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**SERVITIZATION IN SMALL AND MEDIUM-SIZED
ENTERPRISES: CONCEPTUAL AND EMPIRICAL
APPROACHES TO OVERCOME STRATEGIC AND
OPERATIONAL BARRIERS**

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1. EXECUTIVE SUMMARY

Thirtyfour years after the seminal work of Vandermerwe and Rada (1988) that introduced its definition, the *servitization* concept is nowadays one of the recognized opportunities offered by the fourth industrial revolution that dominates manufacturers' innovation trends (Thoben, Wiesner, & Wuest, 2017). Servitization refers to the transition in an enterprise's business model from product to product-service (PSS) system to generate higher use-value, value-based pricing, and capabilities to support customer-dominant orientation (Lightfoot, Baines, & Smart, 2013). The PSS concept first appeared at the end of the 1990s in consultancy (Goedkoop, van Halen, te Riele, & Rommens, 1999) to describe the offer of bundles of products and services in contrast to the traditional focus on stand-alone products.

Servitization is not a recent trend in B2B manufacturing firms (e.g., Levitt, 1972). Over the last decade, what has changed is the sense of urgency in the executive boardrooms caused by customers' pressure and the competition growth within saturated and commoditized markets. Conversely, this scenario stimulates companies to exploit product and technology know-how, capture customer relationship value, and open new market opportunities (Kowalkowski & Ulaga, 2017). Despite those claims, servitization seems far from being extensively applied by firms, especially small and medium enterprises (SMEs) (Federico Adrodegari & Saccani, 2018). SMEs represent 99.8% of all non-financial businesses in the EU-27 (European Commission, 2021). However, scholarly literature on servitization has primarily concentrated efforts on large manufacturing companies (Baines et al., 2017). This focus makes it complex to transfer findings to SMEs attempting to servitize their business model (Queiroz et al., 2020). In particular, the implementation process (i.e., "*how to servitize*") still lacks consistent empirical analyses for SMEs. For example, scholars have highlighted gaps in how to:

- Servitization performances are influenced by SMEs' strategic and contextual factors (Ambroise, Prim-Allaz, Teyssier, & Peillon, 2018).
- Identify customers that could be more suitable than others for SMEs to involve in co-creation activities (Goduscheit & Faullant, 2018).

- Analyze stakeholders' role within the SMEs' service network (Lelah, Mathieux, Brissaud, & Vincent, 2012a) and study its value at strategic, tactical, and operational levels (Kowalkowski, Witell, & Gustafsson, 2013a).

The fil rouge connecting the five essays presented in this thesis sheds light on servitization in SMEs, generating theoretical and practical insights which would help SMEs to *overcome strategic and operational barriers they face during the transition toward a servitized business model*. Accordingly, each contribution will take the research one step toward this objective, searching for alignments tackling internal and external barriers (Alghisi & Saccani, 2015) and offering suggestions and tools for SMEs undertaking servitization.

Figure 1.1 reports the research's overall conceptual framework, detailing what each chapter of the dissertation focuses on and which research question addresses. Each empirical contribution considers SMEs as the scope condition of the research.

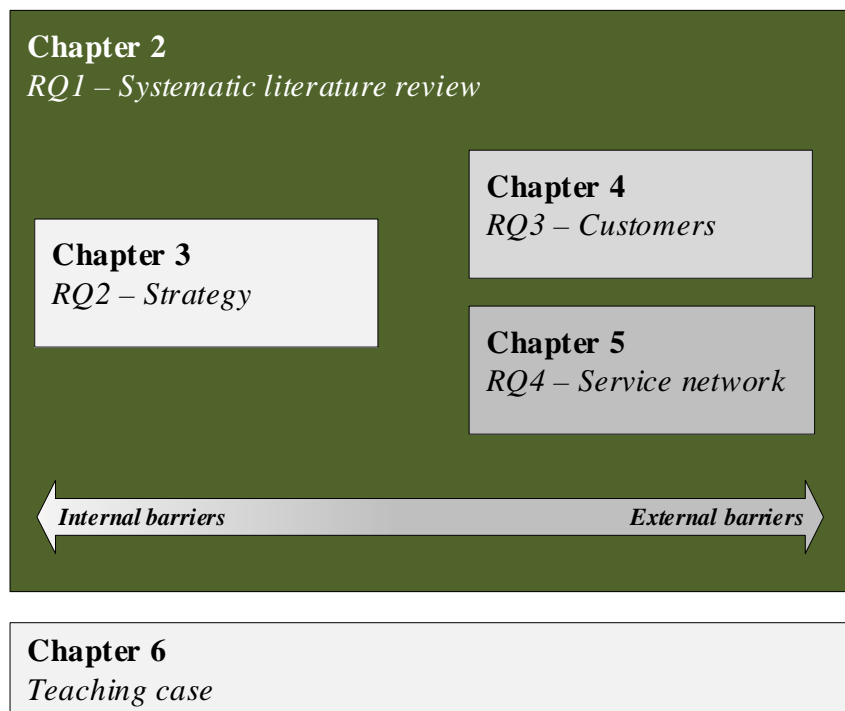


Figure 1.1 – Overall conceptual framework of the dissertation, appendix included

The first essay (chapter 2: "State of the art and research agenda of servitization in SMEs: a critical perspective from a manufacturing firm") reports a systematic literature review of existing research on servitization in SMEs. This work confirmed the theoretical and

industrial interest in the topic treated by the thesis. I apply a mixed-method approach to derive insights from the academic knowledge base while drawing upon the expertise of practitioners from the field. In fact, after conducting the literature review, results were discussed with the Chief Service Manager of an Italian SME operating in the capital goods sector to develop a prioritized list of possible future research directions – with practical relevance – based on identified gaps. Hence, starting from the need to systematize and visualize previous knowledge into a comprehensive framework, the first essay answers the following research question:

***RQ1.** What limitations within the literature on servitization in SMEs could inspire future research directions?*

Results recognize a still growing recent topic clustered, enouncing a set of gaps and possible future research directions for scholars, which will be used to guide and prioritize the development of the subsequent essays. The contribution benefits from collected feedback about the value transfer to practitioners by discussing obtained results with an Italian SME's chief service officer (CSO) and chief commercial officer (CCO). Overall, practitioners recognize a top priority the understanding of barriers to servitization progress to figure out how to shift their firm's service organizational structure and prioritize its service business unit's investments. Obtained results are used as the reference literature review for the subsequent three empirical chapters.

The second essay (chapter 3: "How does product strategy contribute to servitization in SMEs?") investigates the internal alignment needed to overcome the dualism between product and service strategies in SMEs, analyzing the impact of the former on the latter. This study theoretically articulates and empirically validates a mediation model of relationships between SMEs' product strategy – proxied through competitive priorities – and servitization orientation and performances. The model is built on data from the Sixth International Manufacturing Strategy Survey (IMSS-VI). The results indicate that different product strategies affect SMEs' servitization performances, providing a reference framework for SMEs willing to move from a product-based to a servitized business model. Therefore, the second research question is:

***RQ2.** How does the SME's product strategy impact its servitization performances?*

The findings suggest that SMEs' service performance benefits just from explorative product strategy, while the effect of exploitative product strategy is not significant. However, this effect is indirect via the full mediation of servitization orientation.

The third essay (chapter 4: "The influence of the type of aftersales relationship on the co-creation of services: the case of an Italian SME") offers a possible solution to aligning manufacturer service dimensions with the customers by proposing a quantitative method that allows clustering the customer portfolio of the focal SME. In addition, the work aims to analyze different aftersales relationship types as a context for co-creation. Clusters describing the aftersales relationship between the producer and its clients were identified based on data related to 307 customers collected from an Italian SME. These groups are then related to co-creation dimensions as perceived by the manufacturer: aftersales customization and engagement. The findings guide SMEs to profile customers according to different aftersales relationship types, which describe the customers' propensity toward co-creation activities. Accordingly, the third research question addressed in this research is the following:

***RQ3.** How does the aftersales relationship between producer and customer affect the type of co-creation in SMEs?*

Results found four clusters described through three service factors – i.e., service interaction, retention, and potential – that defined different aftersales relationship types. The group characterized by high service potential fosters co-creation. Interestingly, interaction leads to co-creation more than retention.

The fourth essay (chapter 5: "Product-service systems delivered by SMEs during building use stage: sustainability criteria framework") focuses on developing a framework that attempts to align internal service dimensions to external collaborative service partnership networks. This objective is reached by developing a framework to assess SMEs' PSS collaborative partnerships networks implemented to deliver value to stakeholders with the real one perceived from the latter. The work identifies a list of criteria formed into a sustainability multi-criteria framework relevant for assessing PSS delivered by SMEs, combining existing literature with multiple stakeholders' feedback. The proposed framework also supplements PSS-specific criteria, such as PSS types, servitized collaborative networks, and integration forms. The proposed framework would help

SMEs present information about PSS structurally, contributing to a better marketing positioning and understanding of the added value of multiple stakeholders. Consequently, the fourth research question is:

***RQ4.** How can SMEs explain PSS added value delivered in the best possible way to each stakeholder?*

Last, the appendix ("Escaping the “tortoise shell paradox”: digitalization and servitization in the green building construction industry – The case of Marlegno") is the result of a research project oriented toward disseminating servitization concepts among graduate students, managers, and entrepreneurs. The case traces the history of a small and medium-sized family manufacturer based in Bergamo (Italy) that operates in the green building sector. This case asks students to analyze the advantages and disadvantages of innovation mechanisms that benefit from servitization and servitized business models enabled by digital transformation regarding their financial consequences, organizational impact, and strategic approach to customer engagement.

Due to the prevalence of "how" questions, the research design of this thesis aims to create valuable practical outcomes. Figure 1.2 shows the approach proposed by the Centre for Technology Management (CTM) - Institute for Manufacturing (IfM) of the University of Cambridge (United Kingdom), which inspired this work. Inputs from scholars and practitioners allowed the generation of industrial-oriented guidelines and training workshops for practitioners, and conference and journal publications from each contribution. Each chapter will use the figure to recall the research design implemented.

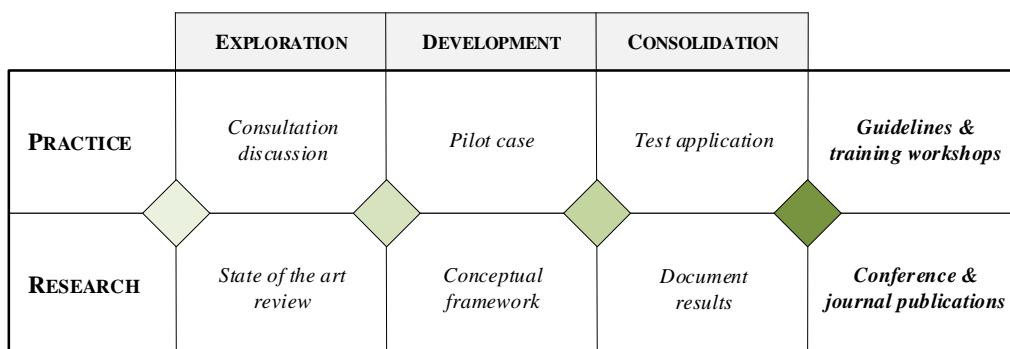


Figure 1.2 – Research design’s phases (readapted from Centre for Technology Management - Institute for Manufacturing, 2021)

2. STATE OF THE ART AND RESEARCH AGENDA OF SERVITIZATION IN SMEs: A CRITICAL PERSPECTIVE FROM A MANUFACTURING FIRM

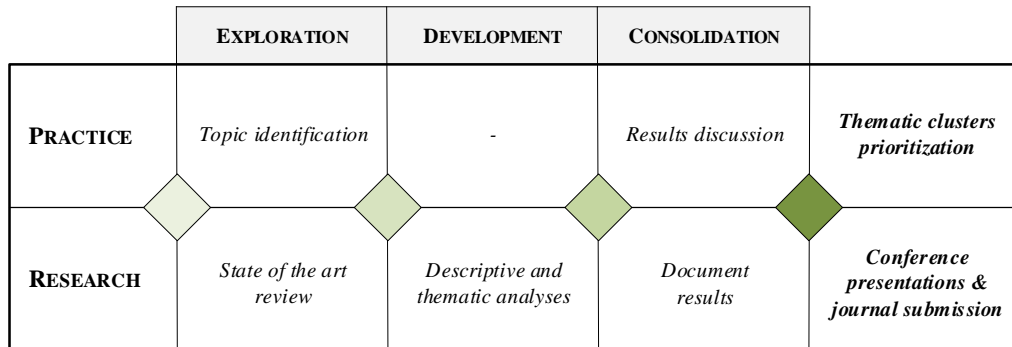


Figure 2.1 – Positioning of the first essay according to the general research design adopted.

Acknowledgment.

This chapter is derived from the article "Gamba, D., Minola, T., Kalchschmidt, M., Pezzotta, G., (2022). State of the art and research agenda of servitization in SMEs: a critical perspective from a manufacturing firm" presented online at the 3rd AEM and TIM Ph.D. programs' joint paper development workshop in May 2022, at the 3rd Conference on Competitive Renaissance through Digital Transformation (online, virtually hosted in Pavia – Italy) in February 2021, at Spring Servitization Conference in May 2021, at the EURAM – European Academy of Management conference in June 2021, and at EurOMA – European Operations Management Association conference in July 2021.

I want to thank my coauthors, Tommaso Minola, Matteo Kalchschmidt, and Giuditta Pezzotta, for the opportunity to work with them and for the guidance received. I am also grateful to Lorenzo Greselin, my industrial tutor and Chief Service Officer of MEI Srl, and Michele Sartirani, Global Sales Director of MEI Srl, who critically discussed the work to tackle achieved results from a practitioner's point of view.

2.1 Introduction

The fourth industrial revolution that dominates manufacturers' innovation opportunities nowadays includes the servitization concept (Thoben et al., 2017), defined in the late '80s by Vandermerwe and Rada. Studies commonly denoted servitization, with slight viewpoint differences, such as service growth, service infusion, service transition, service transformation, servicification, servicizing, and value migration. Servitization refers to the transition in an enterprise's business model from products to product-service systems to generate higher use-value, value-based pricing, and capabilities to support customer-dominant orientation (Lightfoot et al., 2013). The product-service system (PSS) concept first appeared at the end of the 1990s in consultancy (Goedkoop et al., 1999) to describe the offer of bundles of products and services together in contrast to the traditional focus on stand-alone products. Servitization is not a recent trend in B2B manufacturing firms (e.g., Levitt, 1972). What is changed over the last decade is the sense of urgency in the executive boardrooms caused by customers' pressure and proliferation of competition among manufacturers, which conversely stimulates to exploit of products and technology knowhow, capturing customer relationship value and opening new market opportunities (Kowalkowski & Ulaga, 2017). Despite those claims, servitization seems far to be extensively applied by firms, especially by small and medium enterprises (SMEs) (Federico Adrodegari & Saccani, 2018), which represent 99.8 % of all non-financial businesses in the EU-27, providing 65% of total EU-27 non-financial businesses (European Commission, 2021). SMEs have a more straightforward organization and a less hierarchical structure than large firms, allowing them to invest and grow rapidly (Valtakoski & Witell, 2018). Furthermore, over time, they undergo fast organizational changes in their value and supply chain (Tonelli, Taticchi, & Sue, 2009), converting new ideas into marketable products and services (Lelah et al., 2012a). On the other hand, SMEs lack – or are restricted in access to – internal financial and managerial resources, capabilities, and experience (Kowalkowski et al., 2013). In addition, they are more vulnerable to competition (Rapaccini, Mauro, Cinquini, & Tenucci, 2019) because of their significant presence in the industry as suppliers of original equipment manufacturers (OEMs) in concentrated demand marketplaces, and they are subject to reduced economies of scale (Bonfanti, Del Giudice, & Papa, 2018). Last, they have limited access to their installed base (Gebauer et al., 2010) because of the usage of distributors, installers, and

resellers. Overall, different conditions distinguish SMEs' opportunity to establish a servitization strategy by whose understanding would extend the understanding of the servitization process and contingencies.

However, scholarly literature on servitization has primarily concentrated efforts on large manufacturing companies (Baines et al., 2017), even though servitization occurs in all types of supply chains. This focus makes complex transferring findings to SMEs attempting to servitize due to the abovementioned limits (Queiroz et al., 2020). Literature has emphasized the little relative exploration of servitization in SMEs context (Rapaccini et al., 2019) compared to large manufacturing, with recent and growing contributions arising across several research communities (Rabetino, Harmsen, Kohtamäki, & Sihvonen, 2018) distinguished by different research perspectives (Annarelli, Battistella, & Nonino, 2019), scattered among journals and subject areas, sometimes skewed by the inclusion of large companies in their research samples, and composed mainly through technical conference papers that had not yet become well cited enough in comparison to other research papers based on large manufacturers (Clegg et al., 2017). Despite there is a growing body of literature that recognizes the importance of SMEs (de Jesus Pacheco, ten Caten, Jung, Sassanelli, & Terzi, 2019), previous literature reviews (e.g., Raddats et al., 2019; Lightfoot et al., 2013; Baines et al., 2009) have not fully systematized servitization in SMEs. The only exception is the review by de Jesus Pacheco et al. (2019), which restricted the analysis to SMEs' barriers to sustainable product-service systems. This scenario indicates a gap in the current body of knowledge. Accordingly, our systematic literature review (SLR) was conducted.

Based on such premises, this study aims to collect, organize, and systematically review existing literature to draw an overview of the essential themes of servitization in SMEs and design a research agenda that highlights further possible research directions founded on the identified gaps. In addition, enounced findings and conclusions would like to practically help small and medium manufacturers' managers willing to start supplying their products through a servitization strategy implementation, collecting empirical case studies from the literature that could serve them as positioning benchmarks.

This article is structured as follows. Section 2.2 describes the literature review methodology used in the current study. Then, a descriptive analysis of the selected sample

is performed, followed by a thematic analysis. Section 5 describes the research agenda for future servitization in SME research based on findings and gaps highlighted by the sample of the selected articles. Lastly, section 6 recaps the findings and presents the limitations of this study.

2.2 Methodology

This SLR aims to provide a stand-alone contribution to servitization in SMEs state-of-art through a rigorous design that minimizes possible biases, which should be used as background for future studies to progress knowledge. Indeed, SLRs offer powerful information sources for academics and practitioners looking for existing evidence to guide decision-making and managerial practices (Templier & Paré, 2015). To compare similarities and differences between selected literature, the intended SLR applies a textual narrative synthesis approach, which allows organizing selected papers in homogenous subgroups based on data extracted from them (Xiao & Watson, 2019). The review process is conducted according to the steps proposed by Tranfield et al. (2003) and Thomé et al. (2016), rearranged into five stages. The first and the fifth stage include contributions from practitioners.

2.2.1 Problem formulation

I built problem formulation around scholars' acknowledged gaps and industry-specific requirements from practitioners. Before designing this SLR's research questions, a high-level review of the prominent servitization literature was done (e.g., Tukker, 2004; Ulaga & Reinartz, 2011; Gebauer et al., 2012; Baines, 2015; Visnjic et al., 2016) reporting as academic works and managerial manuals are profusely dedicated to theories and case studies based on large manufacturing firms (e.g., Roll-Royce's Power-by-the-Hour; Michelin's Price-per-Mile; Caterpillar's Cat Product Link; Alstom's TrainLife Services), covering very few examples of successfully and unsuccessfully SMEs' servitization journeys. In the meantime, numerous debates about servitization were performed with entrepreneurs and managers from Italian small and medium manufacturing companies engaged in service transition programs. Contributions were collected joining the ASAP Service Management Forum (www.asapsmf.org), an Italian community devoted to service research, training, networking, and solution transfer, and from discussions

performed with the board of directors of a private Top 500 Italian manufacturing SME (Polato, 2019) involved in an early-stage servitization project. The main concerns were related to managing the servitization strategy life cycle. For example, the CEO of a manufacturing SME stressed services' value proposition towards the firm's customers segments (i.e., how correctly approach servitization to make clients aware of the value transferred through delivered services and justify their prices?).

Due to these considerations, the authors defined the following research question:

***RQ1.** What limitations within the literature on servitization in SMEs could inspire future research directions?*

2.2.2 Literature research

Studies selection starts with database and journal identification, which allows for defining a research protocol. First, as made by recent servitization SLRs (Paschou, Rapaccini, Adrodegari, & Saccani, 2020; Raddats et al., 2019; Reim, Parida, & Örtqvist, 2015), the Scopus database from Elsevier was identified as the first source instance for literature research. Specifically, the designed research query used fields regarding title, abstract, and keyword, searching for articles and reviews in English starting from 1988 and setting the end of the search period for December 31st, 2020. On the other hand, papers were firstly retrieved from journals included in the Academic Journal Guide (AJG) provided by CABS (Chartered Association of Business Schools, 2018) (Raddats et al., 2019). AJG groups journals listed by diverse fields that constitute Business and Management in the so-called ABS ranking. It evaluates each journal according to the CABS' 4-scale quality rating (Chartered Association of Business Schools, 2018) with a further distinction (4*, journal of distinction) made regarding a small number of journals amongst those with a rating of 4. Including only academic journals for scholars working across the diverse fields of Business and Management, this choice implicitly excluded books and conference contributions.

Keywords were chosen to cover the following areas:

- Servitization's actors, therefore SMEs, as well as young (e.g., start-ups) and family enterprises. The term "SME" was declined according to its empirical characterization adopted within the last two years' issues of journals clustered in

the ABS's entrepreneurship and small-medium business field (ENT-SMB). Each other keyword selected to describe servitization's actors was accepted if it was used at least one time by small business and entrepreneurship high impact factor journals' articles, namely Journal of business venturing (JBV), Small business economics (SBE), Entrepreneurship, theory, and practice (ETP, and Strategic entrepreneurship journal (SEJ). Table 2.1 shows the number of articles and the year of the first published paper among the journals mentioned above for each potential keyword.

- The servitization process (Table 2.2) and its outputs (Table 2.3).

On the other hand, the set of keywords excludes the term “service-dominant logic” (Vargo & Lusch, 2004) because it is an alternative conceptual perspective on marketing that explains tasks facing marketers not directly associated with the servitization concept (Ambler, 2005).

Table 2.4 shows the final Scopus query designed.

Table 2.1 – List of keywords evaluated to describe servitization's actors.

Keyword	Evaluation	SBE		JBV		SEJ		ETP	
		Articles [#]	1 st issue [year]	Articles [#]	1 st issue [year]	Articles [#]	1 st issue [year]	Articles [#]	1 st issue [year]
gazelle	Included	7	2008	0	-	0	-	0	-
unicorn	Included	2	2017	0	-	0	-	0	-
ventur* AND NOT joint	Included	52	2011	168	2002	116	1995	33	2018
start up	Included	8	2018	21	2003	72	2005	7	2013
spin-off	Included	15	2007	6	2002	3	2017	0	-
spin in	Included	0	-	0	-	0	-	1	2019
spin out	Included	0	-	0	-	1	2011	0	-
hyper-growth	Excluded	0	-	0	-	0	-	0	-
high growth	Included	23	2009	2	2003	1	2014	0	-
oriented growth	Excluded	0	-	0	-	0	-	0	-
family firm	Included	39	2007	7	2003	5	2011	18	2018
family enterprise	Included	3	1992	4	1997	0	-	15	2006
family owne*	Included	7	2009	2	2003	0	-	1	2018
family control*	Included	3	2015	3	1996	1	2011	16	2004

Table 2.2 – List of servitization terms and definitions.

Term	Definition	Source
Servitization	“The increased offering of fuller market packages or bundles of customer-focused combinations of goods, services, support, self-service, and knowledge to add value to core product offerings.”	Vandermerwe & Rada, 1988
Service addition	“A switch from selling products to offering solutions.”	Matthyssens & Vandenbempt, 2010
Service growth	“Shifting from developing, manufacturing, and selling products to innovating, selling, and delivering services [...] as a strategic response to reaching the maturity phase in the product lifecycle.”	Kowalkowski et al., 2017a
Service infusion	“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.”	Kowalkowski et al., 2017b
Service transition	“The shift to solution and/or service offerings to improve competitive position.”	Fang et al., 2008
Service transformation	“The journey of transformation process whereby an organization enables its product-service offerings.”	Martinez et al., 2010
Servicification	“Raising the number of services incorporated in manufacturing.”	Lodefalk, 2011
Servicizing	“The transition to business models under which firms sell the use of the products.”	Agrawal & Bellos, 2016
Value migration	“Expanding the scope of the product offering to include services.”	Davies, 2004

Table 2.3 – List of product-service system terms and definitions.

Term	Definition	Source
Product-service system (PSS)	“System of products, services, supporting networks, and infrastructure that is designed to be competitive, satisfy customer needs, and have a lower environmental impact than traditional business models.”	Mont, 2002
Extended product	“Combination of a physical product and associated services/enhancements to improve the marketability.”	Thoben et al., 2001
Functional (total care) product	“Products that comprise [...] hardware combined with a service support system.”	Alonso-Rasgado et al., 2004
Hybrid offering	“A combination of one or more goods and one or more services, creating more customer benefits than if the good and service were available separately.”	Uлага & Reinartz, 2011
Industrial product-service (IPS2 or IPSS)	“The integrated and mutually determined planning, development, provision and use of product and service shares including its immanent software components in Business-to-Business applications and represents a knowledge-intensive socio-technical system.”	Meier et al., 2010
Integrated solution	“Bundle of physical products, services, and information, seamlessly combined to provide more value than the parts alone, that addresses customer’s needs in relation to a specific function or task in their business system; it is long-term oriented, integrates the provider as part of the customer’s business system, and aims at optimizing the total cost for the customer.”	Brax & Jonsson, 2009

Table 2.4 – Scopus query design

Scopus query	Comments
TITLE-ABS-KEY (// Searching within documents' title, abstract, and keyword fields
(servitization OR "service addition" OR "service growth" OR "service transition" OR "service infusion" OR "service transformation" OR servicification OR serviciz* OR "value migration"	// Servitization process
OR "extended product" OR "functional product" OR "integrated solution" OR "hybrid offering" OR "product service system" OR "total care product" OR pss OR ips2 OR ipss)	// Servitization outputs
AND	
("small to mid size*" OR "small and medium" OR "small size*" OR "medium size*" OR sme	// Servitization actors: SMEs
OR gazelle OR unicorn OR (ventur* AND NOT joint) OR "start up*" OR "spin off" OR "spin in" OR "spin out" OR entrepreneur* OR (family PRE/1 (firm OR business OR ("small to mid size*" OR "small and medium" OR "small size*" OR "medium size*" OR sme) OR own*)) OR "high growth" OR "family enterprise" OR "family control*"))	// Servitization actors: young and family enterprises
AND	
(PUBYEAR AFT 1987 AND PUBYEAR BEF 2021)	// Documents from the year of the work of Vandermerwe & Rada (1988) to December 2020
AND	
LANGUAGE (english)	// Documents written in English language only
AND	
LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re"))	// Articles and review only

2.2.3 Data gathering and quality evaluation

Data gathering and quality evaluation were performed using a four-step process based on preferred reporting items for systematic reviews and meta-analyses (PRISMA) selection of literature reviewed (Paschou et al., 2020). Each step of operationalization is described after this and summarized in Figure 2.2.

