and appropriating value from digitalization in manufacturing companies, while digital technology increases the strategic and operational effects of servitization.

It is important to note that managers should acknowledge that the relationship between the two can be positively influenced by organizational ACAP. Specifically, the study shows that entrepreneurs and managers should not only encourage investments in digital technologies, but also become

aware that the transformation towards DS may be enabled by exploratory, transformative, and exploitative learning processes, which should be equally emphasized. In this regard, managers should promote and support the use of digital technologies for the acquisition of external customer knowledge. However, such knowledge becomes valuable once integrated with the prior available knowledge and properly assimilated within the organization. Hence, managers should increase coordination capabilities to support sharing mechanisms by implementing cross-functional and cross-firm interfaces. To enhance the assimilation of knowledge, in addition to informal sharing mechanisms, managers should also encourage the development of routinization through the use of formal documents (e.g. digital data sheets) which facilitate the distribution of information within the firm. Otherwise, relying only on informal mechanisms may jeopardize the internalization of valuable knowledge which can then be lost over time.

The developed knowledge can be then leveraged to create new capabilities and value-added services which allow the firm to appropriate value by enhancing its bargaining power and expanding its market.

7. Conclusions and future research

Firms that experience the digitalization paradox can achieve the expected results from their investments in digital technology by developing dynamic capabilities to leverage cutting-edge technologies to innovate BMs. In this regard, manufacturing companies may use digital technology to embark on DS, thus shifting from product-centric to service-centric BM. Notably, this study provides insights into the role of ACAP as a dynamic capability that can help such a process by exploring, transforming, and exploiting external valuable knowledge.

Yet, as in the case of any research, our study design is subject to limitations, some of which offer opportunities for scholars to expand upon our findings.

First, although single case studies can thoroughly describe a phenomenon and generally allow for more detailed descriptions, this approach suffers from limitations related to the external validity of results. Hence, conducting a multiple case study may overcome such limitations and clarify whether an emergent finding is simply idiosyncratic to a single case or consistently replicated by several cases, thus providing a stronger base for theory explanation (De Massis and Kotlar, 2014; Eisenhardt, 1989). We provide propositions that can be tested in future research to assess the transferability of our findings across industries and contexts.

Second, data collection is primarily based on four semi-structured face-to-face interviews with key informants. Although we used additional data sources, such as on-site visits and archival data, to triangulate findings, increasing the number of interviews and collecting data from other actors (i.e. customers, suppliers, and partners) would be beneficial to gain a more holistic view.

Third, the study is focused on the firm's ACAP to explore, transform, and exploit customer knowledge. Future studies may extend the research

findings to other sources of external knowledge (e.g. competitors and partners) and their role in influencing DS processes. Moreover, future research could address additional factors (e.g. other dynamic capabilities) which might interplay with ACAP in DS.

References

ALI M., SENY KAN K.A., SARSTEDT M. (2016), "Direct and configurational paths of absorptive capacity and organizational innovation to successful organizational performance", *Journal of Business Research*, vol. 69, n. 11, pp. 5317-5323.

ARDITO L., CERCHIONE R., MAZZOLA E., RAGUSEO E. (2021), "Industry 4.0 transition: a systematic literature review combining the absorptive capacity theory and the data-information-knowledge hierarchy", *Journal of Knowledge Management*, In Press.

AYALA N.F., PASLAUSKI C.A., GHEZZI A., FRANK A.G. (2017), "Knowledge sharing dynamics in service suppliers' involvement for servitization of manufacturing companies", *International Journal of Production Economics*, vol. 193, pp. 538-553.

BAINES T.S., LIGHTFOOT H.W., BENEDETTINI O., KAY J.M. (2009), "The servitization of manufacturing: A review of literature and reflection on future challenges", *Journal of Manufacturing Technology Management*, vol. 20, n. 5, pp. 547-567.

BARNEY J. (1991), "Firm resources and sustained competitive advantage", *Journal of Management,* vol. 17, n. 1, pp. 99-120.