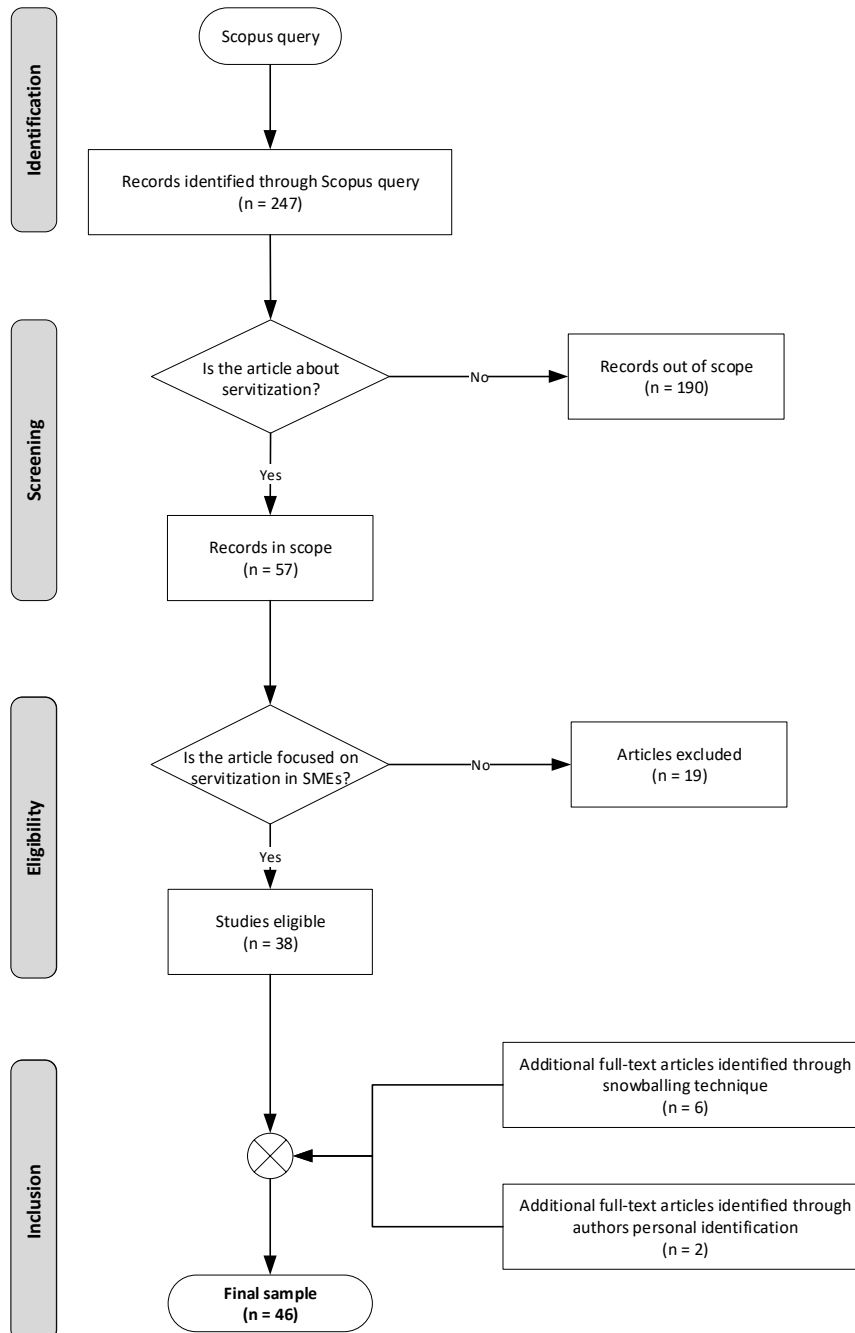


Figure 2.2 – Data gathering and quality evaluation process.

- Identification phase. The Scopus query returned 247 documents. Outcomes were downloaded in BibTeX format and then imported into Zotero reference management software to manage bibliographic data easily (Murimboh & Hollingdale, 2012).
- Screening phase. After reading titles and abstracts, some articles have been rejected because of the associated Scopus's subject areas (e.g., agricultural and biological sciences). Essentially, this was due to the different meanings of PSS (e.g., pseudo-substrates, polystyrene sulfonate, primary Sjögren's syndrome) and IPSS (e.g., international prostate symptom score) in the listed domains. It is interesting to notice that after cleaning these acronyms, the Scopus query retrieved just 136 documents. Hence, the literature collected was screened by carefully reading each paper's title and abstract, obtaining a sample of 57 articles.
- Eligibility phase. After reading the screened articles' full text, an eligible sample of 39 papers that could contribute to answering the research questions was selected. Rejection reasons are related to SMEs' position within the articles' context: for example, SMEs as customers of large financial institutions (Valtanen, 2014) and IT providers (Muhammad, 2020) which apply servitization strategy or as non-specific case studies without direct implication on related theory (Aminoff & Hakanen, 2018).
- Inclusion phase. Eligible sample backward and forward search (Harari, Parola, Hartwell, & Riegelman, 2020) increased papers collection imposed by the protocol by adding six new papers. In addition, three articles come from the authors' identification, obtaining an eligible final sample of 46 studies. Lastly, papers were clustered according to the ABS ranking of 2018's journals to ensure quality.

2.2.4 Data analysis, synthesis, and interpretation

Data were extracted from selected articles and coded into five data-charting forms devoted to articles' header data, body data, journals, citations, and authors. The codebook (Neuendorf, 2017) in Table 2.5 includes open-ended and close-ended codes. The analysis relies on Scopus' attributes for papers, SCImago's SJR (Mañana-Rodríguez, 2015), while ABS ranking 2018's classification was added for journals. Then, data transformation and modeling processes were executed using Microsoft Power BI to perform descriptive analysis based on the textual narrative synthesis approach. Results were chartered in specific visuals to organize items in homogenous subgroups.

Table 2.5 – Data-charting form codebook for descriptive analysis.

Entity	Attribute	Coding options
Article header	ID (table key)	Internal automatic progressive number.
	Title	Open-ended.
	Year of publication	Close-ended, from 1988 to 2020 included.
	Author(s)	Open-ended, paper's authors as an array of [Surname], [First name initial].
	Journal name	Close-ended, list retrieved from Journals entity's key attribute.
	Abstract	Open-ended.
	Keywords	Open-ended, paper's keywords as an array.
	Subject area	Close-ended, categorized according to Scopus's subject area.
	Source	Close-ended options: Scopus query, back and forward search, or outlier.
	Backward	Close-ended, intra-sample backward citations as an array of paper's ID.
	Forward	Close-ended, intra-sample forward citations as an array of paper's ID.
Rejection notes	Open-ended.	
Article body	ID (table key)	Article ID retrieved from Article header's table key.
	Type 1	Close-ended, options available: theoretical or empirical.
	Type 2	Close-ended, options available: <ul style="list-style-type: none"> • If Type 1 = theoretical: literature review, concept development. • If Type 2 = empirical: qualitative, quantitative, mixed.
	Industrial sector	Close-ended, Eurostat NACE rev. 2 industry section code in industries in which empirical studies are applied. The option <i>Heterogeneous</i> is available.
	Thematic cluster	Close-ended options available: PSS business modeling, PSS design and development, collaborative networks, performances, decision-making support systems, territorial servitization, drivers, and barriers.
	Perspective	Close-ended, options available: business, engineering, environment
	Theoretical foundations	Open-ended.
	Research questions	Open-ended.
	Data sources	Open-ended.
	Methodology	Open-ended.
	Results	Open-ended.
Gaps and further research	Open-ended.	
Citations	Article ID (table key)	Article ID retrieved from Article header's table key.
	[<i>i</i> -th year, list from 1988 to 2020]	The number of citations in Scopus received by the article during the <i>i</i> -th year.
Journal	Journal name (table key)	Close-ended, list retrieved from the ABS' ranking 2018.
	Cluster	Close-ended, options available: ABS, not ABS
	ABS ranking 2018	Close-ended, options available: 1, 2, 3, 4, 4*, N.A.
	ABS field	Close-ended, categorized according to ABS' scientific fields.
	SCImago journal ranking (SJR) 2018	Open-ended, number format.
Subject area	Close-ended, categorized according to Scopus's subject area.	
Author	ID (table key)	Internal automatic progressive number
	Author	Open-ended, proxied as [Surname], [First name initials].
	Affiliation 1	Open-ended, author's institution of affiliation.
	State 1	Close-ended, author's institution of affiliation geographical state location.
	Affiliation 2	Open-ended, author's second institution of affiliation (if applicable).
	State 2	Close-ended, author's second institution of affiliation's geographical state location.

2.2.5 Results presentation and updating

The following paragraph outlines the fifth and last stage of the SLR's iterative workflow. By synthesizing and disclosing the findings achieved according to descriptive and thematic analyses through a structured report, academics and practitioners can use results

obtained as critical elements to develop new scientific knowledge via new problem formulation grounded on them and facilitate decision-making processes. Mainly, dissemination should make it easier for entrepreneurs and managers to understand the evidence provided by the research, which could guide – jointly with personal experience and problem-solving skills – their choices. This research-to-practice translation helps blur the boundaries between science, policy, and practice (Tranfield et al., 2003). The paper’s conclusion highlights outcomes from discussing the results with two managers from a private Italian manufacturing SME involved in an early-stage servitization project that enhances insights presented in this paper and highlights the most appropriate future research directions following an evidence-based approach.

2.3 Descriptive analysis

2.3.1 Publication date, journals, and geographical distribution

Figure 2.3 illustrates publication volume and citation evolution over time of the articles set in the final sample. Data were updated to December 31st, 2020. The first contributions to servitization in SMEs were issued in 2006 by Malleret. While the number of articles rose slightly during the last decade, the exponential growth denoted by the Scopus’ citations curve confirms the scientific community’s increasing interest and attention in the phenomenon.

Literature collection distribution through journals is analyzed in Table 2.6 to evaluate information stocks and flows among the researchers. Articles are published in 36 journals, 28 included in the AJG 2018 and 8 not. If eligible, journals are listed according to the number of articles associated with their SJR 2019, their total intra-sample co-citation count, and their ABS 2018 field and indexes. Among ABS journals, 13 are classified in the operations and technology management field (OPS&TECH), 4 in sector studies (SECTOR, namely the extension of service management to include specialisms in manufacturing and primary industries), and three both in marketing (MKT) and ethics, corporate social responsibility, and management (ETHICS-CSR-MAN). Lastly, one journal is categorized in the regional studies, planning and environment field (REGIONAL STUDIES, PLANNING, AND ENVIRONMENT), as well as in entrepreneurship and small business (ENT-SBM), information management (INFO

MAN), business strategy (STRAT), and creativity and innovation management (INNOV). Only six of the 36 journals have published two or more articles. Articles follow a similar kind of distribution. These proofs demonstrate the literature's high degree of dispersion and fragmentation. This finding is confirmed by the Scopus database subject area, which classifies each journal into one or more groups (Table 2.7). As expected, most articles are clustered in the subject of Business, Management, and Accounting since 82% belong to ABS journals.

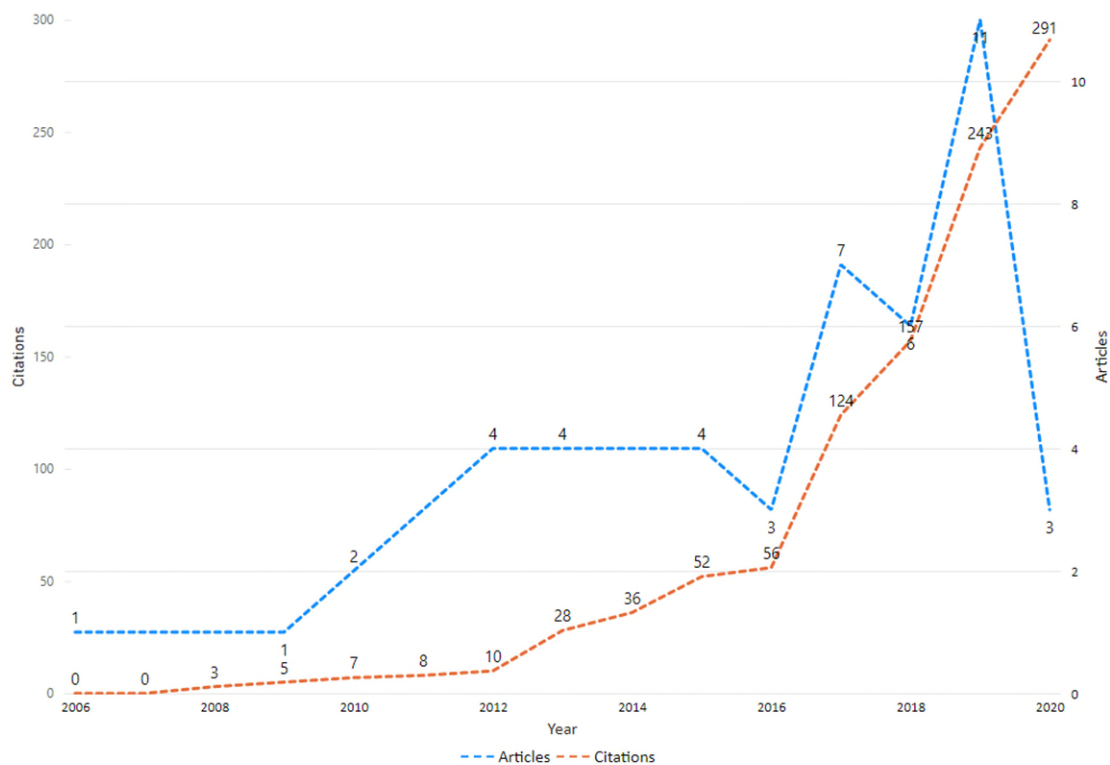


Figure 2.3 – Yearly publications and citations time distribution.

Table 2.6 – Journal, cumulative citations, SJR, and ABS features

Journal	N. articles	Scopus citations	Average citations	SJR 2019	ABS field	ABS rank
Industrial Marketing Management	3	155	51.7	2.08	MKT	3
International Journal of Production Research	1	130	130.0	1.78	OPS&TECH	3
European Management Journal	1	99	99.0	1.31	ETHICS-CSR-MAN	2
Journal of Cleaner Production	3	98	32.7	1.89	SECTOR	2

International Journal of Production Economics	2	70	35.0	2.38	OPS&TECH	3
Scandinavian Journal of Management	1	54	54.0	0.59	ETHICS-CSR-MAN	2
Production Planning and Control	3	50	16.7	1.39	OPS&TECH	3
Journal of Economics and Management Strategy	1	49	49.0	0.99	STRAT	2
Managing Service Quality	1	38	38.0	N.A.	OPS&TECH	1
Regional Studies	3	35	11.7	1.54	REGIONAL STUDIES, PLANNING AND ENVIRONMENT	3
Journal of Business-to-Business Marketing	1	30	30.0	0.23	MKT	2
Journal of Decision Systems	1	22	22.0	0.30	INFO MAN	1
Journal of Product Innovation Management	1	18	18.0	3.13	INNOV	4
IEEE Transactions on Engineering Management	1	18	18.0	1.07	OPS&TECH	3
International Journal of Operations and Production Management	1	16	16.0	2.19	OPS&TECH	4
Journal of Manufacturing Technology Management	2	15	7.5	1.17	OPS&TECH	1
Journal of Intellectual Capital	1	14	14.0	1.18	ETHICS-CSR-MAN	2
Journal of Service Management	1	10	10.0	1.71	SECTOR	2
International Journal of Logistics Management	1	9	9.0	1.06	OPS&TECH	1
International Journal of Entrepreneurship and Small Business	1	8	8.0	0.41	ENT-SBM	2
International Journal of Internet Manufacturing and Services	1	7	7.0	0.12	OPS&TECH	1
Journal of Service Research	1	4	4.0	3.37	SECTOR	4
International Journal of Engineering Business Management	1	4	4.0	0.31	OPS&TECH	1
Building Research and Information	1	1	1.0	1.18	SECTOR	2
Business Process Management Journal	1	1	1.0	0.73	OPS&TECH	2
Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture	1	1	1.0	0.812	OPS&TECH	1

Journal of Business and Industrial Marketing	1	0	0.0	0.69	MKT	2
International Journal of Services and Operations Management	1	0	0.0	0.29	OPS&TECH	1
Sustainability	1	45	45.0	0.55	-	-
WSEAS Transactions on Business and Economics	1	16	16.0	0.13	-	-
Journal of Applied Business Research	1	7	7.0	0.17	-	-
Journal of Open Innovation: Technology and Complexity	1	5	5.0	N.A.	-	-
She Ji	1	4	4.0	N.A.	-	-
IFAC-PapersOnLine	1	3	3.0	0.33	-	-
Agris On-line Papers in Economics and Informatics	1	1	1.0	0.58	-	-
International Journal of Financial Research	1	0	0.0	N.A.	-	-

Table 2.7 – Journals and articles count by Scopus subject area.

Scopus subject area	No. of journals	No. of articles
Business, Management, and Accounting	28	36
Engineering	11	17
Decision Sciences	8	10
Economics, Econometrics, and Finance	8	7
Social Sciences	7	9
Computer Science	4	8
Environmental Science	4	8
Energy	2	4
Agricultural and Biological Sciences	1	1
Psychology	1	1

The authors' affiliation analysis provides the geographical distribution of the interest in servitization in SMEs. The 46 articles selected involve 120 authors from universities, private research centers, and private companies in 22 states. Among them, France leads the ranking with 23 (e.g., from École des Mines de Saint-Étienne), followed by Italy with 17 (e.g., University of Brescia), the UK with 14 authors (e.g., Aston University), then Brazil with nine, as well as Sweden and Finland with eight (e.g., from Linköping University and University of Vaasa). This result is consistent with the evidence that

European countries such as the United Kingdom and Scandinavian countries have a strong historical interest in servitization research, specifically focused on the environmental perspective of the topic. On the other hand, Italy and France have their economic backbone based on SMEs, especially the family ones. The selected articles' relevant authors are also involved in more general servitization studies than those related to SMEs. Figure 2.4 shows the intra-sample interaction network based on the number of citations of each article among the selected studies, which allows us to understand the relationships between contributions graphically. The size of each dot represents the number of citations received by the paper (i.e., the greater the dot is, the higher the number of citations received by the paper by articles). Table 2.8 lists the nine articles excluded by the intra-sample interaction.

The following findings are proposed based on the analysis described above:

Finding 1.1. Literature on servitization in SMEs is still a growing recent topic. Existing contributions – especially from European authors – are fragmented and distributed among different fields.

Finding 1.2. Servitization is virtually absent from entrepreneurship journals.

Table 2.8 – Articles excluded from the interaction network.

Article	Journal	Article Scopus subject area
Ahmad et al. (2019)	International Journal of Financial Research	Business, Management and Accounting
Fornasiero & Sorlini (2010)	International Journal of Internet Manufacturing and Services	Computer Science; Decision Sciences; Engineering
Guo & Jiang (2019)	Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture	Engineering
Kanovska & Tomaskova, (2016)	Agris On-line Papers in Economics and Informatics	Economics, Econometrics and Finance; Social Sciences; Environmental Science; Agricultural and Biological Sciences
Lappalainen et al. (2019)	International Journal of Services and Operations Management	Decision Sciences; Engineering; Business, Management and Accounting
Michalik et al. (2019)	IFAC-PapersOnLine	Engineering
Pardalis et al. (2020)	Building Research and Information	Engineering
Roos & O'Connor (2015)	Journal of Intellectual Capital	Social Sciences; Business, Management and Accounting
Tauqeer & Bang (2018)	Journal of Open Innovation: Technology, Market, and Complexity	Economics, Econometrics and Finance; Social Sciences

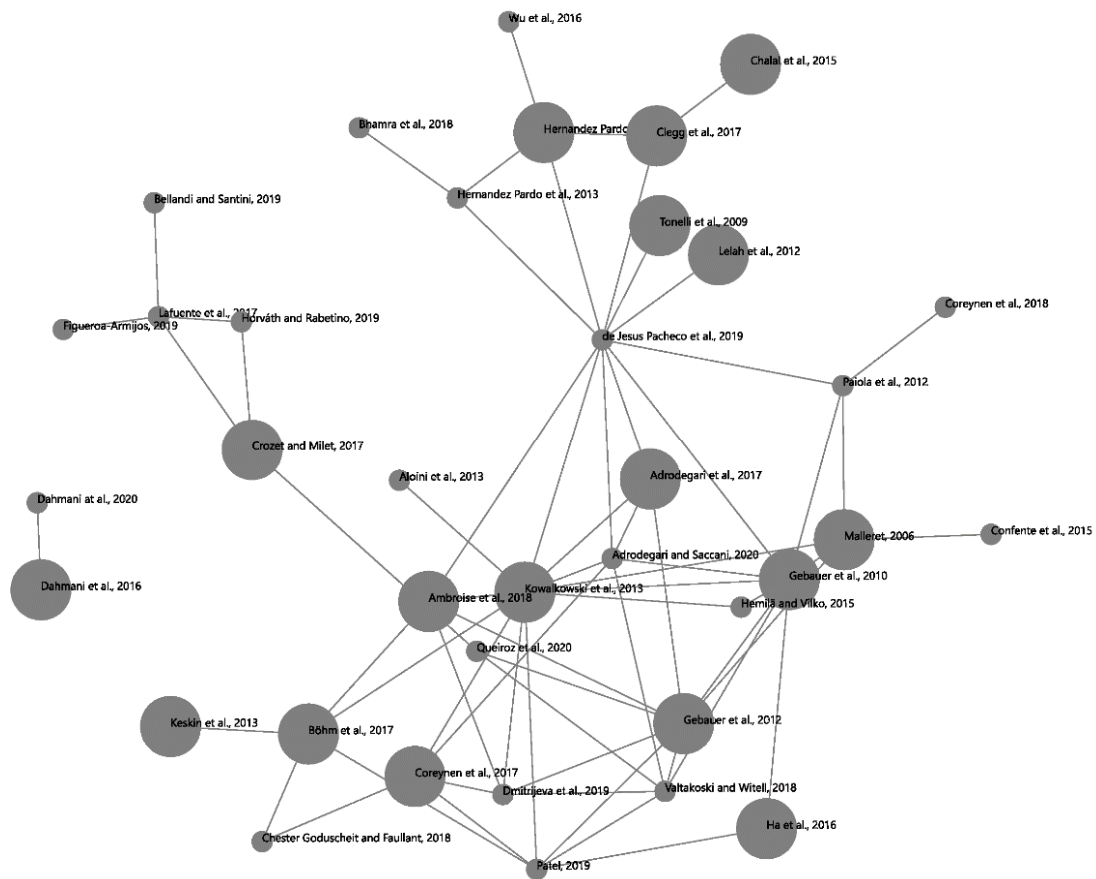


Figure 2.4 – Intra-sample co-citations network.

2.3.2 Methodological approaches

Each article included in the literature collection was classified according to the Articles' body attributes, specifying the methodological approach adopted. The first classification is between *Theoretical* and *Empirical* contributions, while the second is constrained according to the previous sorting. Specifically, theoretical articles were further divided into literature reviews and concept development. On the other hand, three clusters to further classify the empirical papers. In particular:

- Qualitative, thus engaging empirical research methods such as single and multiple case studies, action research, or the Delphi method.
- Quantitative, therefore employs surveys, statistical regressions, or simulations.
- Mixed, as the combination of both qualitative and quantitative methods.

As reported in Table 2.9, about 83% of contributions rely on empirical methodologies, while just 17% of the articles are defined as theoretical. Among empirical papers, 24 adopted qualitative methods confirming that emerging fields trust in single or multiple case studies (von Krogh, Rossi-Lamastra, & Haefliger, 2012) since scholars are still trying to create a standard vocabulary, clarify definitions, and explore the topic. This cluster dominates contributions by 18 multiple case studies (e.g., Aloini et al., 2013) and seven single case studies (e.g., Lelah et al., 2012). Among qualitative studies, eight cases are based on action research (e.g., Clegg et al., 2017), two cases on fuzzy set qualitative comparative analysis (Goduscheit & Faullant, 2018), and 1 case Delphi method (Dmitrijeva, Schroeder, Ziaee Bigdeli, & Baines, 2019). Quantitative research includes statistical models and surveys, accounting for 11 articles, while just three are mixed-method studies. Conversely, only eight papers are clustered as theoretical, with five concept development contributions and three literature reviews. Amongst empirical studies, case studies' industries were classified according to NACE rev. 2 protocol (Table 2.10). The manufacturing industry accounts for 28 articles. Two contributions embrace cases from the construction industry, while one paper selected a case from the waste management industry and one from the information and communication industry. Lastly, six papers included cases from heterogeneous businesses in the same study (i.e., from different NACE rev. 2' sections or not explicitly stated by the authors). It is interesting to notice that none of the selected empirical papers focus on cases regarding family businesses and start-ups.

Table 2.9 – Articles methodological approaches.

Type	Method	Total	Percentage %
Theoretical	Literature review	3	6,52%
	Concept development	5	10,88%
	<i>Total</i>	8	17,40%
Empirical	Qualitative	24	52,17%
	Quantitative	11	23,91%
	Mixed	3	6,52%
	<i>Total</i>	38	82,60%
Overall total		46	100%

Table 2.10 – Case studies classification according to NACE rev. 2 protocol.

NACE section code	NACE section description	Total	Percentage %
C	Manufacturing	28	73,68%
E	Waste management	1	2,63%
F	Construction	2	5,26%
J	Information and communication	1	2,63%
-	Heterogeneous	6	15,80%

Finding 2. Literature on servitization in SMEs is developed mainly through empirical qualitative studies from the manufacturing industry. Most of them are based on multiple case studies, confirming that it is still an emerging research field. Scholars have not yet analyzed cases regarding family businesses and start-ups.

2.4 Thematic analysis

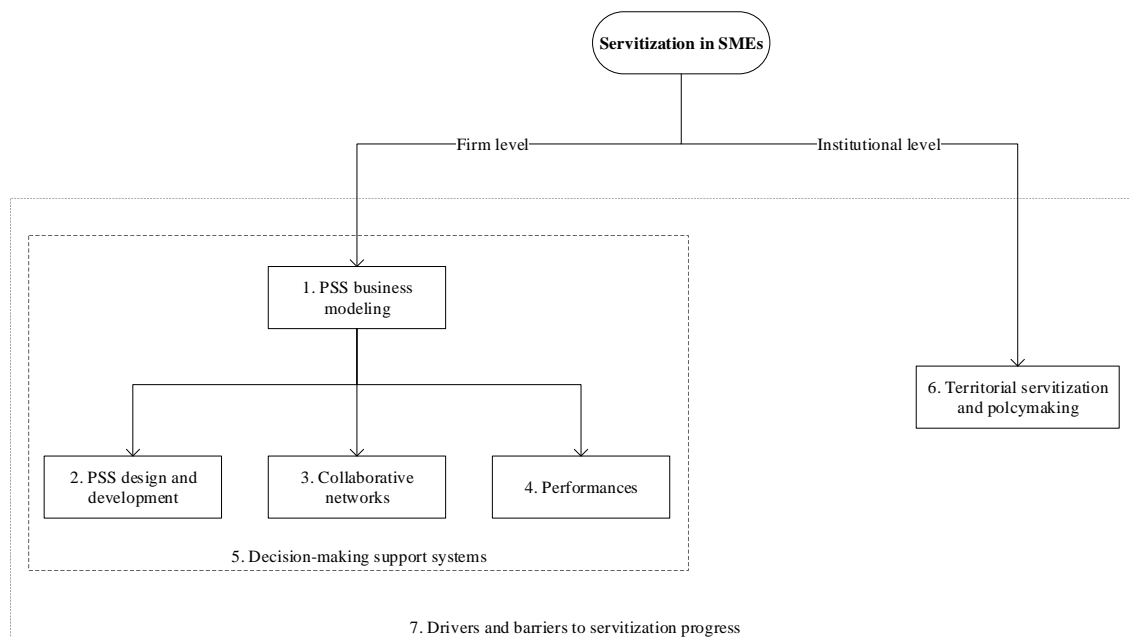


Figure 2.5 – Thematic analysis framework.

The thematic analysis of the articles' final sample concerns seven main thematic clusters related to SMEs organized within the framework proposed in Figure 2.5. Previous literature reviews (Raddats et al., 2019; Reim et al., 2015) inspired thematic cluster identification. At the firm level, it includes (1) the PSS business modeling and related (2) PSS design, (3) collaborative networks, and (4) performances. In addition, the authors

identified a cluster composed of a couple of papers focalized on (5) servitization decision-making support systems. On the other hand, another set of papers is dedicated to (6) territorial servitization and policymaking at an institutional level. Last, a group of papers about (7) drivers and barriers to servitization progress was identified. The latter can be considered a cross-clusters that embraces the abovementioned themes.

2.4.1 PSS business modeling

Since servitization mainly refers to a transition in the company's business model focusing on PSS offering, the first group of articles retrieved from this SLR refers to PSS business modeling. In this context, the business model (Chesbrough & Rosenbloom, 2002) describes how companies create and deliver values through PSS. Adrodegari et al. (2017) developed a two-level framework for PSS business modeling to support small and medium manufacturers' servitization progress, useful to formalize service offerings delivered and the related revenue models. The authors applied it in two small and medium product-centric enterprises to highlight its contribution to the setup of the incremental and radical PSS business model. The framework adopts the business model canvas perspective (Osterwalder & Pigneur, 2010). At a second level, a set of twenty-five specific variables operationalize each business model canvas' component. Again, Adrodegari and Saccani (2020) developed and tested in two medium-sized firms a bi-dimensional servitization maturity model (SeMM) combining business model canvas dimensions with five firm's maturity dimensions (i.e., organizational approach, process management, performance management, tools, and capabilities). The model aims to assess and position product-centric companies in the servitization journey by assessing 85 critical requirements and recommendations along a five-dimension maturity scale.

The study of Pardalis et al. (2020) examined twenty-one Swedish construction small enterprises' perceptions and level of preparedness regarding adopting the one-stop-shop (OSS) business model for house renovations. In such a model, a unique actor (i.e., an OSS entrepreneur) coordinates all the energy renovation projects' services to increase resource efficiency. While they consider the OSS business model appealing due to the apparent benefits for their business, SMEs involved in the research declared that risks and uncertainties perceived prevail over the gains from the potential adoption. This evidence highlights that SMEs' low organizational capabilities awareness and lack of recognition

of existing policy and funds to support innovation negatively impact new PSS business models. Organizational capabilities needed in SMEs for developing service structure moving from a transactional to a PSS business model are stressed by Gebauer et al. (2012) and Paiola et al. (2012). According to these authors, service business development in small and medium manufacturers is associated with specific pathways and capabilities, which depend on buyer-supplier relationships, sales channels (i.e., direct sales vs. indirect sales through distributors), and customer structures (i.e., few strategic customers vs. many customers).

Finding 3. PSS business modeling frameworks are addressed by a limited number of qualitative studies based on the business model canvas framework. The literature stresses SMEs' lack of organizational capabilities as barriers to implementing PSS business models.

2.4.2 PSS design and development

The second cluster of papers includes topics related to PSS design and development. The first represents design toward stakeholders' value by utilizing products or services, specialized competencies, and specific exchanges between provider and user (Sakao, 2011). PSS's concept and detailed design use specific practices, such as eco-design, to increase PSS sustainability (Pigosso & McAloone, 2015). On the other hand, PSS development indicates the set of processes – including the design process – that characterize the entire PSS lifecycle, from planning to utilization and end-of-life (Maleki, Belkadi, & Bernard, 2017). Each PSS lifecycle's process should account for four main technical sub-lifecycle devoted to hardware, software, service-support systems, and operations management (Lindström, Dagman, & Karlberg, 2015).

2.4.3 Sustainable PSS design

PSS design literature devoted to SMEs focuses its attention on sustainable PSS design. Sustainable PSS is defined as a bundle of products and services in which the economic and competitive interest of the providers continuously seeks environmentally and socio-ethically beneficial new solutions over cleaner and efficient production and delivery processes (Vezzoli, Ceschin, Diehl, & Kohtala, 2015). First, Keskin et al. (2013) discovered that new ventures involved in new product and service design – including PSS

– experience difficulties integrating sustainability in the process due to their lack of understanding about it, as well as to the uncertainty around the nature and magnitude of problems related to sustainable design and the approaches to fix them. This fact is confirmed by the Hernandez-Pardo et al. (2013) paper based on an exploratory study with a group of thirty-eight Colombian SMEs. The authors found evidence of a lack of understanding in SMEs about sustainability meaning and implications for PSS design. In addition, the authors showed that sustainable design practices are not the focal point of SMEs' strategies due to their profitability uncertainty in the short period, as confirmed by Bhamra et al. (2018). Through a set of empirical cases collected in Botswana and Colombia, the latter identified two other common issues to sustainable PSS design: the need for collaborative support networks among SMEs and conditions set up by governments to facilitate the deployment of these types of PSS. In general, the absence of solutions to overcome these issues represents a barrier to sustainable PSS design, as de Jesus Pacheco et al. (2019) discussed in their list of barriers to sustainable PSS (see paragraph 2.4.9.2). While no empirical evidence of a connection between technology use and sustainable PSS design in SMEs was identified, papers included in this cluster (Hernández Pardo, Bhamra, & Bhamra, 2012; Hernandez-Pardo, Bhamra, & Bhamra, 2013) discussed the enabling role of digitalization for sustainable design. Digitalization of information, communication, and manufacturing (e.g., simulation platforms) potentially leads to organizational intervention toward the sustainability of PSS design. In these cases, digital systems can act as design pillars or just as support for commercial purposes.

Finding 4.1. The literature emphasizes SMEs' lack of understanding of sustainability to tackle this concept's complexity and related PSS design barriers. Scholars discuss digitalization's role and government policies in facilitating SMEs' access to PSS sustainable design practices.

2.4.4 Frameworks and tools for PSS development

As SMEs lack resources and time, they require easy-to-use and efficient development frameworks and operative tools that require minimal time to understand and use. Taking care of the supply chain point of view, Hemilä and Vilko (2015) built up a step-by-step new service development (NSD) framework for small and medium manufacturers.

Compared to traditional ones, this model aims to include service-dominant logic (Vargo & Lusch, 2004), underlining customers' role as co-designers and co-creators of value. Applying the framework to two Finnish machine manufacturer SMEs shows that digitalization is essential in how service providers and customers interact. Fornasiero and Sorlini (2010) developed a multi-criteria tool supported by a knowledge base and collaborative platform for helping small companies develop innovative product-service systems. The tool comprises three modules dedicated to diagnosing customers' needs, implementing the PSS innovation process from the organizational point of view, and recognizing opportunities. Tauqeer and Bang (2018) developed a seven-step model to develop servitized products analyzing options of increasing utility and lowering hindrances of a product. Since just qualitative judgments from users independent of any data collection requirements are needed, this simplified methodology allows SMEs to analyze and increase their service offerings despite their lack of resources.

On the other hand, Tonelli et al. (2009) built a four-phase framework for PSS assessment and implementation from an action research project in the healthcare sector. The framework includes analyses of the current market expressed and unexpressed demand for PSS and the development of different value and supply chain scenarios based on the service level and associated risk, cost, profit, and sustainability analysis. Then, the tool aims to verify the internal and external availability of competencies for the selected scenario implementation and develop a marketing plan to promote the new strategy versus customers and prospects.

Last, a paper concerns a production system' framework for PSS development. Wu et al. (2016) describe the architecture of a real-time dynamic cellular manufacturing system (DCMS) for PSS, which was implemented and empirically prototyped through function block standard and web services middleware. Due to its low design, development, and maintenance cost, this DCMS meets SMEs' requirements.

Finding 4.2. The literature describes frameworks and tools for PSS development that help SMEs tackle the concept's complexity and related barriers. One article proposes a framework specifically devoted to PSS production systems. Frameworks are usually based on digital tools and are characterized by an easy-to-use approach to overcome SMEs' lack of capability and resources.

2.4.5 Collaborative networks

The third cluster of articles is related to SMEs' role within collaborative networks to deploy and deliver servitized products. Due to their lack of resources and capabilities, SMEs benefit from co-creating services based on exchanging knowledge and assets. In their top-cited article, Kowalkowski et al. (2013) detected nine network configurations (i.e., value constellations) where SMEs participate proactively or reactively to achieve their service strategies. Lappalainen et al. (2019) identified eleven co-evolution phases of the provider-customer B2B relationship that facilitate SMEs' network development and strategic repositioning over time. Based on SMEs' lack of critical resources and capabilities, the concept of enterprization studied by Clegg et al. (2017) enriched literature referring to the transformative process by which companies' operations move from being predominantly autonomous towards coordinated multi-organization enterprise (MOE) of suppliers and partners. Collaboration among groups enormously benefits from implementing enterprise systems (ES, such as ERP and CRM). Compared to un-orchestrated networks, enterprization allows SMEs that constitute MOE's enterprise module to share competencies, resources, and infrastructure to deliver a set of PSSs to end-users efficiently. Although it is neither a necessary nor a sufficient condition alone for service innovation, digitalization broadens SMEs' boundaries to connect with more stakeholders and expand the heterogeneity of resources integrated with the network. Unfortunately, SMEs generally do not have in-house resources capable of carrying out advanced analyses based on existing data, as Goduscheit and Faullant (2018) demonstrated through a multiple case study of twenty-four Danish B2B manufacturing SMEs. The latter study stressed the role of collaboration through the mobilization of resources among the SME's network to develop radical service innovation. Using an environmental perspective, Lelah et al. (2012) described the collaborative network of complementary SMEs behind a big operator-integrator seeking to build a standard backbone for deploying urban public utility services. In this case study, the network moved from vertical to horizontal, drawing attention to the evidence that sustainability depends on the organization of activities built around physical objects and how these objects are used individually or collectively within the network. Aloini et al. (2013) analyzed how the supply chain modifies its structure, including all capabilities needed to satisfy customers' requirements developing a framework for project-based industries

characterized by groups of SMEs as sub-contractors. Last, Guo & Jiang (2019) applied the social manufacturing paradigm to develop a Stackelberg game model to tackle the manufacturing-service order allocation problem. The latter refers to optimizing the order quantities allocated to network' SMEs according to the service capabilities and expected quality of service.

Finding 5. Through business and environmental perspectives, literature related to SMEs' servitized collaborative networks seeks to identify frameworks that describe solutions (i.e., constellations and network structures) to tackle their lack of internal financial and managerial resources, capabilities, and experience. Some qualitative studies highlight the enabling role of digitalization in these forms of collaboration among stakeholders and companies.

2.4.6 Performances

This group of papers is devoted to analyzing the performances of servitized SMEs, defined as small and medium firms that offer any service that exceeds those services necessary for operating in a specific industry (Ahmad et al., 2019). Notwithstanding costs and paradoxes associated with service investments (Gebauer et al., 2005), SMEs' profitability and production performances generally benefit from servitization business model transition (Crozet & Milet, 2017; Ha, Lee, & Kim, 2016), which usually generates more stable margins and competitive market advantage. Böhm et al. (2017) demonstrate that servitization is not mandatory for small and medium manufacturers that aim to increase future revenue streams. Results show that servitization success does not depend on the SME's starting healthy financial position but on allocating appropriate slack resources guaranteed to the service business to increase the chance of growing and obtaining positive service performance. Patel et al. (2019) confirm this finding, which showed a negative relationship between the percentage of service sales (i.e., service intensity ratio) and early-stage firms' survival rate, which is moderated by companies' slack resources. More generally, the servitization-performance link benefits from specific contingency factors – slack resources, service relatedness, networking capabilities, product innovation, industry growth, and turbulence – that influence service intensity ratio, improving labor productivity, and customer-supplier relationships. From the analysis of six small and medium French manufacturers, the seminal work of Malleret

(2006) explained that knowing the cost of services delivered to customers allows SMEs to set up the right pricing policy. Services are not automatically financially profitable. Different service strategies have heterogeneous effects on financial performance, which are mediated by the external environment's effect (Queiroz et al., 2020) and age (Valtakoski & Witell, 2018).

Moreover, sophisticated organizational designs do not necessarily result in higher margins due to costs associated with service customization and structural capabilities development (Ambroise et al., 2018). About the latter, Valtakoski and Witell (2018) identified that back-office capabilities do not positively impact firm performances, while front-office ones do. Finally, Queiroz et al. (2020) show that SMEs' non-financial performances (i.e., customer satisfaction, image, and competitive differentiation) are positively impacted by servitization.

Finding 6. Among the selected studies, financial (e.g., economic revenues and margins) and non-financial (e.g., customer satisfaction and production efficiency) performances in servitized SMEs are analyzed. Scholars have investigated endogenous and exogenous factors that impact or moderate the servitization-performance relationship through quantitative studies, such as internal capabilities, organizational design, slack resources, implemented strategy, and industry environment. SMEs must pay particular attention to the cost of services delivered to set the right price, raising awareness on services to get value out of them.

2.4.7 Decision-making support systems

As already mentioned, two other themes are treated by literature. The first one concerned decision-making systems. The contribution of Dahmani et al. (2016) formalized a servitization decision-making reference model based on GRAI Integrated Methodology (GIM) enterprise modeling framework (Doumeingts, Ducq, Vallespir, & Kleinhans, 2000). The authors developed a reliability assessment applied to this model that enables a reliability diagnosis procedure. Empirically tested in a French SME, the reliability diagnosis procedure allows evaluating the reference and effective process gap. Again, Dahmani et al. (2020) create a three-stage system to help decision-makers deal with associated servitization risk potential occurrence. The model was developed through an action-research project in close collaboration with French SMEs, helping them conduct

high-level complete strategic planning for service transformation and overcoming, which could be tricky due to their limited resources. Considering the features of PSS productive systems, Chalal et al. (2015) developed a decision support system based on an event-driven simulator. The simulator shapes two behaviors: the commercial behaviors, leading to PSS purchase decisions by customers, and the utilization ones, which generate variations in service demands during the PSS life cycle. Scholars tested it on a French SME through an action research project for a decision issued on rules selection for human resource capacity management.

Finding 7. This SLR retrieves papers that specifically face up to decision-making systems. Each model is developed to optimize SMEs' configuration and capacity management during the service transition process for SMEs' lack of resources and capabilities issues.

2.4.8 Territorial servitization and policymaking

This fifth group of papers refers to territorial servitization, namely the territorial value creation processes resulting from the interactions between manufacturing firms, especially SMEs, and knowledge-intensive business services (KIBS) (Lafuente, Vaillant, & Vendrell-Herrero, 2017). KIBS refers to technology-based services (i.e., T-KIBS as IT outsourcers) and traditional professional services (i.e., P-KIBS as managerial consultancy). Horváth and Rabetino (2019) discovered a negative relationship between the average size of manufacturing businesses in a region and the formation rate of KIBS firms. The high cost of integrating product-service systems in-house and their increasing customer demand led small manufacturers to outsource their needs to knowledge-intensive-based services firms. Territorial servitization is the driver of new venture creations: it contributes to local competitiveness and employment creation through the virtuous cycle generated when a resilient local manufacturing base stimulates the creation of complementary KIBS, which facilitates the creation of new manufacturing enterprises (Lafuente et al., 2017). Studying the Italian industrial textile district of Prato, Bellandi and Santini (2019) identified that productive territorial structure depends on three variables: the variety of specialized competencies within and around the manufacturing core; the institutional solutions that lower local transaction costs and foster collaborations among small and medium manufacturers and KIBS; the entrepreneurial drive to

experiment new PSS business models and new institutional solutions, which positively moderate the positive relationship between manufacturing specialization and the rate of new KIBS (Horváth & Rabetino, 2019). The combination of different levels of such variables leads to identifying four territorial servitization trajectories and three business models implemented by SMEs that compose the territorial manufacturing systems. Each of them is strictly connected to conditions concerning servitization transaction costs associated with the role of human labor, knowledge, technology, and value chain insourcing and outsourcing strategies. Last and as already mentioned, the retrieved contributions from Figueroa-Armijos (2019) and Roos & O'Connor (2015) stressed the governments and institutions' critical role in territorial servitization development and industrial policy implementation for local servitization development among SMEs.

Finding 8. Few papers in the literature focus on factors and development trajectories that characterized the territorial servitization process. Specifically, the interaction and collaboration among small and medium manufacturers, KIBS, and governments are studied, highlighting associated implications on local entrepreneurship and development, transaction costs, business models implemented, and industrial policy setting.

2.4.9 Drivers and barriers to servitization progress

The last set of contributions aims to study drivers and barriers that SMEs face during servitization progress, including the formation of the service strategy and its implementation through changes in their organizational structure.

2.4.9.1 Drivers

Throughout a multiple case study based on interviews and action research study on eight small and medium capital goods manufacturers, Gebauer et al. (2010) found four combinations to explain how SMEs develop services strategically driven by their position in the value chain (i.e., suppliers or OEMs) and business environment conditions. These external factors were analyzed jointly with organizational dimensions as drivers of servitization by Dmitrijeva et al. (2019) along the four servitization transformation stages proposed by Ziaee Bigdeli et al. (2017), finding the SME's high dependence on individual customers as a clear threat to its progress across all stages. Customer centricity became particularly important in the case of smart services, namely services tailored to customer

requirements using data intelligence technologies. According to Kaňovská & Tomášková's (2018) multiple case study on eight Czech SMEs, the main factor driving the development of such services (e.g., remote monitoring) is traceable to possible competitive advantage and gainable respect to competitors. In general, servitization drivers in SMEs are directly linked to customer-centric and differentiation strategies. In contrast, financial drivers do not appear to be among the explicit factors leading to the decision to provide services (Confente, Buratti, & Russo, 2015).

2.4.9.2 *Barriers*

On the other hand, Confente et al. (2015) found eight servitization barriers for SMEs linkable to literature issues related to financial performances, knowledge sharing, collaborative networks, and operations management, which were also known from studies of large companies in many cases. Therefore, it seems that similar barriers in SMEs are perceived more strongly due to their smaller size and the lack of resources and capabilities. In this way, Coreynen et al. (2017) used the dynamic resource-based view as a lens to describe different resource configurations obtained to overcome barriers related to different levels of digitally enabled servitization strategies. These configurations are identified along with a framework that presents three distinct pathways (i.e., industrial, commercial, and value servitization) for manufacturers wanting to increase their service offerings. To stress the role of digital transformation, Michalik et al. (2019) categorized servitization barriers according to the four Dortmund management model (DMM)'s pillars (i.e., technology, human resources, organization, and digital information) to highlight necessary considerations that SMEs' digital-driven innovation processes should address. Based on action research data collection over 18 months period on eight cases of SMEs, three internal barriers associated to lack of resources and capabilities when upscaling PSS are identified by Coreynen et al. (2018): design barrier, related to the absence of sufficient knowledge to develop fully integrated PSS; rollout barrier, specifically the lack of a go-to-market strategy to offer services either in a reactive manner; logic barrier, related to the lack of necessary organizational mindset to implement servitization and develop PSS. Firms that want to move into new types of PSS are primarily concerned with the first barrier, while companies that seek to optimize the delivery of current PSS offerings the second.

Regarding the third barrier, small companies seem to have a more cohesive organizational mindset, with employees emphasizing the importance of similar values. Finally, the review of de Jesus Pacheco et al. (2019) identifies a set of forty-four types of barriers to sustainable PSS from the literature. Specifically, they classified these barriers into seventeen categories, and forty-four guidelines to overcome these obstacles organized into fifteen categories in an innovative matrix supporting the decision-making process. The main obstacles are costs, attitude, and the initial investment needed to implement servitization.

Finding 9. Selected studies identify customer-centric and differentiation strategies as SMEs' main servitization drivers. On the other hand, the body of literature emphasizes that small and medium firms lack resources, capabilities, organizational mindset, and strategies are crucial barriers to servitization. Digitalization and technology usage plays a significant role in new services (e.g., smart services) and overcoming barriers. A paper uses the environmental perspective to address the barriers to sustainable PSS, primarily associated with the related economic investments and understanding to overcome them.

2.5 Toward a research agenda

This article is a first endeavor to review the current literature about SMEs' servitization, representing a growing interesting topic for scholars and practitioners. The descriptive analysis found that a few papers have dealt with the SMEs' servitization journey, while the thematic analysis clustered them into seven main groups. These analyses retrieved nine findings, through which research gaps and future research directions are identified (Table 2.11).

The first set of opportunities for future research works arises from findings 1.1 and 2. Selected papers are primarily based on qualitative empirical cases from European manufacturing SMEs. This fact suggests adopting quantitative methodologies searching for new cases from other industries and countries to stress the role of economic, social, and political contexts, practices, and work environments. In addition, finding 1.2 highlights as the literature does not explicitly analyze cases of family businesses and start-ups. From finding 3, we identified chances for statistically test variables included in existing servitized business models and introduced studies to understand SMEs' usage of multiple models simultaneously. The overcoming of the business model canvas

frameworks towards the implementation of other ones is needed. Finding 4.1 underlines that circular models executed over time by SMEs based on sustainable PSS design should be deepened to facilitate their adoption, jointly with the use of ICT technologies in this context. This set of research directions is strictly linked with the request for appropriate frameworks and tools devoted to PSS development (finding 4.2), which should stress SMEs' lack of resources and capabilities in a collaborative network environment. Based on this fact, finding 5 highlights gaps related to the interaction among different servitized collaborative network' actors and the impact of digitalization on these networks' performance. Research opportunities are found in the relationship between the service provider and its customers (i.e., co-creation) that should be longitudinally analyzed at strategic, tactical, and operational levels. In addition, an appealing path is represented by the study of resource mobilization among SMEs involved in the servitized supply chain to exploit digitalization. Our study identified some gaps related to the financial and non-financial performances of servitized SMEs (finding 6). They highlight the need for qualitative and quantitative longitudinal studies over different stages of the servitization life cycle and analyses to determine factors influencing SMEs' general performance growth.

Additional effort should be invested to deal with service capabilities and organizational lack of reliable scales that evaluate performances. A set of opportunities arises from enhancing current decision-making models (finding 7), which should be empirically tested by including SMEs' contextual and environmental factors. Territorial servitization and policy making's gaps from proposition 8 lead to longitudinal evaluation of policy implemented by governments and institutions to incentivize KIBS formation and servitization initiatives among SMEs, including the analysis transferred from the first to the second. Last, the digitalization concept is picked up also by gaps from finding 9. Digitalization can serve to drive servitization progress within SMEs. Future scientific works should focus on its impact on resource configuration. More generally, frameworks and tools to overcome knowledge, capabilities, resources, and information barriers represent a viable research pathway. These instruments should stress the role of digitalization and technology as servitization drivers and account for SMEs' environmental context. Further studies should analyze business model contextual factors as driver and driver to service performance.

Table 2.11 – Research gaps and suggested future research directions.

Finding	Research gap	Future research direction
# 1.1	1. Contributions mainly come from Europe and are fragmented among different fields, with empirical cases from Europe and a few countries in Latin America.	1. Address empirical cases from North America, Asia, and developing countries to stress the role of economic, social, and political contexts, practices, and work environments.
# 1.2	2. Servitization is absent from entrepreneurship journals.	2. Address empirical cases from family businesses and start-ups. 3. Compare family firms' servitization journey to the managerial ones.
# 2	3. Most contributions are empirical qualitative case studies from the manufacturing industry.	4. Extend empirical research to other sectors from manufacturing, both in B2B and B2C industries. 5. Adopt quantitative methodologies (e.g., surveys) that compare different companies from the same or different industries.
# 3	5. Only a few qualitative studies have analyzed the PSS business model's implementation when just one model is executed. 6. Models are based on the business model canvas framework.	6. Investigate how PSS business model frameworks and SeMM can support the configurations of variables, especially resources and capabilities when multiple BMs are deployed within the same company (Federico Adrodegari & Saccani, 2020; Federico Adrodegari et al., 2017). 7. Develop new PSS business models based on different frameworks regarding business model canvas (Federico Adrodegari et al., 2017). 8. Define archetypal configurations of servitized BMs that describe the strategic shift from products to PSS along service growth trajectories (Federico Adrodegari et al., 2017). 9. Extend the SeMM, focusing on variables that cross between BM components and maturity dimensions to identify critical requirements to be added (Federico Adrodegari & Saccani, 2020).
	7. PSS business variables' significance is not statistically tested.	10. Perform explanatory surveys to test the significance of the PSS business model's variables (Federico Adrodegari et al., 2017).
	8. The role of value co-creation with suppliers is not sufficiently analyzed.	11. Analyse how key relationships between SMEs and their suppliers can create new value propositions beyond the existing industry logic (Gebauer et al., 2012).
# 4.1.	9. Cases related to sustainable PSS design are developed through cross-sectional analysis.	12. Develop longitudinal and cross-sector empirical studies looking for sustainable PSS transition patterns, determining minimum capabilities necessary to support the evolution, and approaches to unlock design and sustainability leadership capabilities (de Jesus Pacheco et al., 2019).
	10. The role of digitalization and ICT tools selection for PSS design is not sufficiently analyzed.	13. Find mechanisms to determine on an individual basis when sustainable PSS development through integrating ICTs and the design process is a suitable concept for SMEs (Hernandez-Pardo et al., 2013). 14. Developing frameworks guiding SMEs in choosing more suitable ICT systems and increasing their diffusion internally, defining the role of the Industry 4.0 technologies and paradigms (de Jesus Pacheco et al., 2019). 15. Provide tools to support sustainable PSS risk, cost, and profit analysis, helping SMEs conduct organizational changes and detail the sustainable PSS offer along the life cycle (de Jesus Pacheco et al., 2019). 16. Develop a structure to link the elements in Hernandez-Pardo et al. (2012)'s research reference model with the four types of systems that describe the relationships between product and service design and the use of ICT to develop sustainable PSS in SMEs.
	11. Any article does not explore the circular economy model by SMEs.	17. Study the connections of sustainable PSS in SMEs to circular economy models (de Jesus Pacheco et al., 2019).