BHATTI S.H., SANTORO G., KHAN J., RIZZATO F. (2021), "Antecedents and consequences of business model innovation in the IT industry", *Journal of Business Research*, vol. 123, pp. 389-400.

BORTOLUZZI G., CHIARVESIO M., ROMANELLO R., TABACCO R., VEGLIO V. (2020), "Industry 4.0 technologies and the servitization strategy: a good match?", *Sinergie Italian Journal of Management*, vol. 38, n. 1, pp. 55-72.

BUSTINZA O.F., GOMES E., VENDRELL-HERRERO F., TARBA S.Y. (2018), "An organizational change framework for digital servitization: evidence from the Veneto region", *Strategic Change*, vol. 27, n. 2, pp. 111-119.

CASPRINI E. (2015), "Business model innovation: a typology", S*inergie Italian Journal of Management*, vol. 33(May-Aug), pp. 181-197.

CHEN J., WANG L., QU G. (2021), "Explicating the business model from a knowledge-based view: nature, structure, imitability and competitive advantage erosion", *Journal of Knowledge Management,* vol. 25, n. 1, pp. 23-47.

CHICHKANOV N. (2021), "The role of client knowledge absorptive capacity for innovation in KIBS", *Journal of Knowledge Management*, vol. 25, n. 5, pp. 1194-1218.

COHEN W.M., LEVINTHAL D.A. (1990), "Absorptive capacity: A new perspective on learning and innovation", *Administrative Science Quarterly*, vol. 35, n. 1, pp. 128-152.

COREYNEN W., MATTHYSSENS P., VANDERSTRAETEN J., VAN WITTELOOSTUIJN A. (2020), "Unraveling the internal and external drivers of digital servitization: A dynamic capabilities and contingency perspective on firm strategy", *Industrial Marketing Management,* vol. 89, pp. 265-277.

COREYNEN W., MATTHYSSENS P., VAN BOCKHAVEN W. (2017), "Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers", *Industrial Marketing Management*, vol. 60, pp. 42-53.

DELL'ANNO D., DEL GIUDICE M. (2015), "Absorptive and desorptive capacity of actors within university-industry relations: does technology transfer matter?", *Journal of Innovation and Entrepreneurship*, vol. 4, n. 1, pp. 1-20.

DE MASSIS A., KOTLAR J. (2014), "The case study method in family business research: Guidelines for qualitative scholarship", *Journal of Family Business Strategy*, vol. 5, n. 1, pp. 15-29.

DUBOIS A., GADDE L.E. (2002), "Systematic combining: an abductive approach to case research", *Journal of Business Research,* vol. 55, n. 7, pp. 553-560.

EISENHARDT K.M. (1989), "Building theories from case study research", *Academy of Management Review*, vol. 14, n. 4, pp. 532-550.

ESCRIBANO A., FOSFURI A., TRIBÓ J.A. (2009), "Managing external knowledge flows: The moderating role of absorptive capacity", *Research Policy*, vol. 38, n. 1, pp. 96-105.

FRANK A.G., MENDES G. H., AYALA N.F., GHEZZI A. (2019b), "Servitization and Industry 4.0 convergence in the digital transformation of product firms: A business model innovation perspective", *Technological Forecasting and Social Change*, vol. 141, pp. 341-351.

GEBAUER H., PAIOLA M., SACCANI N., RAPACCINI M. (2021), "Digital servitization: Crossing the perspectives of digitization and servitization", *Industrial Marketing Management,* vol. 93, pp. 382-388.

GEBAUER H., FLEISCH E., LAMPRECHT C., WORTMANN F. (2020), "Growth path for overcoming the digitalization paradox", *Business Horizons*, vol. 63, pp. 313-323.

GEBAUER H., WORCH H., TRUFFER B. (2012), "Absorptive capacity, learning processes and combinative capabilities as determinants of strategic innovation", *European Management Journal*, vol. 30, n. 1, pp. 57-73.