# 4.2.	12. Not all the frameworks and tools for PSS development are empirically tested.	18. Test tools with empirical data, refining their reliability (Fornasiero & Sorlini, 2010; Tauqeer & Bang, 2018).
	13. Co-creation with suppliers and customers is not sufficiently emphasized.	19. Significantly, new cases that stress collaboration with suppliers and co-creation with customers in different business environments are needed to evaluate the use of frameworks and tools in practice (Hemilä & Vilko, 2015).
		20. Study how PSS co-creation and testing before commercialization impact service business' success (Hemilä & Vilko, 2015).
		21. Develop assessment tools for suppliers identification according to the selected PSS strategy (Tonelli et al., 2009).
	14. Specific tools to guide internal competencies and resources verification do not exist.	22. Provide tools to assist the company in verifying the internal competencies and resources needed for selected PSS strategy implementation (Tonelli et al., 2009).
# 5	15. The role and the interaction among different servitized network' actors are not analyzed.	23. Extend the value constellations to include internal business units and external partners (Kowalkowski et al., 2013).
		24. Analyse the role of customers (Lelah et al., 2012a) and project owners (Aloini et al., 2013) in the value constellations to study the co-creation of value at strategic, tactical, and operational levels (Kowalkowski et al., 2013a).
		25. Explore whether some customers could be more suitable for companies to involve in co-creation activities (Goduscheit & Faullant, 2018).
		26. Developing longitudinal studies focusing on transformation dynamics of provider-customer relationships (Lappalainen et al., 2019),
		27. A couple of new hypotheses about the Guo & Jiang (2019)'s game model could be established, namely (a) give to SMEs the maximum power to perform the first step, and (b) evaluate the quality of service through other indicators then lead time.
	16. Digitalization's impact on network performance is explored just by an article.	28. Differentiate between the companies' digitalization levels of advancement and dimensions in the paths toward radical service innovation, highlighting the role of resource mobilization among SMEs (Goduscheit & Faullant, 2018).
# 6	17. No longitudinal on servitized SMEs' performances has been developed.	29. Prefer quantitative longitudinal case studies to examine how SMEs perform over different life cycle stages to reach generalizable conclusions. Nevertheless, qualitative studies can be implemented to understand how new manufacturing ventures initiate, develop, and sustain service intensity (Patel et al., 2019).
	18. Digitalization is not sufficiently emphasized.	30. Analyse the role of SMEs' level of digitalization and service heterogeneity on financial and non-financial performances (Queiroz et al., 2020).
	19. The factors determining deservitization for SMEs' general performance growth are not explored.	31. Understand why service emphasis contributes to firms' revenue growth and the conditions under which companies decide to reduce their service emphasis, causing deservitization. The latter allows investigating the circumstances under which service emphasis causes deteriorating performance (Böhm et al., 2017).
	20. Service capabilities and organizations lack reliable scales that evaluate the evolution and performance impact through time.	32. Analyse how service capability variation within firm influences firm performance differentiating between new SMEs and those transitioning from a product-centric business (Valtakoski & Witell, 2018), focusing on how ventures develop capabilities for transitioning manufacturers into services and reallocate resources during their early years (Patel et al., 2019).
		33. Analyse how the structure of back and front office organizations influences firm performance (Valtakoski & Witell, 2018).
		34. Developing scales for service capabilities and other servitization-related constructs based on the previous works by Gebauer et al. (2011) and Sousa and da Silveira (2017).
		35. Analyse how performances are influenced by the relationship among servitization strategy, organizational design, and environmental factors, focusing on the retroactive effect between strategy and environment (Ambroise et al., 2018). Along this way, analyze whether the successful implementation of specific service types requires the presence of different organizational characteristics (Böhm et al., 2017).

# 7	<p>21. Selected models are not always empirically tested and compared in different SMEs.</p> <p>22. Selected decision-making models do not consider the influence of contextual and environmental factors.</p>	<p>36. Implement a shared database on servitization projects to trigger Dahmani et al. (2016)'s decision-making reference model to discern critical risk contexts and factors that generate more generic but statistically proved knowledge on risk management.</p> <p>37. Confront the influence of additional factors within the Chalal et al. (2015) decision support system, from both the user-oriented and production-oriented subsystem, accounting for more aggregated indicators in the simulator which would interpret it as cost and revenue models of service-oriented transitions.</p> <p>38. Introduce a classification of the different contextual and environmental factors that can influence servitization strategy for industrial SMEs within the Dahmani et al. (2020)'s decision-making model. Furthermore, this model should consider variables influencing decision-making, such as risk impacts or severity, the cost of questioning high-risk decisions, and decision-makers risk appetite or risk aversion.</p>
# 8	<p>23. No longitudinal about territorial servitization has been developed.</p> <p>24. KIBS formation and value proposition offered to SMEs is still an unexplored topic.</p> <p>25. Regional policies' impact on SMEs and KIBS' servitization initiatives can be extended.</p> <p>26. Only intellectual capital navigator (ICN) is presented as a government tool for regional servitization policy making and formulation.</p>	<p>39. Analyse KIBS' value added to manufacturers through longitudinal studies (Horváth & Rabetino, 2019). The Guerrieri and Meliciani (2005) service types for knowledge-intensive manufacturers classification should be used for this intent.</p> <p>40. Extend KIBS formation rates studies incorporating additional sources of territorial heterogeneity, such as regional policy priorities (Horváth & Rabetino, 2019).</p> <p>41. Evaluating the drivers of KIBS formation rates at the manufacturing clusters scale focusing on territorial heterogeneity, such as the distribution of sectors unrelated to KIBS' operations (Horváth & Rabetino, 2019).</p> <p>42. Evaluate the connections between KIBS and new manufacturing businesses, determining whether they collaborate with one or several manufacturing businesses in areas with different levels of strategic relevance (Bellandi & Santini, 2019; Lafuente et al., 2017).</p> <p>43. Focus on Guerrieri and Meliciani's (2005) service types for knowledge-intensive manufacturers turn to certain types of services.</p> <p>44. Study how specific policies seeking to revitalize manufacturing activities in territories with relatively undeveloped manufacturing industries (e.g., digital infrastructures) align the interests of managers of manufacturing firms with those of new investors in knowledge-based service sectors (Lafuente et al., 2017).</p> <p>45. Analyse the use of intellectual capital navigator (ICN) for policy making and formulation, categorizing different resource deployment structures and their impact on firm performance (Roos & O'Connor, 2015)</p>
# 9	<p>27. The role of the context is not well-studied, both as a driver and a barrier.</p> <p>28. The literature misses the literature to evaluate knowledge, capabilities, resources, and information gaps compared to the optimal level.</p> <p>29. Lack of studies related to technology as a driver to servitization.</p>	<p>46. Develop and test hypotheses regarding the impact of different dynamic resource configurations on service growth and the return of investment on digital investments (Coreynen et al., 2017).</p> <p>47. Analyse how the manufacturer balances exploration and exploitation efforts and cross-fertilization to reduce ramp-up time for new service propositions to compare SMEs to large manufacturers (Wim Coreynen et al., 2018).</p> <p>48. Explore how SMEs respond differently to contextual factors and modify their context through their servitization efforts, focusing on the individual decisionmaker's sense-making process to explain the diversity of adaptations (Dmitrijeva et al., 2019).</p> <p>49. Analyse the relationship between different PSS strategies, barriers, and performance: for example, investigate whether companies dealing with a design barrier would benefit mostly from emphasizing exploration activities (Wim Coreynen et al., 2018).</p> <p>50. Study how SMEs can identify a lack of knowledge, capabilities, resources, and information (Michalik et al., 2019)</p> <p>51. Explore the main drivers deeply for smart servitization (Kanovska & Tomaskova, 2016).</p>

2.6 Discussion

The authors collected feedback about the value transfer to practitioners by deeply discussing obtained results with the chief service officer (CSO) and the chief commercial officer (CCO) of an Italian SME that produces optical industry machinery. It emerges as SMEs could link their needs to the thematic clusters identified by this research and prioritize their servitization roadmap action-list according to them. Table 2.12 shows the cluster priority list identified by the selected SME, which is discussed after this.

Table 2.12 – Thematic clusters priority list according to the interviewed SME.

Priority cluster	Thematic cluster	Sub-cluster (if available)
High	<i>Drivers and barriers to servitization progress</i>	-
	<i>PSS design and development</i>	<i>Frameworks and tools for PSS development</i>
	<i>PSS business modeling</i>	-
Medium	<i>Performances</i>	-
	<i>Collaborative networks</i>	-
Low	<i>PSS design and development</i>	<i>Sustainable PSS design</i>
	<i>Decision-making support systems</i>	-
<i>Out of scope</i>	<i>Territorial servitization and policymaking</i>	-

First, both respondents acknowledged that contributions from different industries from manufacturing are requested as reported by the CSO: “*We could analyze our remote support service taking inspiration from hospitals’ intensive care units. How do several doctors and nurses guarantee service continuity in an environment characterized by complex information and zero errors?*”. After this, they recognize that digitalization represents a crucial driver to PSS development, granting collaboration among the SME and its customers. The managers mentioned that the company would invest in implementing specialized software that aims to reengineer current front-office (e.g., field service operations) and back-office processes (e.g., technicians scheduling) and potentially allow the development of new services. As mentioned by the CSO: “*We are very interested in artificial intelligence and machine learning applications for smart services development. [...] We thought that frameworks for PSS development should question digitalization. The latter would not solve all customers’ problems, but we*

acknowledge that technology should not be excluded from PSS development. In the bad scenario, we can immediately turn back to the human touch: there are no conflicts among the two parties.”. This picture calls for an effort to tackle further research opportunities about digitalization's role within frameworks and tools to overcome SMEs' resources and capabilities-related barriers. Overall, the SME considers drivers and barriers to servitization progress to understand how to shift its service organizational structure and prioritize its service business unit's investments.

On the other hand, the CSO stressed new approaches to service growth based on appropriate PSS business models: *“The service department needs a different rationale to define customer segments compared to the ones used by salespeople. [...] How do other manufacturing companies understand the value transferred by the service to customers? Tailored services must respond to service profiling logics, not product ones”*. He also stated: *“Customer segmentation is crucial because it is the starting point for service offering. We have a lot of unexploited data that could be used to cluster our customers using advanced methods, such as the ones based on machine learning, but we do not know how.”* These statements aim to enhance the SME's service performance by better understanding PSS business modeling. Based on the collected judgments, the managers decided to include the topics mentioned above in the high-priority cluster, requiring new research on digitalization's role in the SMEs' servitization journey by gaining knowledge through cases from heterogeneous industries.

Nevertheless, it is interesting that service performances are not in the high-priority cluster. Moreover, non-financial performances are preferred compared to financial ones. Services delivered account for about 5% of the selected company's total turnover. This percentage is justified because of the services marketing usage as differentiating competitive factor to enhance long-term customer relationships. *“Profit and revenues are generated mainly through the company's core products, while the contribution of services is low in terms of revenues and profit but quite high in customer satisfaction.”*, the CSO said. This sentence highlights the current product-centric strategy of the SME. As the CCO stated: *“In our company, remote assistance throughout the life cycle of the machine is included the price of the latter: into a lab, the first machine is sold by the sales team, while for the second one, the contribution of the service is fundamental. [...] Nevertheless, we experienced vicious situations with customers that call us just because it is for free.*

Maybe something could be changed in the future.” The selected SME collaborates internally with its three branches – in North America, Latin America, and Asia-Pacific – and externally with several distributors and resellers. The latter delivers machine-related services in specific geographical areas (e.g., Japan and Germany) in collaboration with the SME. The present SLR questioned the interviewed managers about the impact of a shared standard collaborative network. The CSO believed that *“We aim to standardize service processes worldwide. I expect to create a shared environment where coordination among the different service actors will be facilitated and measurable”*, while the CCO said that *“Indirect service channel management through distributors and resellers must be strictly defined over standard policies that specify tasks and responsibility for all services provided.”*

Conversely, the sustainable PSS design and the decision-making support systems clusters received less interest since the concepts seemed hard to be understood by the interviewed managers, as the literature already emphasized. This fact calls for extensive effort on these two topics to develop related future research directions identified and help SMEs understand servitization aspects.

Last, territorial servitization and policy-making topics do not obtain interest due to the passive role played by SMEs in these processes.

2.7 Conclusions

2.7.1 Implications for theory

From the seminal work of Vandermerwe & Rada (1988), servitization and PSS-related research have progressively gained attention among scholars and practitioners. During the last years, servitization applications were boosted by Industry 4.0's technologies (e.g., remote monitoring), theoretical contributions, and empirical cases analyzed primarily focused on large firms. Considering the SMEs' key role in the contemporary economy, research on servitization in small and medium firms is still an early-growth phase with limited contributions spread among different disciplines. Therefore, a systematic literature review of the available scientific literature was organized, capturing state of the art in the area.

First, this study organized existing knowledge summarizing results through descriptive and thematic analyses. Nine findings were stated, pointing out the findings. Specifically, descriptive analysis highlights (i) the distribution of the selected articles' final sample along time, research fields, geography, and (ii) the methodological approaches applied. On the other side, the thematic analysis outlined literature's features about (iii) PSS business modeling, (iv) PSS design and development practices adopted by SMEs, (v) analyses of servitized SMEs' collaborative networks, and (vi) financial and non-financial performances, (vii) decision-making support systems, (viii) territorial servitization and policymaking, as well as (ix) drivers to servitization and faced barriers to its progress. Propositions allowed the identification of 29 gaps in the body of knowledge that led to the definition of 51 future research directions for scholars, which constituted the second output of this article. The subsequent dissertation's chapters are developed leveraging some identified gaps and further research directions (Table 2.13).

Table 2.13 – Association of the next dissertation's chapters to gaps identified.

Chapter	Gap #	Further research direction #
3	3, 7, 27	5, 10, 49
4	12, 13, 15, 28	18, 24, 25, 26, 50
5	3, 12, 13, 14, 29	4, 18, 19, 22, 51
Appendix	2, 3	2, 4

2.7.2 Implications for practice

The work represents a time-saving tool for practitioners. Shading light on the different dimensions in SMEs, this paper aims to summarize available state-of-art knowledge providing a guide for entrepreneurs, managers, and consultants from small and medium companies during their servitization journey. Hence, this SLR makes it easier to understand the evidence provided by the research. Furthermore, I introduced a thematic clusters priority list based on the discussion with managers from a manufacturing SME that should help other companies prioritize their servitization roadmap's tactical and strategic actions.

2.7.3 Limitations and future research opportunities

The approach embraced during this SLR has been characterized by some authors' choices that constitute limitations to the research. Future studies should include conference papers to expand the source of potential findings. Furthermore, the Scopus query potentially excludes papers related to the same topic but labeled with keywords not used.

Gaps identified (Table 2.11) should be classified according to their recipient company, namely gaps focusing on all-sized enterprises or SMEs. Analyzing the second group of gaps will be paramount to recognizing why scholars neglected to tackle them within servitization literature. Additionally, analyzing SMEs' gaps should discriminate gaps that could concern family businesses and start-ups.

Last, thematic analysis clustering should benefit from quantitative techniques to prevent subjective bias, such as the LDA (Latent Dirichlet Allocation) modeling (Pirola, Boucher, Wiesner, & Pezzotta, 2020). In this sense, scholars are encouraged to use a co-citation network specialized software to detect the domain's thematic clusters (C. Chen, Ibekwe-SanJuan, & Hou, 2010).

3. HOW DOES PRODUCT STRATEGY CONTRIBUTE TO SERVICE PERFORMANCE IN SMES? THE MEDIATING ROLE OF SERVITIZATION ORIENTATION

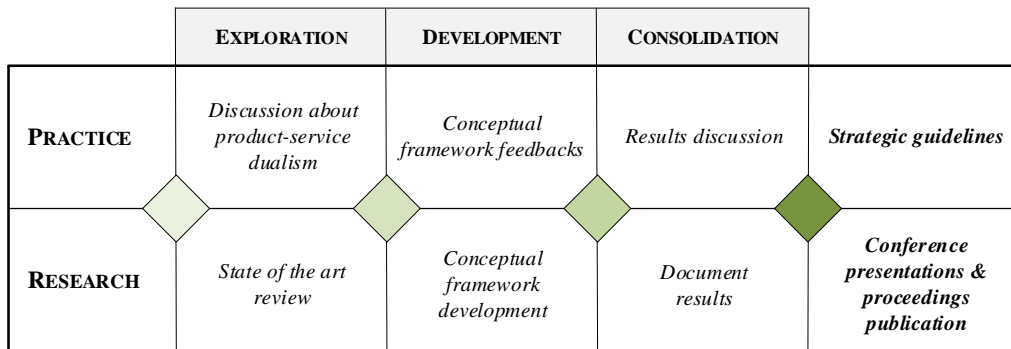


Figure 3.1 – Positioning of the second essay according to the general research design adopted.

Acknowledgment

This chapter is readapted from the article "Gamba, D., Minola, T., Kalchschmidt, M., Adrodegari, F., (2022). How does manufacturing strategy contribute to servitization orientation?" presented at Spring Servitization Conference in Florence (Italy) in May 2022 and at APMS Conference in Gyeongju (South Korea) in September 2022. The work is published in "Kim, D.Y., von Cieminski, G., Romero, D. (2022). Advances in Production Management Systems. Smart Manufacturing and Logistics Systems: Turning Ideas into Action. IFIP Advances in Information and Communication Technology, Vol. 663. Springer, Cham." I am personally responsible for any changes made from the last version. I want to thank my coauthors, Tommaso Minola, Matteo Kalchschmidt, and Federico Adrodegari, for the opportunity to work with them and for the guidance received. I am grateful to my Bergamo colleagues for their feedback gathered during the internal Networking Seminar organized by the University of Bergamo's WAVE Lab in June 2022. Suggestions collected made me significantly improve the methodology adopted in this article. Last, I recognize the value gained during the seminal phase of this project from discussions with Lorenzo Greselin, my industrial tutor and Chief Service Officer of MEI Srl. He allowed me to properly define the problem tackled by this article from a practitioner's point of view.

3.1 Introduction

According to Dohale et al. (2020), manufacturers need to effectively define a clear manufacturing strategy to plan their business model's long-range objectives. Manufacturing strategy is a pattern of decisions to develop specific manufacturing properties as a competitive weapon to move from where it is to where it wants to be (Miltenburg, 2008). It is reasonable to assume that the product-centric firm's manufacturing strategy is manifested as a product strategy. Product strategy is the pattern of product introductions that emerge from the organization's competitive priorities throughout time (Firth & Narayanan, 1996). This definition implicitly emphasizes the competitive priorities concept, which refers to factors on which strategies are based and how firms want to compete in the market. Some competitive priorities reflect exploitative strategies that in product-centric firms imply better products than competitors, while others reveal explorative product strategies implying newer and more innovative products (Chaudhuri & Boer, 2016). Firms that bring together exploitation and exploration are called ambidextrous (Chang & Hughes, 2012).

Market pressure to create more flexible offerings leads many product-centric firms to shift their business model from products to product-service systems (F. Adrodegari & Saccani, 2020). In that sense, servitization assumes that companies that initially offer just products begin adding more and more services to their total offering (Viljakainen & Toivonen, 2014). Transitioning to a servitized business model requires an organizational-level orientation to services. The latter is depicted by the organization's investments in new service development, employees' upskilling for service delivery, and the development of products for enhancing service operations (Shah, Jajja, Chatha, & Farooq, 2020). Along the transition from product-centric to servitized business model (Figure 3.2), product strategy represents the starting point (Oliva & Kallenberg, 2003).

Managers must allocate available resources to develop a subset of prioritized competitive priorities to win orders in the market (Netland & Frick, 2017). In this sense, small and medium enterprises (SMEs) relatively lack internal resources compared to large companies (Kowalkowski, Witell, & Gustafsson, 2013b). Prioritizing competitive capabilities is crucial for SMEs to ensure servitization orientation. In addition, literature shows that the availability of slack resources (Wang, Choi, Wan, & Dong, 2016)

guarantees to increase in the chance of investing and growing in servitization, obtaining positive financial and non-financial service performance (Queiroz et al., 2020). SMEs are relatively penalized about slack resources availability compared to large companies (Wang, Choi, Wan, & Dong, 2016). Service performance success does not depend on the SME's starting healthy financial position but on allocating appropriate slack resources guaranteed to the service business to increase the chance of growing and obtaining positive service performance (Böhm et al., 2017).

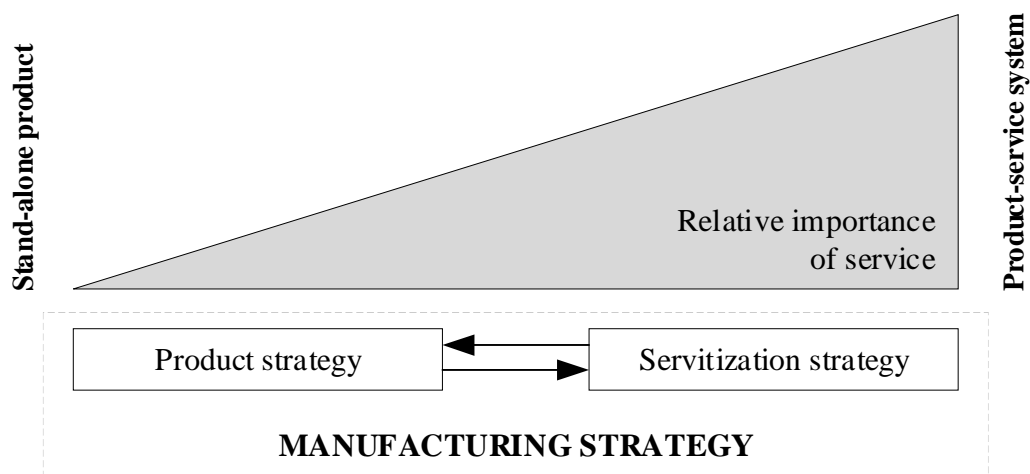


Figure 3.2 – The transition from product to servitization strategy in manufacturing firms.

To the best of our knowledge, there is a gap in the literature about the association between the contextual role of firms' product strategy and service performance in SMEs, and the underlying mediating mechanism of servitization orientation in this relationship. For these reasons, I designed the following research question:

RQ2. *How does the SME's product strategy impact its servitization performances?*

The present article reports the findings from a quantitative study built on a mediation model based on data from the sixth round of the International Manufacturing Strategy Survey (IMSS-VI) to tackle the mentioned gap. This choice answers the need for quantitative studies to test some variables of the PSS business model and their role as internal barriers to service performance, as described in paragraph 2.5.

The paper is structured as follows. First, I discuss the relevant literature declaring the proposed model's hypotheses. Second, the design and methodology of this research are described. In the main section, I present achieved results by analyzing the relationship between product strategy and service performance. Finally, findings are discussed, suggesting further research and implications for scholars and practitioners.

3.2 Related literature

3.2.1 *Service performance*

A more expanded theoretical overview of the literature concerning servitization in SMEs can be found in the systematic review of this doctoral dissertation (see paragraph 2.4.6). However, the crucial contributions to the aim of this study are briefly described from now on. Service performance measures are strictly related to the manufacturer's objectives (Ziaee Bigdeli et al., 2018), as different strategies have heterogeneous effects on service performances (Queiroz et al., 2020; Valtakoski & Witell, 2018).

Literature highlights that integrated performance measurement frameworks include different points of view (Franco-Santos, Lucianetti, & Bourne, 2012). In this research, I consider the internal perspective to capture the organization's outcome service delivery performance. In addition, a sophisticated organizational design does not necessarily result in higher margins due to costs associated with service customization and structural capabilities development (Ambroise et al., 2018). About the latter, Valtakoski and Witell (2018) identified that back-office capabilities do not positively impact firm performances, while front-office ones do. By the way, despite costs and paradoxes associated with service-oriented investments (Gebauer et al., 2005), SMEs' performances generally benefit from servitization business model transition (Crozet & Milet, 2017; Ha et al., 2016; Queiroz et al., 2020).

3.2.2 *Manufacturing and product strategies*

The manufacturing organization influences a firm's competitive advantage, which leads to superior firm performance (Chikán, Czakó, Kiss-Dobronyi, & Losonci, 2022; Dohale et al., 2020). The competitive advantage is transferred to a functional level: the manufacturing strategy. A manufacturing strategy is a system of competitive priorities realized by strategic choices to achieve strategic objectives and improve competitive

performance (Hoang, Phan, & Le Thai, 2020; Miltenburg, 2008). From the seminal work by Porter (1980) and on, the strategic management literature identifies two extreme strategic profiles (Das & Canel, 2022). The first profile's business challenge is establishing a steady market by creating a single-core technology that is incredibly cost-effective to dominate a small portion of the potential market.

In contrast, the second profile maintains a wide and constantly expanding domain while keeping an eye on various environmental factors and events to look for new products and business prospects. As mentioned in paragraph 3.1, assuming that the product-centric firm's manufacturing strategy matches the product strategy is realistic. This assumption is particularly true in SMEs, where the relative lack of financial and managerial resources led them to focus predominantly on their core business driver (i.e., the product).

These concepts suggest that specific competitive priorities entail exploitative product strategies for better products than competitors, while others indicate explorative product strategies that focus on newer and more innovative products (Chaudhuri & Boer, 2016). SMEs that have successfully adopted an exploitation product strategy focus on improving and enhancing the organization's current practices (Cui, Walsh, & Zou, 2014), which means capitalizing on product-related economies of scale and knowledge leaving out different investments. On the other hand, SMEs that have successfully implemented an exploration product strategy focus on learning new skills, product development, discovering new customer segments and expanding their products to new markets (Cui et al., 2014). These shreds of evidence denote the openness and inclination towards investments in new strategies, such as servitization.

3.2.3 Servitization orientation

Literature refers to servitization orientation as the inclination and the capability to create and supply services that a firm wants to offer in addition to its product offering (Sousa & da Silveira, 2017). Servitization orientation is conceptualized at the individual and organizational levels (Oliveira & Roth, 2012). In the first case, orientation reflects a person's attitude toward services. In contrast, the second instance concerns the extent of organizational arrangements oriented to overcome a product orientation and develop a servitization strategy. Since the scope of this research is related to the firm's strategic orientation toward servitization strategy, the organizational conceptualization is

considered more correct. At this level, scholars measure servitization orientation as actions to increase the number of services offered and their broadness and emphasis (Homburg, Hoyer, & Fassnacht, 2002). Increasing service offering implicitly led organizations to offer more customized outputs and boost customer involvement compared to product-centric firms (Lenka, Parida, Sjödin, & Wincent, 2018). Hence, investments in new service development, employees' service-related upskilling, and aftersales-oriented product development describe the manufacturing organization's inclination and capability toward servitization (Shah et al., 2020).

Based on the fact that an exploitative product strategy implies a more conservative approach compared to an explorative product strategy, which favors investments in product-related new skills and development, I firstly I hypothesize that:

H1A. Exploitative product strategy is negatively associated with servitization orientation.

H1B. Explorative product strategy is positively associated with servitization orientation.

Subsequently, notwithstanding costs and performance paradoxes associated with service investments (Gebauer et al., 2005), I theorize that:

H2. Servitization orientation is positively associated with service performance.

The discussion proceeding H1_A, H1_B, and H2 indicate that the manufacturing firm's product strategy would improve service performance. Supposing the negative impact of the exploitative product strategy on service performance and the positive association of the explorative product strategy to the latter, I suggest – combining the previous hypotheses – that the relationship between product strategy and servitization performance can be explained only through the underlying mediating role of servitization orientation. Consequently, I defined the following hypotheses to test the direct effect of the two different product strategies on service performance, and the related indirect effects via servitization orientation:

H3A. Servitization orientation mediates the relationship between exploitative product strategy and service performance. Exploitative product strategy is negatively associated with service performance.

H3B. Servitization orientation mediates the relationship between explorative product strategy and service performance. Explorative product strategy is positively associated with service performance.

Figure 3.3 illustrates the whole model hypothesized in this paper. The indirect effects are represented by the product of a_1 and a_2 with b , while the direct effects by c'_1 and c'_2 .

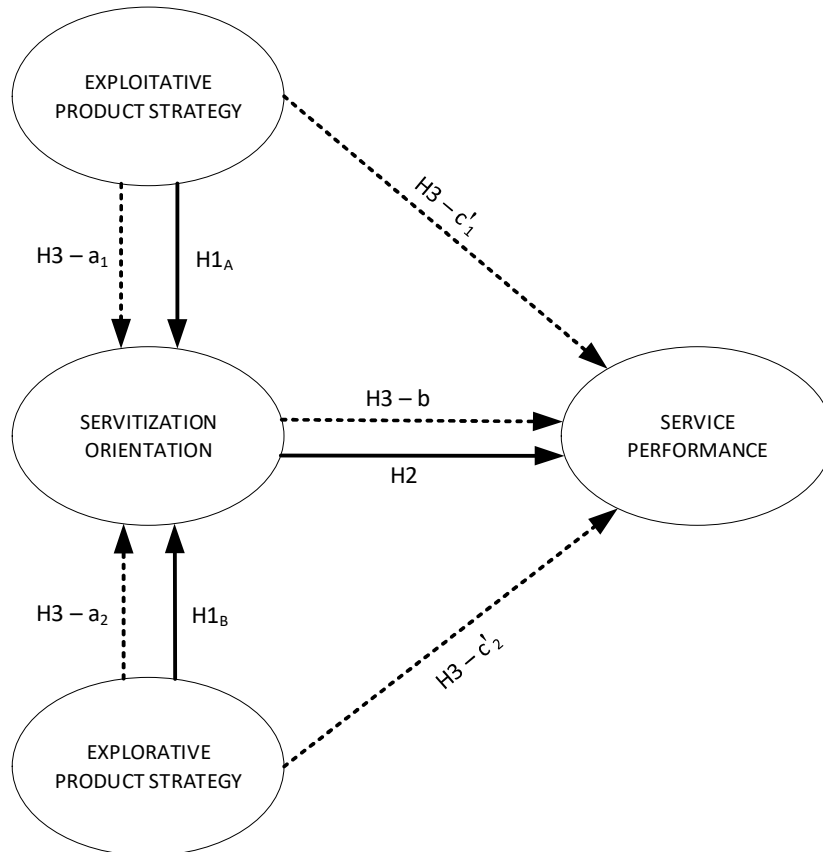


Figure 3.3 – Hypothesized model. Solid arrows indicate direct paths, while dashed arrows represent mediation's effects.

3.3 Research model design

3.3.1 Sampling and data collection

The survey approach was chosen to test the proposed theoretical model as a suitable research method. I used data from the sixth edition of the International Manufacturing Strategy Survey (IMSS-VI) to test the research hypotheses (IMSS, 2015). IMSS is a periodic data gathering of a large and representative sample of worldwide manufacturing

business units (ISIC 25-30). This initiative was launched in 1992 by the London Business School and Chalmers University. Data collection is carried out every 4 to 5 years through the cooperation of an international network of operations management scholars. IMSS-VI collected data between 2013 and 2014 in 22 countries, including 961 valid responses from 7,167 initial contacts. Responses focused on the manufacturing business unit and utilized either perceptual or objective metrics. The survey evaluated the strategies, practices, and performance of manufacturing business units from ISIC sectors 25 to 30. The initial English-language survey was administered in 11 nations. Versions provided mostly through double parallel translations were utilized in the remaining 11 nations. Previous studies have used the IMSS-VI and earlier rounds of this initiative data to analyze several servitization aspects (e.g., He et al., 2015; Kang et al., 2017; Shah et al., 2020; da Silveira & Cagliano, 2006; Sousa & da Silveira, 2018, 2017; Szász & Seer, 2018; Szász et al., 2017; Tian et al., 2012).

Due to the specific target of the present research, I reduced the number of observations by deleting respondents from business units classified as large companies by the European Commission definition (European Commission, 2003). The updated dataset included 367 records about SMEs (see Table 3.1 for sample demographics).

Table 3.1 – Reduced sample demographics.

Sample characteristics	Number	%
Firm size (number of employees and turnover)		
Small (≤ 50 employees & turnover ≤ 10 M€)	27	7.36
Medium size (51-250 employees & turnover 10-50 M€)	340	92.64
Industry		
ISIC 25 – Fabricated metal products, except machinery and equipment	137	37.34
ISIC 26 – Computer, electronic and optical products	46	12.53
ISIC 27 – Electrical equipment	54	14.71
ISIC 28 – Machinery and equipment not elsewhere classified	98	26.70
ISIC 29 – Manufacture of motor vehicles, trailers, and semi-trailers	19	5.18
ISIC 30 – Other transport equipment	13	3.54
Region and Country (country sample size)		
<i>Europe and North America</i>	260	70.84
Belgium (11), Canada (21), Denmark (16), Finland (20), Germany (3), Hungary (32), Italy (21), Netherlands (30), Norway (9), Portugal (8), Romania (34), Slovenia (10), Spain (19), Sweden (2), Switzerland (9), USA (15)		

The reduced sample was inspected to analyze missing values. All variables considered include less than 5 percent of missing values. Thus, the missing values of a variable could be replaced with the respective mean of valid values if these were missing completely at random (MCAR) (Hair et al., 2021). I performed Little's MCAR test (Little, 1988) to verify this hypothesis (Table 3.2). It is a χ^2 test of the null hypothesis that the data are MCAR. The χ^2 statistic was insignificant ($p = 0.12$), so the data could be considered MCAR.

Table 3.2 – Little's MCAR test.

Statistic	Value
Number of observations	367
χ^2 distance	115.79
Degrees of freedom	99
$p > \chi^2$	0.12

Last, I successfully tested data for common method bias (CMB) using Harman's single-factor test employing principal component analysis (Sousa & da Silveira, 2020). The percentage of variance explained is 33.7%, which is less than the acceptable threshold of 50%. This result confirms that IMSS-VI was designed according to the guidelines to minimize CMB by Podsakoff et al. (2003).

3.3.2 Measurement development and validation

The model includes four constructs: exploitative product strategy, explorative product strategy, servitization orientation, and service performance. Following the guidelines by Diamantopoulos & Siguaw (2006) and previous IMSS-related research, each construct was developed as a first-order reflective containing multiple items (Table 3.3).

Quality was the competitive priority used to measure exploitative product strategy. Then again, innovation was employed as a proxy to measure explorative product strategy (Y.-Y. Chang & Hughes, 2012; Chaudhuri & Boer, 2016; Netland & Frick, 2017). Both were operationalized as reflective constructs and captured the importance of the competitive

priority to win orders in the last three years using a 1 (none) to 5 (high) Likert scale. Servitization orientation was operationalized as in Shah et al. (2020), who used the effort put into inclination and capacity to expand service offering to customers using a Likert scale from 1 (none) to 5 (high). On the other hand, service performance was measured according to the approach proposed by Szász & Seer (2018). IMSS requires respondents to evaluate product-related assistance and customer service quality current performance compared to three years ago on a 5-point Likert scale, ranging from -5% or worse (1) to +25% or better (5).

Table 3.3 – Constructs and manifest variables.

Construct	Main concept of the question and related items	IMSS code	Timeframe
Exploitative PS	<i>Importance of the following attribute to win orders from major customers:</i>	A3	Importance in the last three years
	• Better product design quality to win orders	A3.B	
	• Better conformance to customer specifications to win orders	A3.C	
Explorative PS	<i>Importance of the following attribute to win orders from major customers:</i>	A3	Importance in the last three years
	• Offer new products more frequently to win orders	A3.J	
	• Offer products that are more innovative to win orders	A3.K	
Servitization orientation	<i>Effort put into implementing action programs related to:</i>	S3	Effort in the last three years
	• Expanding the service offering to your customers	S3.A1	
	• Developing the skills needed to improve the service offering	S3.B1	
Service performance	<i>How has the following manufacturing performance changed:</i>	B6	Increase/decrease compared to three years
	• Product assistance/support	B6.G1	
	• Customer service quality	B6.H1	

I carried out analyses in Stata version 17. Table 3.4 presents the observed indicators' means, standard deviations, and indexes related to validity, internal consistency, and discriminant validity criteria. The Cronbach alpha (CA) and Raykov's composite reliability (CR) of each construct are higher than the acceptable threshold of 0.7, confirming the scales' reliability and internal consistency (Nunnally, 1975; Raykov, 1997). In addition, I successfully tested the dataset's suitability for data reduction through

the Kaiser-Meyer-Olkin's test (KMO) and Bartlett's sphericity test (Table 3.5). Last, I checked the model's unidimensionality, validity, and reliability of scales with confirmatory factor analysis (CFA). Values of the fit indices ($\chi^2_{21=df} = 29.775$, $p = 0.097$, CFI = 0.992, TLI = 0.986, RMSEA = 0.034 [0.000; 0.060]) indicated a satisfactory fit (Bagozzi & Yi, 1988). All items had significant factor loadings exceeding the acceptable minimum of 0.60 (Hair et al., 2010). Average variance extracted (AVE) values are above 0.50, fulfilling the condition of convergent validity (Fornell & Larcker, 1981).

Table 3.4 – Internal consistency, convergent validity, and discriminant validity criteria.

Construct	Item	Mean	S.D.	CA	CR	Loading	S.E.	AVE
Exploitative PS	A3.B	4.09	0.96	0.716	0.749	0.887	0.065	0.593
	A3.C	4.20	0.88			0.631	0.055	
Explorative PS	A3.J	3.09	1.09	0.773	0.774	0.819	0.040	0.631
	A3.K	3.44	1.09			0.769	0.040	
Servitization orientation	S3.A1	2.91	1.13	0.767	0.774	0.791	0.030	0.549
	S3.B1	2.97	1.07			0.806	0.030	
	S3.C1	2.91	1.23			0.609	0.040	
Service performance	B6.G1	2.90	0.91	0.784	0.786	0.767	0.041	0.648
	B6.H1	2.91	0.91			0.841	0.042	

Table 3.5 – KMO and Bartlett's test.

Statistic	Value
No. of items	0.739
Kaiser-Mayer-Olkin (measures of sampling adequacy) ^A	0.669
Bartlett's test of sphericity ^B	
χ^2	1072.06
Degree of freedom	45
Significance	0.000
Notes.	
^A KMO above 0.6 is acceptable (Kim & Mueller, 1978).	
^B Bartlett's test of sphericity is significant, hence acceptable (Hair et al., 2010).	

Table 3.6 shows pairwise correlations between latent variables, while the square roots of AVE are across the matrix main diagonal. In all cases, correlations are lower than the squared root of e AVEs. Therefore, discriminant validity is supported (Fornell & Larcker, 1981).

Table 3.6 – Correlations between latent variables for discriminant validity test.

Code	Constructs	1	2	4	4
1	Exploitative product strategy	<i>0.770</i>			
2	Explorative product strategy	0.602	<i>0.794</i>		
3	Servitization orientation	0.212	0.503	<i>0.741</i>	
4	Service performance	0.129	0.373	0.689	<i>0.805</i>

Note. The square root of AVE is in italic across the main diagonal.

3.4 Results

I employed structural equational modeling (SEM) using maximum likelihood estimates for hypothesis testing (Hair et al., 2021).

Table 3.7 presents the direct path estimates and model fit. Exploitative product strategy is not significantly related to servitization orientation ($p = 0.452$), failing to support hypothesis H1_A. Conversely, explorative product strategy positively relates to servitization orientation, supporting hypothesis H1_B. Finally, servitization orientation is positively associated with service performance, confirming hypothesis H2.

Table 3.7 – Direct path estimates.

Hypotheses	Path coefficients	S.E.	p-value
Exploitative PS → Servitization orientation (H1 _A)	-0.061	0.081	0.452
Explorative PS → Servitization orientation (H1 _B)	0.455	0.085	<0.001***
Servitization orientation → Service performance (H2)	0.561	0.060	<0.001***
χ^2/df (21)	1.418	RMSEA	0.034
CFI	0.991	CI upper	0.000
TLI	0.986	CI lower	0.060
SRMR	0.033	pclose	0.831

Note. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.8 illustrates the mediation effects analysis of servitization orientation on the relationship between product strategy and service performance. The direct and indirect effects of exploitative product strategy relation are statistically insignificant. In contrast, despite its direct effect is not supported, the explorative product strategy relation's indirect effect is significant. Thus, a full mediation of servitization orientation exists

(Carrión, Nitzl, & Roldán, 2017) in the relationship between explorative product strategy and service performance.

Table 3.8 – Mediation's indirect, direct, and total effects (H3).

Effect	Path coefficients	S.E.	p-value
Indirect effect 1 ($a_1 \cdot b$) Exploitative PS → Servitization orientation → Service performance	-0.027	0.036	0.454
Indirect effect 2 ($a_2 \cdot b$) Explorative PS → Servitization orientation → Service performance	0.200	0.045	<0.001***
Direct effect (c_1) Exploitative PS → Service performance	-0.033	0.061	0.586
Direct effect (c_2) Explorative PS → Service performance	0.071	0.069	0.304
Proportion of total effect that is mediated	0.820		
Ratio of indirect to direct effect	4.553		
Ratio of total to direct effect	5.553		

Note. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.5 Discussion and implications

3.5.1 Implications for theory

that product strategy affects servitization orientation and performance. Servitization is challenging as firms need to reconfigure their business models, introduce new resources, and realign existing ones. The analyses show that:

- Explorative product strategy is positively associated with servitization orientation ($H1_B$), while the relationship with exploitative product strategy is negative but not significant ($H1_A$).
- Servitization orientation has a direct positive effect on service performance ($H2$).
- Explorative product strategy has a fully mediated positive effect on service performance through servitization orientation ($H3_B$). On the other hand, no significant mediation between exploitative product strategy and service performance is identified ($H3_A$).

Based on these results, I develop the following contributions to the existing theory on servitization.

First, the study supports the hypothesized link between product strategy and servitization. While exploitation leverages current resources to optimize products, exploration relies on new knowledge and partners to innovate manufactured goods. Firms more prone to explorative product strategy (e.g., launching a new product more frequently than their competitors) are more inclined to servitize their business model by investing in new service development, developing the skills needed to improve the service offering, and designing products to facilitate aftersales service operations management. Contrary to my hypothesis, no significant direct relationship exists between the exploitative product strategy and servitization orientation. This finding may be traced to the servitization logic that requires a progressive transition from products to services. Due to a lack of resources and capabilities, SMEs that follow exploitative product strategies have fewer incentives to invest in business model innovation. Further research is needed to validate this tentative theory.

Second, I find a robust positive association between servitization orientation and service performance. Most studies on the link between servitization and performance consider the financial perspective, while this paper uses internal process evaluation measures. This result confirms the general assumption that a firm should overcome cognitive barriers to benefit from service offerings.: the higher the inclination to invest in servitization through an appropriate service culture, the greater the company's service performance (Gebauer et al., 2005).

Last, my findings suggest that no direct effects exist between product strategy and service performance. The mediation of service orientation confirms that servitization is a shift in product-centric firms and its benefits emerge only under appropriate conditions. This fact is confirmed by the exploitative product strategy's insignificant direct and indirect effects on service performance. Exploitative product strategy concentrates on improving and enhancing the organization's current practices, allocating resources to the products and not to new business models. Opposite, explorative product strategy implicitly involves inclination and investments in product innovation that should include service to develop product-service systems (PSS) (Mont, 2002).

3.5.2 Implications for practice

Given the nature of this research, the practical implications of this paper primarily inform strategic decision-makers at small and medium-sized manufacturing companies. Results show that servitization orientation is a viable option to increase service performance. This strategic path should be pursued considering the manufacturer's products and strategies. Due to differences from large companies, managers from SMEs should prioritize specific competitive priorities to allocate available resources to develop appropriate strategies for increasing service performance. However, searching for product exploitation has not improved service performance: managers must invest in product exploration to create the right culture and orientation to handle the transition to a servitized business model.

3.5.3 Limitations and future research opportunities

This paper is not exhaustive, and it presents a set of limitations. Due to the limited number of industries involved, the abovementioned findings cannot be fully generalized. In addition, IMSS-VI collected cross-sectional data that did not catch the different firms' behaviors over time and did not collect the recent fourth industrial revolution trends. Last, the reduced number of competitive priority measures selected could not entirely describe SMEs' exploitative and explorative product strategies. This study opens a set of potential further research based on the above-listed limitations. Firstly, given that manufacturing is rapidly growing, especially with digital technologies (e.g., cloud manufacturing), results should be confirmed by replicating analysis on more recent datasets that could include respondents from different industrial sectors (e.g., the construction industry). Secondly, the use of longitudinal datasets is strongly suggested. Thirdly, future research opportunities arise by expanding the current proposed model. For example, other competitive priorities could be added, and the firm's servitization outcomes could be included by analyzing the product strategy's impact on the financial perspective. Finally, the present work's findings should be deepened, considering that SMEs are typically more servitization-oriented than large companies (de Souza, Trento, & Dauer, 2020).

3.6 Conclusions

This study theoretically articulates and empirically validates a relationship model between product strategy, servitization orientation, and service performance in SMEs.

The model considers exploitative and explorative product strategies proxied through a firm's competitive priorities. In doing so, it tries to cover the existing literature gap concerning the dualism between product and service within SMEs that moves from a product-centric business model to a servitized one. The findings suggest that service performance benefits just from explorative product strategy, while the effect of exploitative product strategy is not significant. However, this effect is indirect via servitization orientation. This result supports the notion that growth in service performance may be associated with the intention and capability of the firm to allocate existing resources in organizational structural changes – which should also include products – that lead to a new servitized culture.

4. THE INFLUENCE OF THE TYPE OF AFTERSALES RELATIONSHIP ON THE CO-CREATION OF SERVICES: THE CASE OF AN ITALIAN SME

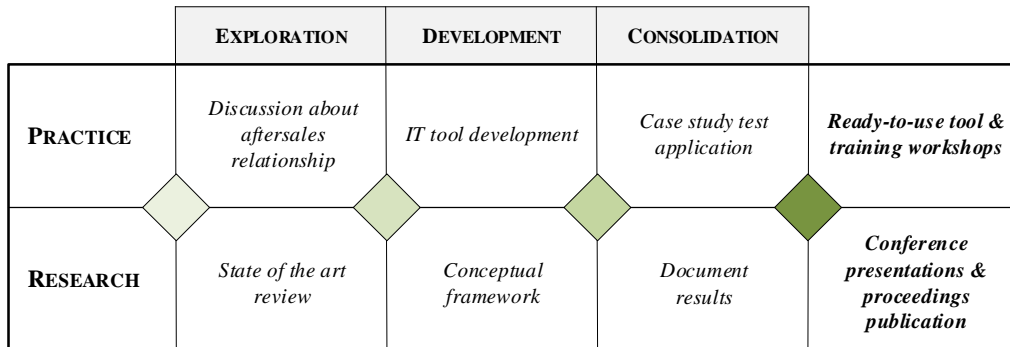


Figure 4.1 – Positioning of the third essay according to the general research design adopted.

Acknowledgment

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4.1 Introduction

Traditionally, the manufacturing value was embedded in the product and transactionally transferred from the producer to the customer (Baines et al., 2017). As extensively described in chapter 2, servitization moves the manufacturer's business model from transactional to relational exchange (Lightfoot et al., 2013), recognizing value co-creation as a significant source of competitive advantage (Vargo & Lusch, 2017). In this sense, the aftersales relationship between the producer and the customer is a means of value co-creation.

Because small and medium enterprises (SMEs) have relatively limited resources compared to large companies (Kowalkowski et al., 2013), a more comprehensive network of co-creators is essential to enhance their service capabilities. Literature shows that SMEs can enormously benefit from collaborations with customers (Brunswicker & Vanhaverbeke, 2015). On the other hand, SMEs should carefully identify customer segments on which to invest their resources to develop profitable aftersales relationships. Service offering implies intensive relations and could be inefficient to establish a tight relationship with all customers as the costs of sustaining the relationships are more significant than the profits. As mentioned in section 2.5, literature gaps are found in studying the relationship between the service provider and its customers (i.e., co-creation), which should be longitudinally analyzed. Despite many methods to identify customer segments having been developed, and the need to understand the dynamics of provider-customer relationships is recognized by scholars and practitioners (Lappalainen et al., 2019), no techniques have been developed tailored for servitization purposes.

Segmentation is one of the most important concepts in marketing literature and a key element of the firm's services positioning strategy (Wirtz & Lovelock, 2021), providing guidelines for allocating the company's resources (Hutt & Speh, 2018). It plays a critical role in the servitization process, leading to developing partnership programs to shape the relationship between the manufacturer and its customer (Baltacioglu, Ada, Kaplan, Yurt And, & Cem Kaplan, 2007). However, the literature has not yet analyzed whether some customer segments could be more suitable for companies to involve in co-creation activities (Goduscheit & Faullant, 2018). Segmentation can be performed using qualitative and quantitative methods. The formers are the most used, accounting for over

80% of academic articles on the topic (Brickey, Walczak, & Burgess, 2012). The main differences that stand out between these two methodologies are the methods of data collection and analysis. Qualitative methods should limit the analysis to a few customer samples, but they need experience in qualitative research. Opposite, quantitative techniques need more data, but they overcome qualitative methods problems by reducing ambiguities of interpretation since they are based on statistical analysis. Some quantitative segmentation techniques are relatively easy to use, such as the RFM model (Hughes, 1994). Conversely, others techniques imply advanced statistics and coding knowledge. In addition, SMEs could have difficulties acquiring customer data due to their lack of resources and capabilities (Hemilä & Vilko, 2015), limiting the usage of quantitative segmentation methodologies.

To the best of our knowledge, there is a gap in the literature about quantitative clustering methodology affordable by SMEs to identify types of relationships in aftersales based on service-oriented dimensions between the manufacturer and its customers. In addition, the relationship type's effect on co-creation remains unexplored. For these reasons, I designed the following research question:

***RQ3.** How does the aftersales relationship between producer and customer affect the type of co-creation in SMEs?*

The paper is structured as follows. First, I discuss the relevant literature on which the model is based. Second, the methodology and the case study sample are described. I present the results in the main section by illustrating the obtained empirical taxon. The latter are then related to different co-creation dimensions. By this means, co-creation dimensions related to different types of aftersales relationships using analysis of variance (ANOVA) and Bonferroni pairwise multiple-comparison post hoc test. Finally, findings are discussed, suggesting implications for theory and practice, the study limitations, and further research directions.

This research answers the need tracked in literature for empirically testing frameworks and tools for PSS business model development, emphasizing customer value co-creation, and overcoming customer-related knowledge and information external barriers, as mentioned in paragraph 2.5.

4.2 Related literature

4.2.1 Aftersales relationship

Literature has sought to extend the understanding of the producer–customer relationship as co-creator of value for aftersales services (Story, Raddats, Burton, Zolkiewski, & Baines, 2017). Aftersales relationship is grounded on products at a customer's sites. The aftersales relationship potential can be measured through the customer's installed base, which offers particular potential for aftersales service for the manufacturer (Stormi, Lindholm, Laine, & Korhonen, 2020). Aftersales relationship involves interaction between the manufacturer and its customers, namely information exchange and cooperation (Gruner & Homburg, 2000), which defines the effects of co-creation for new products and service development. Parallel, the aftersales relationship increases the installed base's intangible value, such as trust, commitment, and attractiveness (Grönroos, 2011), allowing for long-term aftersales retention of customers (Jang, Bae, & Kim, 2021). Retention is the propensity of the customers to stay with their service provider and the commitment to rebuy a service consistently in the future, despite situational influences and marketing efforts having the potential to cause switching behavior (Mohd Kassim & Souiden, 2007). The notion of customer retention coincides with customer loyalty (Cossío-Silva, Revilla-Camacho, Vega-Vázquez, & Palacios-Florencio, 2016).

Therefore, manufacturers that aim to move from a product-centric to a servitized business model should invest in customer management to develop aftersales relationships with their customers. To this end, IT tools – e.g., customer relationship management (CRM) systems – help the company to collect, organize, and analyze data.