GEBAUER H., GUSTAFSSON A., WITELL L. (2011), "Competitive advantage through service differentiation by manufacturing companies", *Journal of Business Research*, vol. 64, n. 12, pp. 1270-1280.

GREGOLINSKA E., KHANAM R., LEFORT F., PARTHASARATHY P. (2022), *Capturing the true value of Industry 4.0*, McKinsey & Co., April.

HUSSAIN N., BHATTI W. A., KHAN S. A., ARSLAN A., TARBA S. Y. (2022), "Firm absorptive capacity: multidimensionality, drivers and contextual conditions", *Journal of Knowledge Management*, In Press.

JANSEN J.J., VAN DEN BOSCH F.A., VOLBERDA H.W. (2005), "Managing potential and realized absorptive capacity: how do organizational antecedents matter?", *Academy of Management Journal*, vol. 48, n. 6, pp. 999-1015.

KOHTAMÄKI M., PARIDA V., PATEL P. C., GEBAUER H. (2020), "The relationship between digitalization and servitization: The role of servitization in capturing the financial potential of digitalization", *Technological Forecasting and Social Change*, vol. 151, 119804.

KOHTAMÄKI M., PARIDA V., OGHAZI P., GEBAUER H., BAINES T. (2019), "Digital servitization business models in ecosystems: A theory of the firm", *Journal of Business Research,* vol. 104, pp. 380-392.

KOSTOPOULOS K., PAPALEXANDRIS A., PAPACHRONI M., IOANNOU G. (2011), "Absorptive capacity, innovation, and financial performance", *Journal of Business Research*, vol. 64, n. 12, pp. 1335-1343.

KRANZ J.J., HANELT A., KOLBE L.M. (2016), "Understanding the influence of absorptive capacity and ambidexterity on the process of business model change - the case of on-premises and cloud-computing software", *Information Systems Journal*, vol. 26, pp. 477-517.

LANE P.J., KOKA B.R., PATHAK S. (2006), "The reification of absorptive capacity: A critical review and rejuvenation of the construct", *Academy of Management Review,* vol. 31, n. 4, pp. 833-863.

LIAO Y., DESCHAMPS F., LOURES E.D.F.R., RAMOS L.F.P. (2017), "Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal", *International Journal of Production Research*, vol. 55, n. 12, pp. 3609-3629.

MAHMOOD T., MUBARIK M.S. (2020), "Balancing innovation and exploitation in the fourth industrial revolution: Role of intellectual capital and technology absorptive capacity", *Technological Forecasting and Social Change*, vol. 160, 120248.

MARTINELLI E. M. (2018), "Customer centric innovation: adoption of 3D printing in the Italian jewellery sector", *Piccola Impresa/Small Business,* vol. 2, pp. 59-85.

MILES M.B., HUBERMAN A.M. (1994), *Qualitative data analysis: An expanded sourcebook*. sage.

MIROSHNYCHENKO I., STROBL A., MATZLER K., DE MASSIS A. (2021), "Absorptive capacity, strategic flexibility, and business model innovation: Empirical evidence from Italian SMEs", *Journal of Business Research*, vol. 130, pp. 670-682.

MÜLLER J.M., BULIGA O., VOIGT K.I. (2021), "The role of absorptive capacity and innovation strategy in the design of industry 4.0 business Models-A comparison between SMEs and large enterprises", *European Management Journal*, vol. 39, n. 3, pp. 333-343.

MÜLLER J.M., BULIGA O., VOIGT K.I. (2018), "Fortune favors the prepared: how SMEs approach business model innovations in Industry 4.0", *Technological Forecasting and Social Change*, vol. 132, n. 2, pp. 2-17.

NAEEM H.M., DI MARIA E. (2021), "Customer participation in new product development: an Industry 4.0 perspective", *European Journal of Innovation Management,* In Press.

OLIVA R., KALLENBERG R. (2003), "Managing the transition from products to services", *International Journal of Service Industry Management*, vol. 14, n. 2, pp. 160-172.