4.2.2 Customer value co-creation

The traditional process to generate customer value is based on Porter's value chain (1985). According to it, two types of activities exist: primary and support. Both activities consider the customer as the endpoint of the value creation process to which value is transactionally transferred through the product (Ramirez, 1999).

Unlike Porter's value chain, servitization requires increased awareness of co-creation (Christian Kowalkowski & Ulaga, 2017) to involve the customer across the entire process and offer customized solutions to solve its problems (Annarelli et al., 2019). (Grönroos,

2012) defined value co-creation as “the joint collaborative activities by parties involved in direct interactions, aiming to contribute to the value that emerges for one or both parties”. Since ideally there is no ownership transfer in a service-oriented process, the customer becomes a partner who shares risks with the provider and shares access to its assets’ information along the process (Prahalad & Ramaswamy, 2004). Value co-creation represents the hallmark of a customer-oriented value creation process (Vargo & Lusch, 2004).

From a manufacturer's point of view, the organization co-creates value by customizing its offering (Gummesson, 2007). Customization refers to integrating the customer in the value creation process to develop an individualized offering inherently included in the service definition (Kaur Sahi, Sehgal, & Sharma, 2017), offering the flexibility to choose service components, service mechanisms, service levels, and service frequency (Zine, Kulkarni, Chawla, & Ray, 2014). The literature distinguishes two types of service types according to the degree of interaction and customization required (Mathieu, 2001): services supporting the supplier’s products (SSP) and services supporting customer processes (SSC). SSP services are characterized by a low customization level, such as functional training and remote monitoring (Carlborg, Kindström, & Kowalkowski, 2018). Opposite, SSC services have a high customization level compared to the former. Examples of SSC services are spare parts provision and managing the customer’s evolving requirements (Tuli, Kohli, & Bharadwaj, 2007).

On the other hand, the customer co-creates value according to its involvement within the service deployment process. Due to a lack of time, money, or incentives, the customer can assume a passive role implying a low level of engagement and human-to-human interaction (van Doorn et al., 2010). Contrary, strong drivers can lead the customer to engage in service deployment actively, investing its internal resources to achieve the best possible result (Forkmann, Ramos, Henneberg, & Naudé, 2017). In this sense, engagement is symbolized by the interaction level between the producer and the customer (Libai et al., 2010). Engagement is a psychological state that occurs under co-creative customer experiences in service relationships that generate value (Brodie, Hollebeek, Jurić, & Ilić, 2011). Merging the two perspectives described above, Carlborg et al. (2018) define a framework to identify different types of co-creation between producer and

customer, recognizing four roles that firms can adopt in the aftersales customer relationship.

4.2.3 Customer segmentation

4.2.3.1 RFM model

The RFM model is a clustering technique for ranking customers exploiting CRM data. It is widespread in business circles because its implementation does not require professional computer information systems support (Maraghi, Adibi, & Mehdizadeh, 2020). The model was introduced by Hughes (1994) and evaluated a customer based on three parameters: recency (R), the number of days since the last purchase; frequency (F), how frequently the customer has made transactions; monetary (M), how high the monetary value of the purchases has been. As a rule of thumb, the lower recency, the higher frequency, and the higher monetary value are valuable (Mesforoush & Tarokh, 2013). Literature developed more sophisticated analyses for customer segmentation based on RFM scores to overcome specific contextual problems (Bizhani & Tarokh, 2011; H.-C. Chang & Tsai, 2011; Dursun & Caber, 2016; Marín Díaz, Carrasco, & Gómez, 2021; Marisa, Ahmad, Yusof, Hunaini, & Aziz, 2019; Sarvari, Ustundag, & Takci, 2016; Tkachenko, Kochenderfer, & Kluza, 2016; Xu, Dang, & Wang, 2022). The use of machine learning clustering algorithms (e.g., k-means) after applying the RFM model is widespread in the literature (D. Chen, Sain, & Guo, 2012).

However, the RFM model has some limitations. Short relationships with new customers could distort the results. In addition, the model lacks general results because the importance of RFM parameters strictly depends on the business (Yeh, Yang, & Ting, 2009). For this reason, at times, the management could prefer to employ ad-hoc rules to judge the operative level of their customers. This fact represents a gap that led us to propose a novel RFM model for servitization purposes.

4.2.3.2 Data cluster algorithms

Clustering is an unsupervised machine learning technique to find subgroups from a dataset (Madhulatha, 2012). The subdivision occurs by grouping observations with common characteristics and features that differ from the other groups. Clustering has wide applications in marketing and many other fields (James, Witten, Hastie, & Tibshirani,

2013). Data available from economic transactions allows companies to segment their market, identifying groups of customers to whom they can direct highly customized offers.

The literature proposes a variety of hierarchical and non-hierarchical clustering algorithms (Gülagiz & Sahin, 2017). The k-means algorithm was introduced by MacQueen (1967) to solve partitional clustering problems. Due to its simplicity and effectiveness, it is one of the most easy-to-use algorithms for producing clusters (Na, Xumin, & Yong, 2010). The k-means algorithm is a non-hierarchical clustering method that partitions a dataset into a given number of k clusters, distinct and non-overlapping. The central concept behind the k-means is that sum of the squared distance between each cluster's data points and its centroid (i.e., the arithmetic mean of all the data points that belong to that cluster) is at the minimum. When the number of clusters is unknown, several k-means solutions with different numbers of groups k ($k = 1, \dots, K$) are computed and compared. The literature suggests plotting the within-clusters sum of squared errors (WSS) of the K results and searching for an elbow – namely, the point where the WSS curve becomes first starts to diminish – the curve generated to detect the k^* optimal solution (Syakur, Khotimah, Rochman, & Satoto, 2018).

4.3 Research model specifications

4.3.1 Methodology

The methodological approach includes four different stages. Figure 4.2 illustrates the data analysis model implemented in this paper described in this paragraph.

First, I pre-processed data to create this research's data model, which was developed on a star schema (Sanchez, 2016). Data employed to segment customers were accessible through the company's CRM. Demographic data about customers represent the dimension table of the model, while the aftersales relationship dimensions are coded in three different fact tables. To easily measure aftersales relationship dimensions, I proxied interaction collecting data on the SME's remote support activities while retention with spare parts and consumables sale transactions data. Remote support is usually a fixed-price service contract (Roy & Cheruvu, 2009) in which the customer pays a flat price for specific deliverables regardless of the number of requests (i.e., service tickets) opened or

the costs incurred by the manufacturer. It is reasonable to speak about service retention if the customer interacts through frequent and long-lasting service tickets. Conversely, spare parts and consumables selling service is a time-and-materials service contract in which the customer purchases the manufacturer's direct labor invested in the service. This service is subject to intense competition because a client can replace a supplier with a different competitor. Therefore, it is reasonable to affirm that a retained customer frequently acquires a sizable quantity of parts. Last I proxied the service potential through data concerning the customer's installed base. Table 4.1 shows entities and variables involved in the data model.

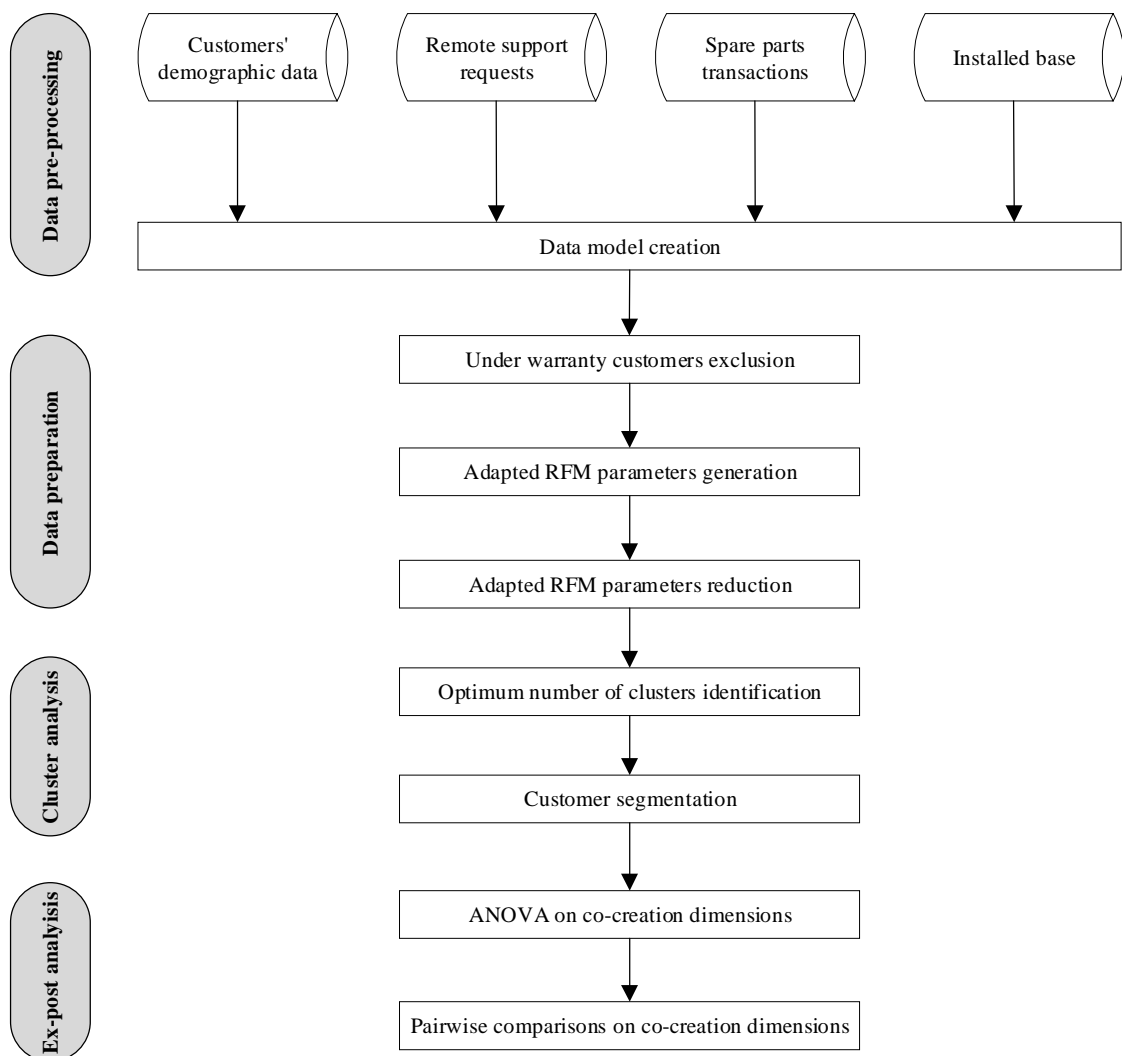


Figure 4.2 – Methodological approach adopted

Table 4.1 – Data model.

Entity	Variable	Description
Demographic data	ID (table key)	Customer ID.
	Business name	Customer's extended business name.
	Commercial transaction	Customer's principal activity (B2B, B2C, Other).
	Commercial affiliation	Customer's ID of the parent company.
	Geographical location	Customer's geographical location.
Remote support	ID (table key)	Support request ID.
	Creation date	Support request's creation date.
	Duration	Difference between closing date and creation date.
	Customer ID	Supported customer, as demographic data's table key.
Spare parts	ID (table key)	Invoice ID.
	Price	Invoice's total price.
	Issuing date	Invoice's issuing date.
	Customer ID	Invoiced customer, as demographic data's table key.
Installed base	ID (table key)	Machine's serial number.
	Model	Machine's model.
	Installation date	Machine's installation date.
	Customer ID	Machine owner, as demographic data's table key.

Secondly, I generated novel adapted RFM parameters for each aftersales relationship dimension's proxy based on RFM existing literature. To generate remote support parameters, I started substituting the M factor with D (duration), a measure that sums up each ticket's lifetime (Marín Díaz et al., 2021). Then, I generated the installed base's parameters motivated by Stormi et al. (2020) fleet variables. For each customer, I computed the installed base size (depth) and the number of different machine models owned (width) as a measure of knowledge needed to serve it. In addition, I calculate the commercial relationship length (age) between the customer and manufacturer (Marisa et al., 2019). Spare parts' parameters were instead initially calculated using the standard RFM model. Then I reversed R for spare parts and remote support. This choice allows aligning the evaluation criteria for all the parameters: the higher the value, the better. Last, I divided remote support's F and D parameters by the installed base's depth to obtain average values per machine, and spare parts' F and M parameters by the installed base's equivalent depth. Equivalent depth describes the equivalent units of machines based on their nominal production capacity. These selections aim to delete biases due to customers'

different sizes. Table 4.2 shows the final dataset's adapted parameters for aftersales relationship dimensions. After that, I reduced the number of parameters through exploratory factor analysis (EFA) (Costello & Osborne, 2019).

Table 4.2 – Adapted RFM parameters for aftersales relationship dimensions.

Entity	Parameter	Description
Remote support	R_{reversed}	Analysis period less the difference between today and the last support request's creation date.
	F^*	Average number of support requests issued in the period per machine.
	D^*	Average support requests' duration per machine.
Spare parts	R_{reversed}	Analysis period less the difference between today and the issuing date of the last invoice.
	F^*	Average number of invoices issued in the period per equivalent machine.
	M^*	Average invoices' price per equivalent machine.
Installed base	Depth	Number of installed machines.
	Width	Number of models installed.
	Age	Difference between today and the first machine's installation date.

To identify the empirical aftersales relationship types, I performed a cluster analysis of the dimensions described in paragraph 4.2.1.

Finally, since co-creation dimensions are dependent variables, they are not used during the clustering procedure. These are related to each aftersales relationship type identified by ANOVA and Bonferroni pairwise multiple-comparison test. All analyses were carried out in Stata version 17.

4.3.2 Case study data sample

Alpha is a medium-sized Italian company whose main activity is manufacturing miller for ophthalmic and solar eyeglass lenses. The firm is responsible for the product throughout the entire supply chain. Its current market is mainly oriented toward industrial laboratories that produce eyeglass lenses as subcontractors (B2B market) and retail chains that sell directly to the final glasses' user (B2C market). Some of Alpha's customers are affiliated with other large companies that dominate the market. Alpha currently proposes a portfolio of basic and intermediate services (Baines et al., 2017), which includes spare parts and consumables, installation, remote support, maintenance, and training.

The whole decision about service design is centralized. In particular, all decisions concerning servitization are under the only responsibility of the chief service officer (CSO), who has recently joined Alpha. The CSO highlights the difficulty of transferring qualitative clustering logics developed by the company for products selling to aftersales as the relationship between the manufacturer and the customer change. While Alpha should allocate its available aftersales resources to the most profitable customers, it occurs that the latter's budget and decision process change compared to product purchasing, and the competition from other players increases.

The sample consists of data collected from the company's CRM about 307 customers in the EMEA region, spanning a three-year range from January 1st, 2019, to December 31st, 2021 (see Table 4.3 for sample demographics).

Table 4.3 – Sample demographics.

Sample characteristics	Number	%
Commercial transaction type		
B2B	270	87.95
B2C	28	9.12
Other (e.g., professional schools and trade fairs)	9	2.93
Commercial affiliations		
Stand-alone customers	204	66.45
Affiliated customers	103	33.55
Region and Country (country sample size)		
<i>Europe</i>	268	87.30
Austria (3), Belgium (8), Bulgaria (2), Croatia (1), Czech Republic (9), Estonia (1), Finland (4), France (19), Germany (23), Greece (3), Hungary (6), Ireland (2), Italy (95), Latvia (1), Lithuania (1), Netherlands (3), Norway (1), Poland (7), Portugal (11), Romania (8), Russia (8), Serbia (2), Slovak Republic (3), Slovenia (4), Spain (14), Sweden (3), Switzerland (4), United Kingdom (22)		
<i>Middle East</i>	26	8.47
Iran (2), Israel (7), Jordan (1), Kuwait (3), Lebanon (1), Saudi Arabia (6), Turkey (2), United Arab Emirates (4)		
<i>Africa</i>	13	4.23
Algeria (1), Egypt (3), Kenya (1), Morocco (2), Namibia (1), South African Republic (5)		

4.3.3 Measurement development and validation

4.3.3.1 Clustering factors

After the adapted RFM model was generated from the dataset, I excluded 21 observations with only under-warranty machinery by identifying the ones with the installed base's age equal to or lower than 365 days, as the ALPHA's standard warranty is one year from the installation. This choice will avoid problems concerning short relationships with new customers. This set of observations constitutes a stand-alone cluster.

Then, I standardized all nine variables of the model. I examined the relationship between the adapted RFM parameters using exploratory factor analysis (EFA). It allowed me to generate a new model composed of latent variables without any a priori theory (Henson & Roberts, 2006). The correlation matrix (Table 4.4) shows coefficients over 0.30, meaning the factorability of the adapted RFM model's parameters (Tabachnick, Fidell, & Ullman, 2007). In addition, I successfully tested the dataset's suitability for data reduction through the Kaiser-Meyer-Olkin's test (KMO) and Bartlett's sphericity test (Table 4.5, see Original model column).

Table 4.4 – Correlation matrix for adapted RFM model's parameters.

Code	Entity	Parameter	1	2	3	4	5	6	7	8	9
1	Remote sup.	R _{reversed}	1.000								
2		F*	0.357*	1.000							
3		D*	0.260*	0.571*	1.000						
4	Spare parts	R _{reversed}	0.265*	0.210*	0.113	1.000					
5		F*	0.196*	0.485*	0.328*	0.527*	1.000				
6		M*	0.208*	0.395*	0.285*	0.509*	0.876*	1.000			
7	Installed base	Depth	0.193*	-0.106	-0.058	0.070	-0.014	0.117*	1.000		
8		Width	0.274*	-0.028	-0.022	0.165*	0.050	0.167*	0.705*	1.000	
9		Age	-0.110	-0.136	-0.062	-0.085	-0.018	0.073	0.362*	0.360*	1.000

Note. *p < 0.05

Table 4.5 – KMO and Bartlett's test.

Statistic	Original model	Adjusted model
No. of items	9	7
Kaiser-Mayer-Olkin (measures of sampling adequacy) ^A	0.669	0.633
Bartlett's test of sphericity ^B		
χ^2	1016.127	874.323

Degree of freedom	36	21
Significance	0.000	0.000

Notes.

^A KMO above 0.6 is acceptable (Kim & Mueller, 1978).

^B Bartlett's test of sphericity is significant, hence acceptable (Hair et al., 2010).

I extracted factors using principal components analysis (PCA), suggested when no prior model exists in theory (Gorsuch, 2014), followed by varimax rotation. I extracted three factors following Kaiser's criteria, looking for eigenvalues greater than one (Kaiser, 1960). Table 4.6 displays the EFA result of the adapted RFM model. However, communalities lower than 0.6 shows that the model does not fit the data (Hair et al., 2010). Hence, I adjusted the model by progressively dropping the parameters with the lowest communality index. I removed the service potential's *Age* parameter with a first drop, then the interaction's *R_{reversed}* parameter through a second iteration. The adjusted model is described in Table 4.7. Each construct's Cronbach alpha (CA) is higher than the acceptable threshold of 0.7, confirming the scales' reliability and internal consistency (Nunnally, 1975). The Kaiser-Meyer-Olkin's (KMO) and Bartlett's sphericity tests are also successfully tested for the adjusted model (Table 4.5, see Adjusted model column).

Table 4.6 – Original model's result of exploratory factor analysis ^a.

Factor	Dimension	Eigenvalue	CA	Variance explained	Communalities	Loading ^b
Interaction		1.171	0.666	19.75		
	<i>R_{reversed}</i>				0.589	0.694
	<i>F*</i>				0.714	0.757
	<i>D*</i>				0.611	0.755
Retention		2.983	0.839	26.53		
	<i>R_{reversed}</i>				0.540	0.727
	<i>F*</i>				0.891	0.921
	<i>M*</i>				0.866	0.913
Potential		1.816	0.743	22.83		
	<i>Depth</i>				0.784	0.885
	<i>Width</i>				0.806	0.892
	<i>Age</i>				0.419	0.577

Notes.

^a Extraction method: principal component.

^b Factor communalities values greater than 0.6 are acceptable (Hair et al., 2010).

Table 4.7 – Adjusted model’s result of exploratory factor analysis ^a.

Factor	Dimension	Eigenvalue	CA	Variance explained	Communalities	Loading ^b
Interaction		1.60805	0.727	22.97		
	<i>Frequency</i>				0.762	0.812
	<i>Duration</i>				0.807	0.892
Retention		2.31140	0.841	33.02		
	<i>Recency</i>				0.652	0.799
	<i>Frequency</i>				0.875	0.886
	<i>Monetary</i>				0.839	0.878
Potential		1.72238	0.827	24.61		
	<i>Depth</i>				0.856	0.924
	<i>Width</i>				0.852	0.918

Notes.

^a Extraction method: principal component.

^b Factor communalities values greater than 0.6 are acceptable (Hair et al., 2010).

4.3.3.2 Co-creation parameters

After analyzing the taxonomic structure of aftersales relationship types, I studied the co-creation degree of the clusters. To operationalize the value co-creation dimensions proposed by Carlborg et al. (2018), I choose the survey approach as a suitable research method. Table 4.8 shows the items used. I asked the Chief Service Officer and the Service Technical Manager to evaluate for each customer the importance of customization and the customer’s engagement during service delivery according to a five-point Likert scale. The sample consists of data collected during May 2022 1st. Then, I computed the mean between the two responses for each observation.

Table 4.8 – Selected items to measure customer co-creation degree

Dimension	Item	Source
Customization	Importance of offer more customization to win aftersales orders from the customer (1 = not important; 5 = very important)".	IMSS (2015)
Engagement	Feeling of active participation of the customer during service delivery (1 = completely disagree; 5 = completely agree)	Kaur Sahi et al. (2017)

4.4 Results

4.4.1 Clustering contextual patterns

To retrieve the best cluster solution, I used 20 different cluster solutions ($k = 1, \dots, 20$) with random starting points. Then, I compute WSS through ANOVA's residual sum of squares for each solution (Makles, 2012). Figure 4.3 shows the plot of the calculated statistics. The results indicate clustering with $k = 4$ to be the optimal solution.

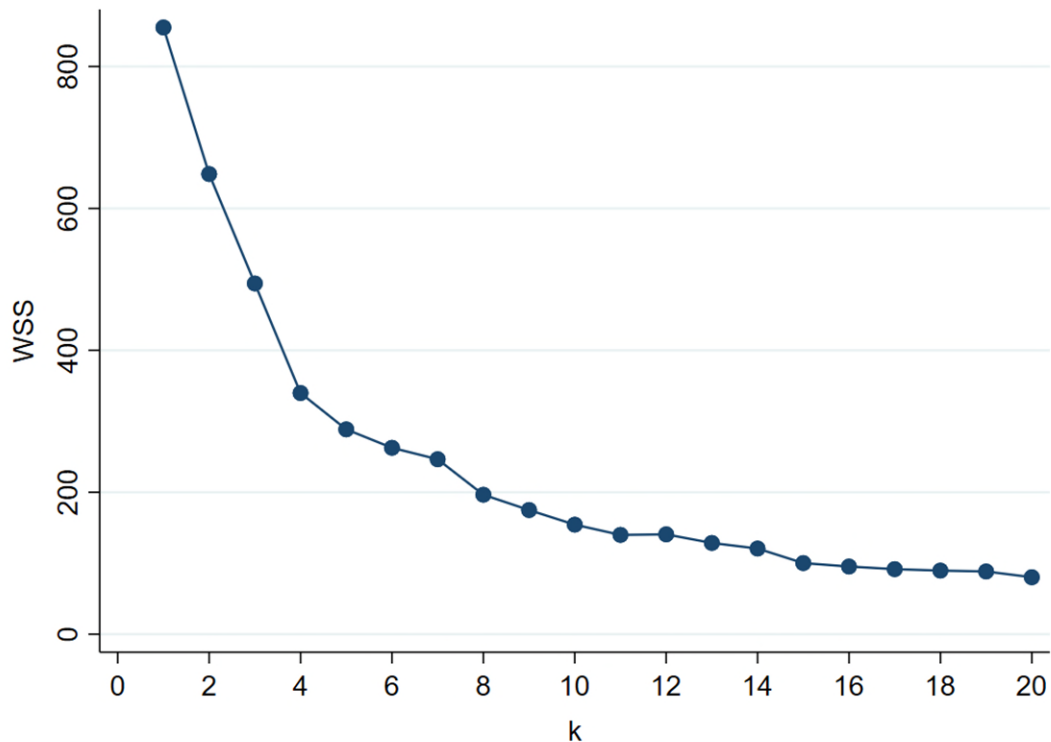


Figure 4.3 – WSS for all 20 cluster solutions

I applied a two-step clustering approach based on hierarchical and non-hierarchical clustering (Clauß, 2012). First, I performed a hierarchical classification based on Ward's minimum variance method (Murtagh & Legendre, 2014). Secondly, I used the centroids of the hierarchical Ward clustering as starting points for the non-hierarchical k-means clustering technique. Table 4.9 exhibits cluster demographics. Figure 4.4 shows the 3D scatter plot of the four aftersales relationship types identified.

Last, I compare the four clusters achieved. Levene's test (Carroll & Schneider, 1985) was performed to assess the homogeneity of the variances of the clustering factor between the

four aftersales relationship types identified. The values test statistic ($W = 15.050$, $p = 0.000$) show significant heterogeneity. Then, the Scheffé or Games-Howell post hoc test was used to test the significance of differences among clusters' means (Clauß, 2012). The final solution is presented in Table 4.10.

4.4.1.1 Cluster A: Interactive and retained

Cluster A comprises 14.2 percent of the sample. While the service potential factor is moderate, this group is described by the highest interaction and retention factors among the four clusters. These results show a strong relationship between the machinery producer and its customers. The latter likes to have an active role during the aftersales operations undertaking a cooperative path built on trust with the supplier (e.g., buying genuine spare parts).

4.4.1.2 Cluster B: Retained but not interactive

This context is symptomatic for the largest cluster, consisting of 44.1 percent of the customers. The installed base factor is moderated, like cluster C. While the retention factor is slightly above the average, the group shows a negative value for interaction. These customers may prefer to remain passive during service deployment and rely solely on the service provider's capabilities.

4.4.1.3 Cluster C: High service potential

Cluster C contains 5 percent of the customers. A high service potential factor value characterizes this cluster, including large B2B customers affiliated with industrial groups who own many machines and models to tackle various lens milling processes. Opposite, this cluster is characterized by the relatively low value for the interaction factor among the four groups, showing a cluster of passive customers with few incentives to participate and be involved in service deployment. This result should be associated with the insourcing strategy that distinguishes large companies in aftersales operations (e.g., maintenance performed by internal teams of technicians). Last, a moderate retention factor describes this cluster, as large customers tend to distribute the supply of spare parts among different players to guarantee competition.

4.4.1.4 Cluster D: Interactive but not retained

This 36.7 percent of the customers fall into cluster D. This group includes customers with the lowest installed base and retention factors. Due to their size, it seems reasonable that spare parts sold can suffer from price competition from the market. However, they interact with the manufacturer to their lack of resources and capability compared to large customers.

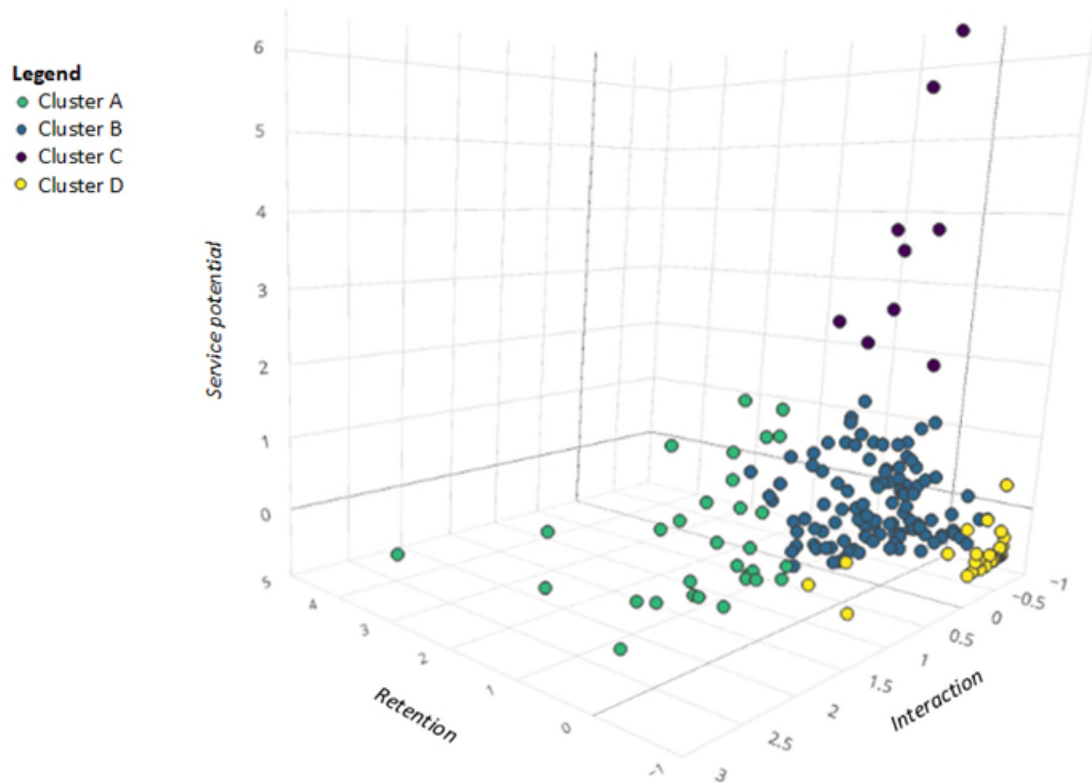


Figure 4.4 – Aftersales relationship types 3D scatter plot

Table 4.9 – Clusters demographics

Sample characteristics	Aftersales relationship types			
	A. Interactive and retained	B. Retained but not interactive	C. High service potential	D. Interactive but not retained
Commercial transaction type				
B2B	32	122	14	93
B2C	3	9	0	4
Other (e.g., schools and trade fairs)	0	3	0	6
Commercial affiliations				

Stand-alone customers	18	106	0	58
Affiliated customers	17	28	14	45
Region and Country (country sample size)				
<i>Europe</i>	32	120	14	84
<i>Middle East</i>	2	9	0	15
<i>Africa</i>	1	5	0	4

4.4.2 Analysis of co-creation parameters

Table 4.11 displays the means of customization and engagement across the clusters. Results show a correlation coefficient of 0.625 between the two co-creation parameters. Both indicators' means are highest for the high service potential cluster (cluster C), revealing the importance of the installed base on co-creation. Opposite, retained but not interactive customers (cluster B) show the lowest values for customization and engagement, while interactive but not retained customers (cluster D) have a negative mean value only for customization. This fact seems to associate a more significant impact of the interaction factor on the two co-creation parameters than retention. Last, the interactive and retained aftersales relationship type (cluster A) has moderate positive values for both indicators.

To test the association between the four aftersales relationship types identified and the two co-creation parameters, I used ANOVA and Bonferroni pairwise multiple-comparison post hoc test. Table 4.12 – ANOVA for Customization Table 4.12 and Table 4.13 show results for customization, while Table 4.14 and Table 4.15 are the ones for engagement. ANOVA is successfully tested for both parameters, explaining that at least one group's mean significantly differs from the others. Then, Bonferroni pairwise multiple-comparison shows that cluster C is well discriminated. On the other hand, clusters B and D's means are not significantly different for both parameters. Hence, they can be analyzed as a unique cluster for co-creation aims. Last, cluster A's mean significantly differs from the others for customization but not for engagement. There is no difference between clusters A and D for the engagement's means.

4.5 Discussion

4.5.1 *Implications for theory*

This paper proposes a customer segmentation method based on a servitization-adapted RFM model to identify aftersales relationship types. The adapted RFM model uses easily accessible data through SMEs' CRM. After that, I studied how these clusters affect the co-creation types. The analyses show that:

- Four different clusters representing different aftersales relationship types were identified.
- Different levels of co-creation dimensions characterize each identified cluster.

Based on these results, I develop the following contributions to the existing theory on servitization.

First, the study proposed three novel RFM models to segment customers according to service-oriented dimensions. In particular, I developed a model to analyze aftersales interaction proxied through remote support data as a fixed-price service contract, retention through remote support data as a time-and-material service contract, and service potential proxied through installed base data. Results show that the canonical RFM model should be readapted to the above-mentioned aftersales dimensions. The interaction model was generated using only the frequency and duration measured per machine of remote support requests, while the service potential model used only the installed base's depth and width. Contrary, the retention model maintains the typical three parameters due to its fit to the sales transactional nature of its data. I decided to reverse the recency parameter to evaluate customers positively as the three values increase and measure frequency and monetary parameters per equivalent machine.

Second, I described four aftersales relationship types, besides an outlier cluster represented by under-warranty customers. The contextual patterns were identified through a clustering methodology triggered by the three service-oriented RFM previously illustrated.

Last, I identified the relation between these clusters and two co-creation dimensions: customization and engagement. Findings argue a pretty strong correlation between the two dimensions. Contrary to Carlborg et al. (2018)'s co-creation framework, my results

identified a potential service co-creation degree instead of distinct roles that a servitized firm can adopt. The customer segment with the highest values for both co-creation parameters – hence, co-creation potential – is the high service potential cluster. Interestingly, the other three groups have overlappings that do not allow for discriminate co-creation dimensions significantly. In particular, the interactive and retained customers differ just on the engagement parameter. Then the last two clusters can be considered a unique customer segment for co-creation aims, representing the group with the lowest potential. Hence, three different levels were identified. The lower degree of co-creation implies standardizing and modularizing service processes to gain efficiency in supporting the products. On the other hand, the higher co-creation degree implies collaboration and resource orchestration to develop ad-hoc customer service solutions and support the customer's processes.

4.5.2 Implications for practice

Managers at small and medium-sized manufacturing companies should benefit from this research when allocating resources to different customers to develop profitable after-sales relationships. First, this study proposes a quantitative service-oriented customer segmentation method based on a few data easily accessible from a firm's CRM. The four aftersales relationship types can guide managers in identifying the different groups of customers in their sales portfolio. Second, the co-creation degree associated with each cluster should help SMEs properly design service contracts. Due to differences from large companies, SMEs should prioritize service resource allocation to specific customers to guarantee a profitable aftersales offering that fits clients' needs.

4.5.3 Limitations and future research opportunities

This study has some limitations that can be addressed by further research. First, the single case study approach prevents complete generalizations of the mentioned findings. In addition, the case study is characterized by an entry-level servitization strategy which can bias the results achieved. Limitations can also derive from the proxies selected in this study.

This study opens a set of potential research opportunities. First, the customer segmentation method proposed should be implemented in other empirical cases in

different servitization maturity stages (F. Adrodegari & Saccani, 2020). Furthermore, other proxies should be tested to measure interaction and retention (e.g., preventive maintenance contracts). In addition, strategic suggestions can be associated with each customer segment identified. For example, practitioners can benefit from the association of different service levels agreement according to the identified co-creation dimensions. Last, life time value (CLV) techniques (Gupta et al., 2006) can be implemented to measure the monetary value of the aftersales relationship types.

4.6 Conclusions

This study theoretically articulates and empirically validates a service-oriented customer segmentation method for SMEs. The method is based on three adapted RFM models that use easily accessible CRM data. I designed models to measure aftersales interaction proxied through remote support activities, retention through spare parts sells, and service potential with an installed base. I grounded the customer segmentation method k-means non-hierarchical algorithm, which was used to identify the optimal number of segments and to allocate customers in each group. A former hierarchical clustering based on Ward's minimum variance method was implemented to identify the centroids starting points. The customer segmentation method empirically identifies four different aftersales relationship types through a unique dataset of an Italian SME. Then, I analyze the impact of each customer segment on service customization and engagement by applying ANOVA and Bonferroni pairwise multiple-comparison test. The empirical findings suggest a correlation between the two dimensions that imply a co-creation scale, which measures the potential for co-creation on a three-level degree scale for each customer segment.

Table 4.10 – Type of aftersales relationship taxonomy.

Factor	Wilks-Lambda	F	Aftersales relationship types							
			A. Interactive and retained (n=35)		B. Retained but not interactive (n=134)		C. High service potential (n=14)		D. Interactive but not retained (n=103)	
			Mean ^{a,b}	St Dev	Mean ^{a,b}	St Dev	Mean ^{a,b}	St Dev	Mean ^{a,b}	St Dev
Interaction	0.585	66.23***	1.281 ^{B,C,D}	1.192	-0.577 ^{A,C,D}	0.417	-0.243 ^{A,B,D}	0.320	0.187 ^{A,B,C}	0.867
Retention	0.384	149.76***	1.200 ^{B,C,D}	1.263	0.409 ^{A,D}	0.405	-0.090 ^{A,D}	0.982	-0.941 ^{A,B,C}	0.271
Service potential	0.329	190.35***	-0.119 ^C	0.664	-0.147 ^C	0.524	3.595 ^{A,B,C}	1.387	-0.252 ^C	0.410

Notes.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

^a Superscript letters indicate significant differences ($p \leq 0.10$) in the means of the construct between the context clusters represented by the letter based on Scheffé's respectively Games-Howell post hoc test of statistical significance. Post-hoc test instrument was chosen through the Levene test for variance homogeneity.

^b All values based on z-transformed factor scores.

Table 4.11 – Means of customization and engagement related to types of aftersales relationship.

Factor	Wilks-Lambda	F	Aftersales relationship types							
			A. Interactive and retained (n=35)		B. Retained but not interactive (n=134)		C. High service potential (n=14)		D. Interactive but not retained (n=103)	
			Mean ^{a,b}	St Dev	Mean ^{a,b}	St Dev	Mean ^{a,b}	St Dev	Mean ^{a,b}	St Dev
Customization	0.808	21.34***	0.365 ^{B,C,D}	1.196	-0.205 ^{A,C}	0.722	1.691 ^{A,B,D}	1.463	-0.140 ^{A,C}	0.865
Engagement	0.880	11.36***	0.201 ^{C,D}	1.175	-0.238 ^{C,D}	0.857	1.316 ^{A,B,D}	1.168	-0.009 ^C	0.895

Notes.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

^a Superscript letters indicate significant differences ($p \leq 0.10$) in the means of the construct between the context clusters represented by the letter based on Scheffé's respectively Games-Howell post hoc test of statistical significance. Post-hoc test instrument was chosen through the Levene test for variance homogeneity.

^b All values based on z-transformed factor scores.

Table 4.12 – ANOVA for Customization

Source	Sum of squares	Degree of freedom	Mean of squares	F	Significance
Between groups	52.285	3	17.428	21.34	0.000
Within groups	219.715	269	0.817		
Total	271.999	272			

Table 4.13 – Results of the Bonferroni pairwise multiple-comparison test for Customization

	Cluster A-B	Cluster B-C	Cluster C-D	Cluster A-C	Cluster B-D	Cluster A-D
Means difference	0.570	-1.896	1.831	-1.32629	-0.065	0.505
Bonferroni-adjusted significance	0.009	0.000	0.000	0.000	0.963	0.031

Table 4.14 – ANOVA for Engagement

Source	Sum of squares	Degree of freedom	Mean of squares	F	Significance
Between groups	30.338	3	10.112	11.36	0.000
Within groups	221.662	249	0.890		
Total	252.000	252			

Table 4.15 – Results of the Bonferroni pairwise multiple-comparison test for Engagement

	Cluster A-B	Cluster B-C	Cluster C-D	Cluster A-C	Cluster B-D	Cluster A-D
Means difference	0.439	1.555	1.307	-1.115	-0.247	0.192
Bonferroni-adjusted significance	0.099	0.000	0.000	0.004	0.335	0.765

5. PRODUCT-SERVICE SYSTEMS DELIVERED BY SMEs DURING BUILDING USE STAGE: SUSTAINABILITY CRITERIA FRAMEWORK

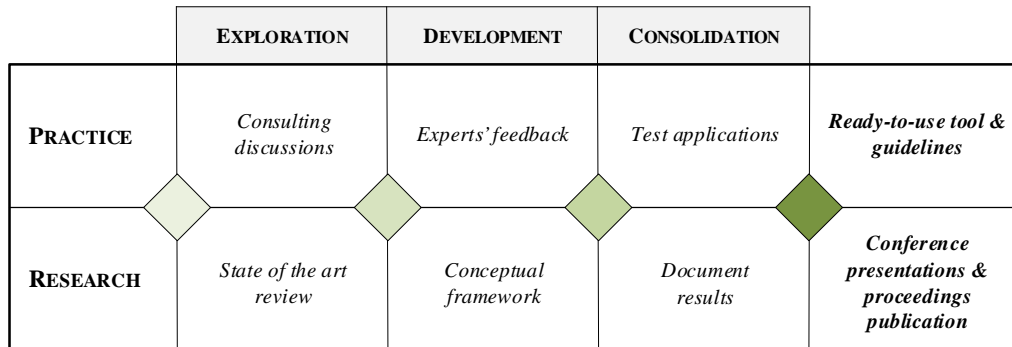


Figure 5.1 – Positioning of the fourth essay according to the general research design adopted.

Acknowledgment

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5.1 Introduction

Achieving sustainable competitive advantage based upon product-service systems (PSS) provision is often claimed to be viable for businesses. However, little evidence has been captured on the application of aspects of servitization in general and developing well-functioning integrated solutions within real estate development in particular (Zighan & Bamford, 2015). Integrated solutions refer to the PSS concept, as they are bundles of physical products, services, and information, seamlessly combined to provide more value than the parts that address customers' needs concerning a specific function or task in their business system (Brax & Jonsson, 2009b). However, PSS seems far to be methodically applied in the real estate industry, especially by small and medium enterprises (SMEs).

Literature has devoted few efforts to servitized collaborative partnerships that involve SMEs (Kowalkowski et al., 2013b; Lelah, Mathieux, Brissaud, & Vincent, 2012b), concentrating on the manufacturing industry and neglecting real estate. This fact highlights a clear research gap. On the other hand, collaborative partnerships with and between SMEs represent a strategic opportunity even for building owners that can enhance the value of their assets during the operating use phase. Recent research (McHale, 2021) involving 340 international companies shows that partnerships with SMEs are expected to impact their total revenues by up to 19% in the three years following the start of the collaboration. While numerous collaborative partnerships and alliances exist between established players in the real estate sector, many industry experts highlight a need to include SMEs in their business ecosystems.

In this paper, I primarily focus on the use stage of the building – also named as operation stage in many professional works of literature – emphasizing end-users related PSS. Grounded on all the above, I concluded that the topic of PSS delivered by SMEs through collaborative partnership to the building use stage is relevant and requires profound and comprehensive research. This study is the first step towards understanding this complex and interdisciplinary field, developing a framework that attempts to bridge SMEs' PSS collaborative partnerships networks through a sustainable perspective implemented to deliver value to stakeholders with the real one perceived from the latter. I identified gaps in the overlap of literature about real estate and building use stage, PSS business model innovation, and the role of SMEs in the business ecosystem. Hence, based on the available

general knowledge about PSS and qualitative data from the interviews with actors representing the building industry, SMEs, and end customers, I developed the central hypothesis: more structured and diverse information about PSS can help to assess its potential and contribute to the more sustainable implementation of PSS delivered by SMEs for the building use stage. Built on the multi-actors' feedback, I have created a list of criteria identified as necessary to understand the PSS's added value better. These criteria were compared and supplemented by the existing criteria in academic practice and formed into the sustainability multi-criteria framework. The proposed framework also supplements PSS-specific criteria, such as PSS type, PSS partnership type, and PSS integration type. This study is explorative and has some limitations, which are listed in the final part.

This research answers the gaps tracked in literature for case studies from different industries from traditional manufacturing, helping to tackle the lack of studies related to technology in servitization by discussing the role of smart services for the building use stage. In addition, the proposed easy-to-use tool to assess PSS sustainability role aims to assist SMEs in overcoming external barriers related to collaborative service networks in which firms are involved.

5.2 Methodology

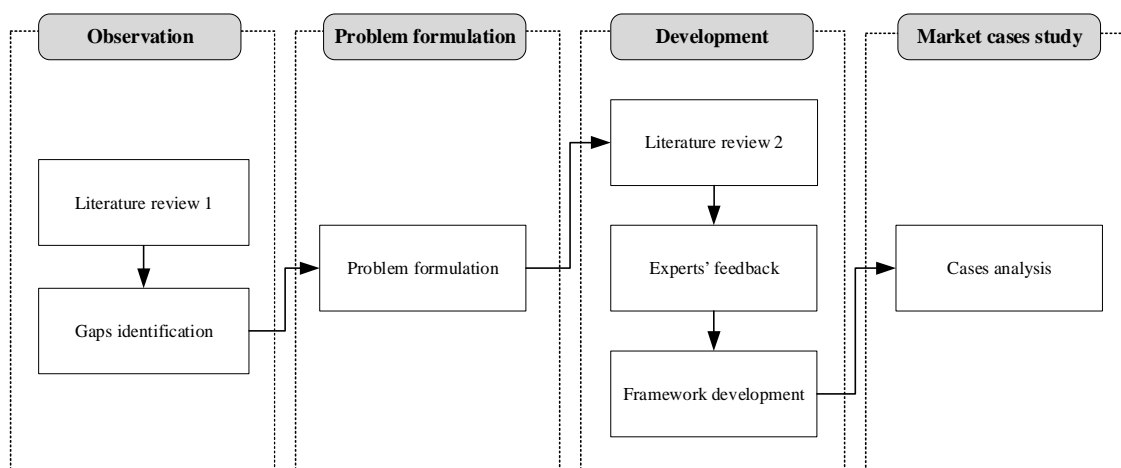


Figure 5.2 – Research design and methodology.

This research's design follows the schema traced in Figure 5.2. The first stage is the observation phase: the research object is interpreted, while gaps and research questions

are detected. I identified the problem during the second phase, based on the current literature review and experts' feedback collected. Last, the third phase – namely theory building and tool development – was carried out to create a tool for evaluating the added value of PSS from three dimensions of sustainability and general PSS characteristics.

In addition, I have added the experts' feedback to align the process with market knowledge. The experts' feedback is based on a mixed-method approach (Hollstein, 2014) that combines semi-structured expert interviews and a quantitative survey. I interviewed KTH Live-in-Lab's 12 key actors in real estate innovation from Sweden, Germany, and France. The critical issues in the interviews were an evaluation of the general relationship with the PSS business model and different sustainability dimensions. Their potential and actual courses of action and strategies towards using more PSS. I analyzed the interviews by applying a category system derived from network theory and frame analysis (Borgatti & Halgin, 2011) to identify the members of the network and their respective priorities for using PSS in the buildings. The list of experts and their roles are presented in Table 5.1.

Table 5.1 – Participants of the feedback sessions.

Actor category	Role	Background
<i>Property related</i>	Director	Large Scandinavian property development firm
	Property manager	Large Scandinavian property development firm
	Chief of Innovation	Large Scandinavian property development firm
	Facility manager	Building IT firm
	Main architect	Large European architecture bureau
	Project manager	Large European architecture bureau
	Head of Smart Home	Furniture producer
	Innovation manager	Home appliances firm
<i>SME</i>	CEO	Last meter services
	CTO	Smart water metering
	Founder	Home energy management
	IT Chief	Smart thermostats
<i>End-user</i>	Tenant at student apartment	Age group 20-25
	Tenant of newly built property	Age group 35-50
	Tenant of retrofit	Age group 55+

5.3 Related literature

The property development process is driven by the interrelationships among actors and therefore requires an institutional research approach supported by qualitative analysis

(Adams, Dunse, & White, 2005). A further institutional approach known as structures of provision (Ball, 1985, 1986) suggests that the production and consumption (i.e., provision) of buildings is a physical and social process guided by economic interests (Gore & Nicholson, 1991).

In this study, our focus will be on the building use stage (i.e., provision), as I see that this stage is the least regulated and most dynamic in terms of innovation and relevance from several points of view. First, during the use of the building, I directly deal with the use of different kinds of resources, which creates an opportunity to influence various consumers' choices and create a prerequisite for changing the building use in a more environmentally sustainable manner. Secondly, during the building use stage, I touch on the everyday life of the end-users and their wellbeing and health, which can bring us the opportunity to increase overall social sustainability and contribute to a more sustainable future for the whole society. Thirdly, the use stage of the building has the highest potential for implementing smart home solutions, more of which are PSS. The latter indicates "marketable systems of products and services capable of fulfilling a user's demand" (Brezet, Bijma, Ehrenfeld, & Silvester, 2001), and a strong relationship with users enhances the market competitiveness of a company. Smart home scenarios (S. Kim & Baek, 2014) suggest that service elements are essential for fulfilling user needs and offering value. As the development of high technology for smart home providing various services are realized through partnership, synergies among stakeholders from diverse areas are required. The PSS development methodology can encourage cooperation among various stakeholders in this context. Constructing multi-dimensional collaborative partnerships allows stakeholders to take advantage of professional knowledge, advanced technology, and other companies' high-quality products or services and simultaneously lower system costs (Tukker & Tischner, 2006). PSS development tools or methods to analyze stakeholders' needs and help their communication and involvement can contribute to PSS development involving various stakeholders.

The transition toward smarter homes and more PSS applications requires not only new design methodologies for the buildings and products that support our everyday life but also needs to redesign business models toward circular and pro-environmental approaches. The next theoretical pillar in PSS is a new approach for an environmentally oriented business model. This study is interdisciplinary and lies at the junction of three

different fields: real estate (building use stage), business model innovation (PSS model), and business ecosystem (collaborative partnership networks with and between SMEs). At the initial stage of the study, it is vital to prioritize which sub-divisions in the selected areas may have practical knowledge. Based on the initial research of these fields, I decided to create some theoretical boundaries within each major field. Considering the overall complexity of the context (i.e., real estate business), I need to expand the business ecosystem and bring new players into the game. SMEs demonstrated the ability to quickly respond to different challenges and deliver value to the end-users through collaborative networks, which makes us focus on them in this study. I will delve deeper into each of these areas in the next chapter.

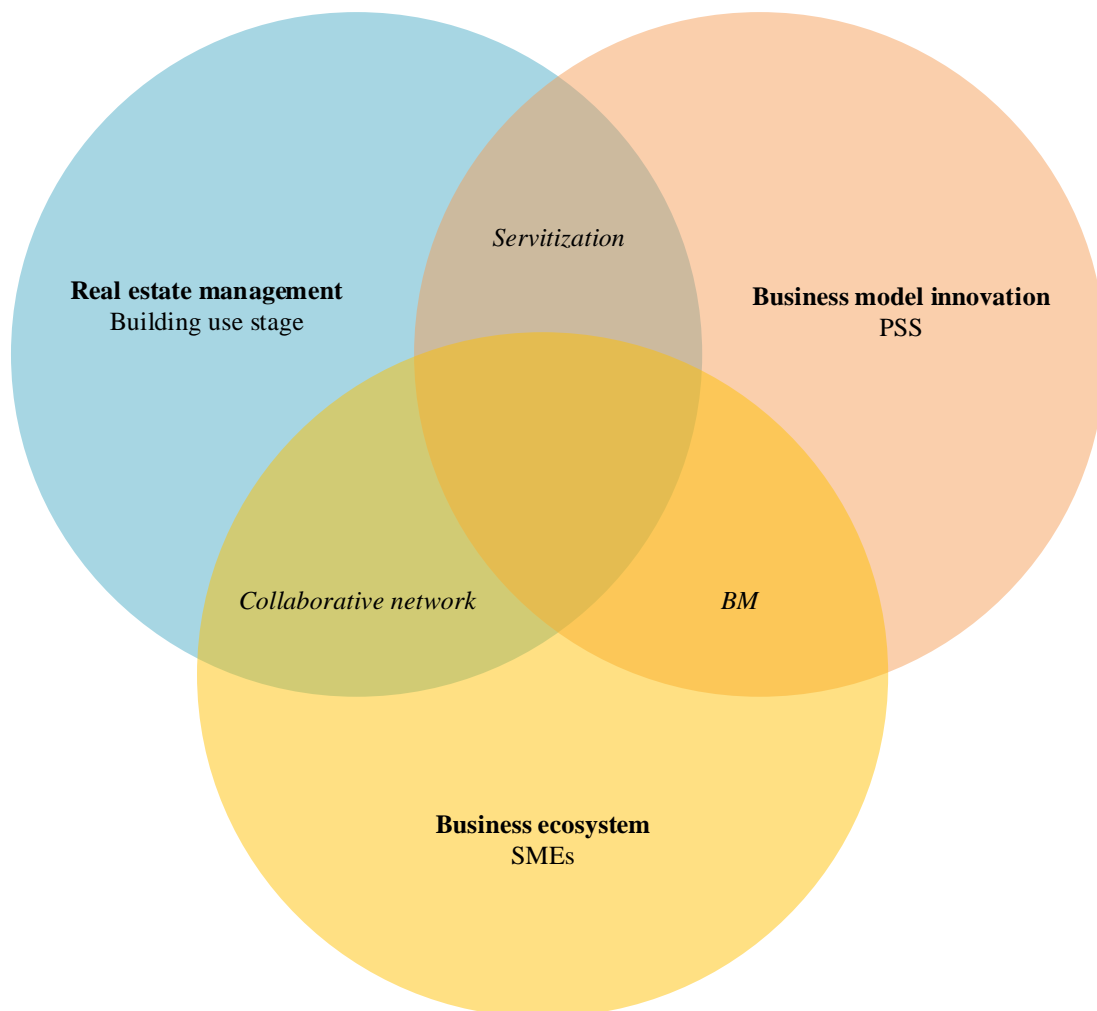


Figure 5.3 – Research's theoretical boundaries.