PAIOLA M., SCHIAVONE F., KHVATOVA T., GRANDINETTI R. (2021), "Prior knowledge, industry 4.0 and digital servitization. An inductive framework", *Technological Forecasting and Social Change*, vol. 171, 120963.

PAIOLA M., GEBAUER H. (2020), "Internet of things technologies, digital servitization and business model innovation in BtoB manufacturing firms", *Industrial Marketing Management*, vol. 89, pp. 245-264.

PAIOLA M. (2018), "Digitalization and servitization: Opportunities and challenges for Italian SMES", *Sinergie Italian Journal of Management,* vol. 36, pp. 11-22.

PASCHOU T., RAPACCINI M., ADRODEGARI F., SACCANI N. (2020), "Digital servitization in manufacturing: A systematic literature review and research agenda", *Industrial Marketing Management*, vol. 89, pp. 278-292.

PORTER M.E., HEPPELMANN J.E. (2015), "How smart, connected products are transforming companies", *Harvard Business Review*, vol. 93, n. 10, pp. 96-114.

RAIMONDI M. (2011), "La servitizzazione delle imprese: una sfida strategica attuale e difficile", *Micro and Macro Marketing*, vol. 20, n. 1, pp. 119-136.

RICCI R., BATTAGLIA D., NEIROTTI P. (2021), "External knowledge search, opportunity recognition and industry 4.0 adoption in SMEs", *International Journal of Production Economics,* vol. 240, pp. 108234.

SAIZ L., MIGUEL D.P., DEL CAMPO M.Á.M. (2018), "The knowledge absorptive capacity to improve the cooperation and innovation in the firm", *Journal of Industrial Engineering and Management*, vol. 11, n. 2, pp. 290-307.

SCHLAGWEIN D., HU M. (2017), "How and why organisations use social media: five use types and their relation to absorptive capacity", *Journal of Information Technology,* vol. 32, n. 2, pp. 194-209.

SIACHOU E., VRONTIS D., TRICHINA E. (2021), "Can traditional organizations be digitally transformed by themselves? The moderating role of absorptive capacity and strategic interdipendence", *Journal of Business Research*, vol. 124, pp. 408-421.

TODOROVA G., DURISIN B. (2007), "Absorptive capacity: Valuing a reconceptualization", *Academy of Management Review*, vol. 32, n. 3, pp. 774-786.

TRONVOLL B., SKLYAR A., SÖRHAMMAR D., KOWALKOWSKI C. (2020), "Transformational shifts through digital servitization", *Industrial Marketing Management*, vol. 89, pp. 293-305.

TSENG C.Y., HUNG C.H. (2011), "Knowledge absorptive capacity and innovation performance in KIBS", *Journal of Knowledge Management*, vol. 15, n. 6, pp. 971-983.

TUKKER A. (2004), "Eight types of product-service system. Eight ways to sustainability? Experiences from SusProNet.", *Business Strategy and the Environment*, vol. 13, n. 4, pp. 246-260.

ULAGA W., REINARTZ W.J. (2011), "Hybrid offerings: how manufacturing firms combine goods and services successfully", *Journal of Marketing*, vol. 75, n. 6, pp. 5-23.

XIE X., ZOU H., QI G. (2018), "Knowledge absorptive capacity and innovation performance in high-tech companies: A multi-mediating analysis", *Journal of Business Research*, vol. 88, pp. 289-297.

YIN R.K. (2014), *Case study research: designs and methods*, 3rd edition, Sage Thousand Oaks (CA).

YUAN R., LUO J., LIU M.J., YU J. (2022), "Understanding organizational resilience in a platform-based sharing business: The role of absorptive capacity", *Journal of Business Research*, vol. 141, pp. 85-99.

ZAHRA S.A., GEORGE G. (2002), "Absorptive capacity: A review, reconceptualization, and extension", *Academy of Management Review*, vol. 27, n. 2, pp. 185-203.

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