5.4 Problem formulation

Based on theoretical gaps highlighted in the previous chapter from the literature review and the first experts' feedback sessions, Table 5.2 identified a few systematic problems related to the PSS delivery to the end-user of the building by SMEs and the related domain.

Table 5.2 – Identified problem summary by multiple actors.

Identified problems	Problem domain	Problem owner
Lack of PSS integration mechanisms for SMEs	ICT Infrastructure	Property owner, SME
Lack of understanding of PSS delivery mechanism	Tool and methods	Property owner, SME
Lack of understanding of PSS added value	Knowledge	Property owner, SME, end-user

All three problems are significant and deserve to be researched. However, due to the specific focus on the end-user perspective, I will focus on the third one (i.e., lack of understanding of general PSS added value). Following the problem formulation, I have designed a working research question for this explorative study:

***RQ4.** How can SMEs explain PSS added value delivered in the best possible way to each stakeholder?*

In addition, I have added two sub-questions:

***RQ4.1.** Which information about PSS would be relevant for each stakeholder?*

***RQ4.2.** Which sustainability-oriented criteria could be relevant for each stakeholder?*

5.5 PSS multi-criteria framework development

Comprehensive literature reviews on sustainability and value assessment in PSS development were done by several authors (Nakada, Sholihah, Mitake, & Shimomura, 2020; Bertoni, 2019; Sundin, Nässlander, & Lelah, 2015). In particular, Sundin et al. (2015) distinguish five aspects – clustered into two groups – that need to be considered when evaluating a PSS, namely provider-oriented (i.e., economic, environmental, and societal) and customer-oriented (i.e., acceptance and satisfaction). In this study, I decided to include customers' related criteria into social sustainability as an individual-level

representation of social sustainability, even if I clearly understand that customers' related criteria also relate to economic sustainability.

To align the general theories about PSS sustainability assessment with the context of the built environment, I have interviewed multiple actors: building owners, SMEs delivering PSS to the existing buildings, and residents of several buildings. Based on the literature analysis, I compiled a list of 18 criteria (six criteria for each sustainability dimension). Then, I provided this list as a survey to our experts to prioritize the criteria. Different actors gave preference to different criteria according to their needs. Table 5.3 shows a generalized summary of criteria from different actors' perspectives and each criteria's correlation with the associated sustainability dimension.

Table 5.3 – PSS sustainability criteria identified by multiple actors.

Actor	Prioritized criteria	Sustainability dimensions
Property owner	Cost optimization	Economic
	Resource consumption	Environmental
	Innovation	Economic
SME	Market size	Economic
	ROI	Economic
	Customer satisfaction	Societal (individual level)
End-user	Price category	Economic
	Overall experience	Societal (individual level)
	Environmental impact	Environmental

Based on this knowledge, I have created an overall PSS sustainability multi-criteria framework, which can help to pre-evaluate different PSS cases and understand how well they address their added values from different sustainability perspectives (Table 5.4). Economic sustainability is represented by market size criteria, cost optimization criteria, and ROI criteria. Social sustainability is represented by social wellbeing (societal level), needs fulfillment, and overall experience (individual level). The environmental dimension of sustainability is represented by resource efficiency criteria, eco-materials criteria, and circularity criteria. Due to the overall assessment and multivariate data for each criterion, I have used a radar chart for comprehensive evaluation.

Because this exploratory study addresses the early decision-making stage, I propose conducting an assessment using a scale-based method using three main categories: low,

medium, and high scores. Thus, I have a simplified system for evaluating each criterion without having many different data types. Of course, this approach is generalized and requires a more detailed qualitative assessment as the next step. Nevertheless, at this stage, this approach is sufficient to have grounds for further, more in-depth study of the criteria and why specific criteria have a particular value.

Table 5.4 – PSS sustainability multi-criteria assessment guidance.

Sustainability dimension	Criteria	Score		
		Low: 1-2	Medium: 3-5	High: 6-8
Economic	<i>Market size [EUR]</i>	< 100,000	100,000 – 1,000,000	> 1,000,000
	<i>Cost optimization</i>	Not part of value prop.	Indirect value prop.	Direct value prop.
	<i>ROI</i>	< 5	5-10	> 10
Social	<i>Overall experience</i>	Mostly negative feedback	Slightly positive feedback	Mostly positive feedback
	<i>Needs fulfillment</i>	-	-	-
	<i>Societal wellbeing</i>	Not part of value prop.	Indirect value prop.	Direct value prop.
Environmental	<i>Resources efficiency</i>	Not part of value prop.	Indirect value prop.	Direct value prop.
	<i>Eco materials</i>	Not part of value prop.	Indirect value prop.	Direct value prop.
	<i>Circularity</i>	Not part of value prop.	Indirect value prop.	Direct value prop.

5.6 Market cases analysis

To apply newly generated knowledge into practice, I decided to select several market cases and analyze them from the point of the proposed framework (Table 5.5). Due to the scope of this paper, the analysis was made empirically. The main selection criteria of SMEs for this case study were:

- Representing different types of PSS.
- End-user oriented (B2C or B2B2C).
- EU based.

Data were collected from secondary sources.

Table 5.5 – Market SMEs’ PSS cases from the building use stage (B2C and B2B2C).

Name	Brief description	Product component	Service component
Sangalli (Italy)	Sangalli Technologies focuses on project consultancy, technical assistance, and maintenance for sound systems, video, lighting and digital signage.	Sound systems, video, lighting, and digital signage.	Project consultancy, technical assistance, and maintenance.
Standard Access (Ireland)	Standard Access focuses on building access management through Sonic Handshake, a technology that eliminates keys and costs associated with locks changing.	Smart access system (e.g., door lock).	Digital platform for access systems remote set-up and management.
Olimpia Splendid (Italy)	Olimpia Splendid is an Italian company that designs, produces, and sells products for building air conditioning, heating, and air treatment.	Air conditioning system.	Product total care business model.
FM Mattsson (Sweden)	FM Mattsson is a Swedish IoT-based water mixer that facilitates the operation of water in public and private environments.	Water tap, integrated smart water sensors.	Water management app.
Tado° (Germany)	Tado° is a technology company and manufacturer of home thermostats and air conditioning controls. Besides reducing energy consumption and increasing savings, the thermostat also considers the residents' overall comfort.	Smart thermostat, Tado internet bridge.	Tado° app.
Tibber (Sweden)	Tibber is a digital platform that buys the cheapest available electricity per hour and also does hourly analytics of electricity consumption on the individual level (via plugged-in smart products)	Diverse smart home devices ecosystem (partnership).	Tibber electricity management app.

5.7 Results and discussion

5.7.1 PSS related criteria

Selected market cases were associated with value constellations (i.e., collaborative partnership network) identified by Kowalkowski et al. (2013), namely the configuration of the firm's direct network relationships into distinct, specific, and integrated structures to create value. In addition, the taxonomy used (Baines et al., 2017) to cluster PSS allows for classifying them among product-oriented (PO) PSS, use-oriented (UO) PSS, and result-oriented (RO) PSS. PO PSS highlights vertical integration partnerships, while UO vertical ones. On the other hand, RO PSS mixes both horizontal and vertical integration types. Results from empirical case analysis are shown in Table 5.6.

Table 5.6 – PSS related criteria summary

Name	PSS type	Partnership type	Service component
Sangalli	Product-oriented (PO)	System integration	Vertical
Standard Access	Use-oriented (UO)	Specialist externality	Horizontal
Olimpia Splendid	Result-oriented (RO)	Dual customer contact partnership	Horizontal and vertical
FM Mattsson	Product-oriented (PO)	Competence co-location	Vertical
Tado°	Use-oriented (UO)	Specialist externality	Horizontal
Tibber	Result-oriented (RO)	System integration	Vertical

The partnership network for each PSS case is presented in Figure 5.4. Based on the summary result in Table 5.6, I can find the following correlations. Product-oriented PSS show mostly vertical integration of service components among involved actors rather than use-oriented and result-oriented ones. These last two PSS types are characterized by horizontal integration forms, which explain a smaller number of partners but more robust relationships. Conversely, vertical integration allows many partners to join the collaboration network openly and quickly. One of the cases selected (i.e., Tibber) is an outlier due to its deservitization approach (Christian Kowalkowski, Gebauer, Kamp, et al., 2017).

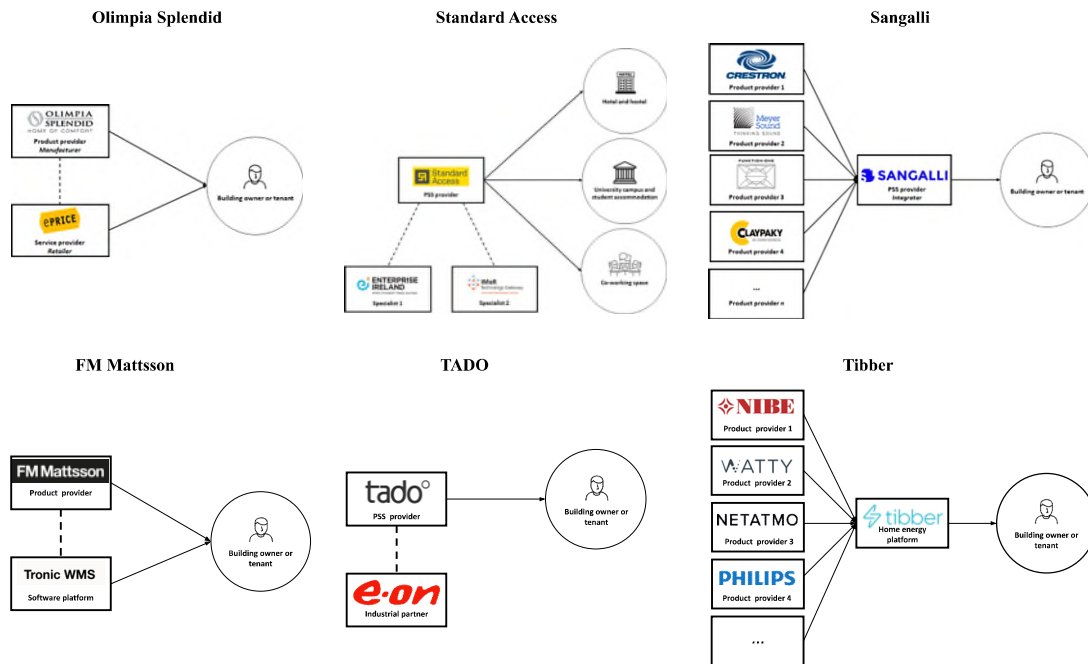


Figure 5.4 – Collaborative partnership network of each of the six cases.

The next logical step is to analyze each case more profoundly by applying the proposed PSS sustainability multi-criteria assessment framework. It is essential to analyze each case from different dimensions to reach an objective vision of each case's performance.

5.7.2 PSS sustainability-related criteria

A PSS sustainability multi-criteria assessment was organized based on the available data about the six proposed cases (Figure 5.5). The analysis results are presented in radar charts, a valuable way to display multivariate observations with an arbitrary number of variables. For this stage of the study, I assume that all criteria will be considered equally important to reflect the general view of each case study. I understand that the proposed list of PSS sustainability multi-criteria is just a first attempt to create an objective framework with many limitations and assumptions, which will be listed in the next chapter.

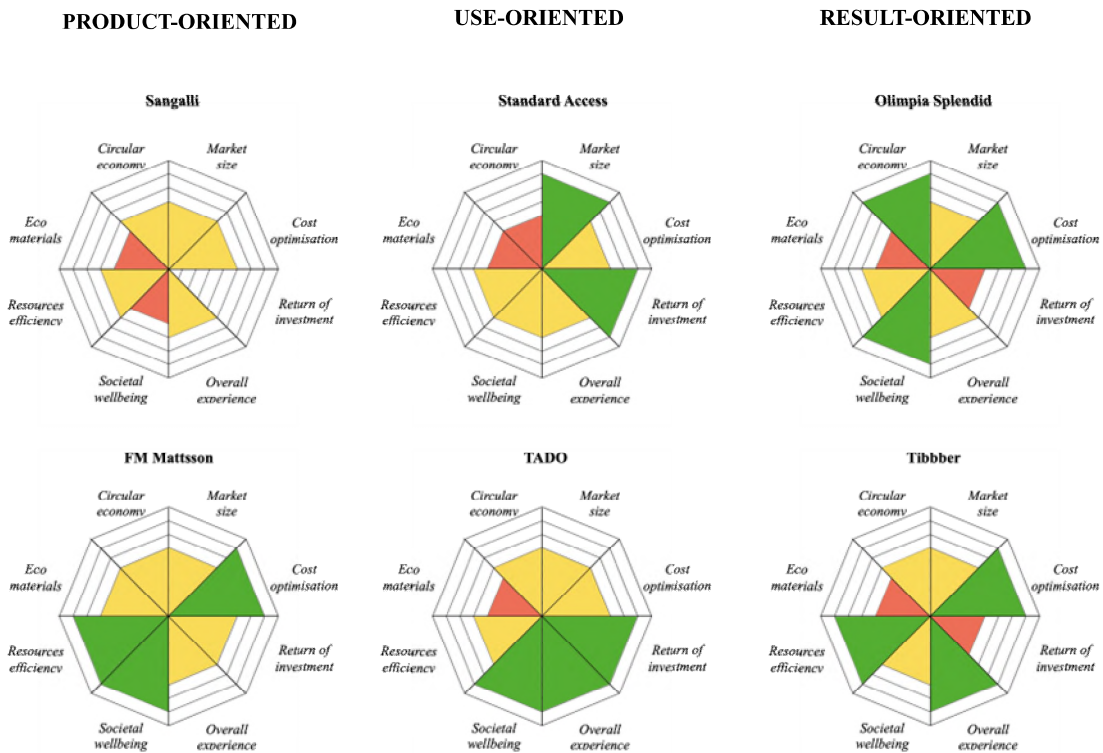


Figure 5.5 – PSS sustainability-related criteria summary for each market case.

5.8 Conclusions

This section summarizes this study's findings, limitations, and further research opportunities, highlighting the role of SMEs' collaborative partnership networks.

The present study explores the role of SMEs network for PSS delivery in the real estate industry's operations stage, which has never been used to describe servitized SMEs in literature to the best of our knowledge. I have developed a framework that attempts to bridge through a sustainable perspective SMEs' PSS collaborative partnerships networks implemented to deliver value to stakeholders with the real one perceived from the latter. This framework represents a tool for practitioners – managers and entrepreneurs from SMEs – that aims to properly design and understand the added value transfer to end-users. Despite multi-actors having different priorities, KTH Live-in-Lab's expert discussions and preliminary analysis of empirical cases suggest correlations between PSS-related and sustainability-oriented criteria. For instance, selected use-oriented PSS cases are delivered through a specialist externalities collaborative partnership network, highlighting the investment return as a critical dimension for stakeholders. Selected result-oriented PSS cases show that stakeholders perceive cost optimization dimension as necessary: economic sustainability is more prior for SMEs than environmental sustainability. This fact makes us conclude that it is not an easy task to balance a high performance of both.

This paper is not exhaustive, and it presents a set of limitations. Due to the field's uniqueness, the findings mentioned above cannot be fully generalized. In addition, the framework is based on the author's personal choices regarding both PSS-related and sustainability criteria. Literature has defined different classifications for PSS, SMEs' collaborative networks, and sustainability criteria. This fact means that the proposed framework represents just a point of view over added values perceived by stakeholders, partially achieving an objective understanding of the argument. The analyses relied on a small number of empirical cases based on secondary data collected, as well as a small group of experts from the KTH Live-in-Lab involved in the discussion that led to the identification of the sustainability criteria.

Based on the findings and limitations described, this study opens a set of potential further research. First, the number of empirical cases and experts involved should be selected

from different industries to get more evidence regarding the correlation among the different dimensions involved in the framework and its general application. All the collaborative partnership networks identified by Kowalkowski et al. (2013) should be analyzed. Then, cases should be based both on primary and secondary data. In addition, data should be collected from all the actors involved in the collaborative network to take care of stakeholders' different interests. The application of the framework in other phases of the building's life cycle constitutes a promising opportunity to validate the tool developed. Once certified, the tool will benefit from ICT contributions for facilitating and spreading data collection from stakeholders and related analysis. Another critical area of research is represented by identifying the optimal business model that successfully manages economic and environmental sustainability values along the collaborative network. In this direction, a deeper understanding of SMEs' unique sees and network mechanisms is needed.

6. CONCLUSIONS

This doctoral dissertation dealt with servitization in SMEs. This phenomenon is still in an early-growth phase with limited contributions spread among different disciplines. However, the topic has been on an increasing trend in the last decade, in terms of both magnitude (i.e., number of papers) and attention (i.e., number of citations).

The main goal of the thesis was to overcome some of the strategic and operational barriers that SMEs face during the transition toward a servitized business model. This overall goal can be broken down into four research questions (Figure 6.1).

- **RQ1.** *What limitations within the literature on servitization in SMEs could inspire future research directions?* (Answered in the first essay, reported in Chapter 2).
- **RQ2.** *How does the SME's product strategy impact its servitization performances?* (Answered in the second essay, reported in Chapter 3).
- **RQ3.** *How does the aftersales relationship between producer and customer affect the type of co-creation in SMEs?* (Answered in the third essay, reported in Chapter 4).
- **RQ4.** *How can SMEs explain PSS added value delivered in the best possible way to each stakeholder?* (Answered in the fourth essay, reported in Chapter 5).

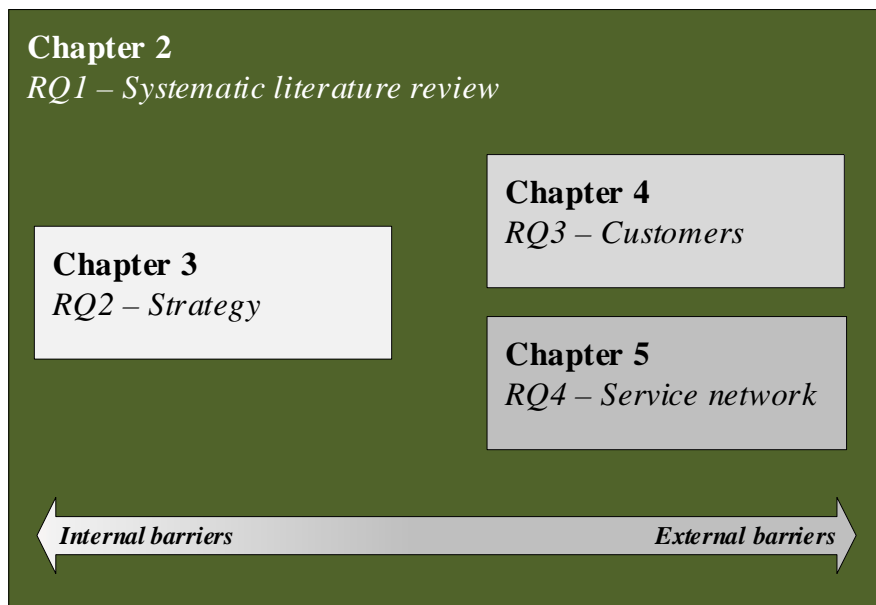


Figure 6.1 – Overall conceptual framework of the dissertation.

The first research question was answered in the first essay – “State of the art and research agenda of servitization in SMEs: a critical perspective from a manufacturing firm” – by identifying 46 papers clustered among seven different thematic groups. Propositions stated in the paper allowed the identification of 29 gaps in the body of knowledge that led to the definition of 51 future research directions for scholars. I used some of them to guide the development of the other three empirical chapters.

The second research question was answered in the second essay – "How does product strategy contribute to servitization in SMEs?" – by designing a mediation model to explain the underlying mechanism between product strategy and service performance through the servitization orientation construct. The model was tested using data from the International Manufacturing Strategy Survey (IMSS-VI). The contribution aims to be a theoretical approach to overcome the internal barrier related to strategy and the configuration of the servitized business model by identifying the most suitable product strategy to impact service performance positively. Results show that the explorative product strategy positively impacts service performance, which is fully mediated by the manufacturer’s servitization orientation. Contrary, an exploitative product strategy does not significantly impact service performance.

The other two research questions concern external barriers to servitization.

The third research question was answered in the third essay – "The influence of the type of aftersales relationship on the co-creation of services: the case of an Italian SME" – facing barriers related to knowledge, capability, and information about the manufacturer’s customers. The study’s contribution is threefolds. First, I propose a novel variation of the RFM model tailored to catch different servitization dimensions. The model reflects service potential, interaction, and retention. Second, based on data from more than 300 customers of an Italian SME, I created a taxonomy to describe four aftersales relationship types. Lastly, the latter are related to co-creation dimensions: customization and engagement.

Finally, the fourth research question was answered in the fourth essay – "Product-service systems delivered by SMEs during building use stage: sustainability criteria framework" – deals with barriers related to collaborative service partnership networks. I primarily focus on the building's use stage, emphasizing the end-users role. Built on the multi-

actors' feedback, I have created a list of criteria identified as necessary to understand the PSS's added value better. These criteria were compared and supplemented by the existing criteria in academic practice and formed into the sustainability multi-criteria framework. The proposed framework also supplements PSS-specific criteria, such as PSS type, PSS partnership type, and PSS integration type.

6.1 Implications for theory

The insights provided by each article offered in this dissertation provide a set of significant theoretical contributions. Instead of concentrating on the individual studies' contributions, which are previously described in each chapter, an additional attempt will be made here to synthesize and summarize the theoretical implications of the dissertation.

First, I developed additional knowledge concerning the servitization process in SMEs. Each contribution treated a specific strategic alignment needed to overcome servitization barriers. After an SLR (Chapter 2) that organized existing knowledge identifying existing gaps in the literature, the dissertation included articles on internal strategy (Chapter 3) and external alignments towards customers (Chapter 4), and collaborative service networks (Chapter 5) to overcome servitization barriers. Results contribute to the servitization in SMEs literature by filling a significant set of gaps from the ones identified, providing insights into the “how to servitize” question, particularly for what concern overcoming barriers.

Second, I identified some factors influencing servitization barriers. In particular, the role of product strategy on service performance is highlighted in the second essay (Chapter 3). Evidence shows that explorative product strategy indirectly impacts service performance through the mediation of servitization orientation. This result is essential to theory as it explains the underlying mechanism regulating the link between product and service. In the third essay (Chapter 4), aftersales relationship types between the manufacturer and the customer are associated with different levels of customization and engagement for co-creation. Each aftersales relationship type is described through a set of factors that explain the customer's behaviors and help to overcome external information barriers. Similarly, the last essay (Chapter 5) presented a framework that attempts to bridge SMEs' PSS collaborative partnerships networks by using a set of factors (i.e., criteria) that describe different sustainability dimensions.

6.2 Implications for practice

The practical potential of this doctoral thesis has benefited from the direct involvement of managers from SMEs and the author's participation in territorial networks related to industrial service. The main implications for practitioners include frameworks and tools for facilitating strategic decisions concerning servitization and overcoming the related barriers. In addition, possible future dissemination of insights through industrial-oriented information channels represents an interesting further implication for the industrial community.

First, the SLR (Chapter 2) offers a guide for entrepreneurs, managers, and consultants from small and medium companies to understand the evidence provided by the research. Furthermore, I introduced a thematic clusters priority list based on the discussion with managers from a manufacturing SME that should help other companies prioritize their servitization roadmap's tactical and strategic actions. Thanks to the study reported in the second essay (Chapter 3), decision-makers in SMEs are now aware that the product strategy (i.e., competitive priorities) implemented leads to different service performance only if adequately supported by an adequate level of servitization orientation. Due to differences from large companies, managers from SMEs should pay particular attention to selecting the optimal product strategy to allocate available resources for its development.

Managers at small and medium-sized manufacturing companies should benefit from the third essay (Chapter 4) when they deal with resource allocation to different customers to develop profitable after-sales relationships. First, this study proposes a quantitative service-oriented customer segmentation method based on a few data easily accessible from a firm's CRM. The method can easily lead to the development of IT tool design to work with SMEs' CRM. Second, the co-creation degree associated with each cluster should help SMEs properly design service business models. Last, the fourth essay (Chapter 5) includes a framework representing a tool for practitioners that aims to design and understand the added value transfer to end-users. The framework allows assessing the economic, social, and environmental sustainability dimensions of PSS solutions delivered in different collaborative networks.

6.3 Limitations and future research opportunities

As any research project, this doctoral dissertation also has limitations due to the research design adopted.

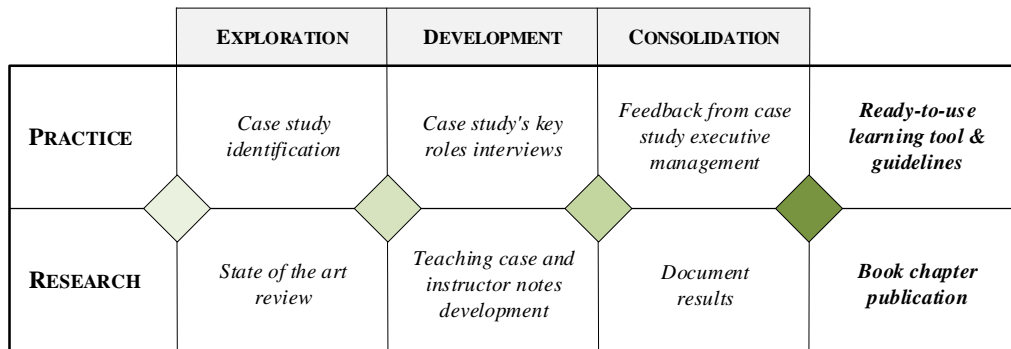
The SLR (Chapter 2) has been characterized by some authors' choices that constitute limitations to the research. In particular, gaps identified (Table 2.11) should be classified according to their recipient company, namely gaps focusing on all-sized enterprises or SMEs. Further examining SMEs' gaps should also discriminate gaps that could concern family businesses and start-ups. Using the entire list of gaps identified to guide the development of the subsequent chapters was a thoughtful decision that allowed me to interpret SMEs mainly as a research scope condition. In the second essay (Chapter 3), the available dataset allowed just cross-sectional analysis that did not catch the different firms' behaviors over time and did not collect the recent fourth industrial revolution trends. In addition, the reduced number of competitive priority measures selected could not entirely describe SMEs' exploitative and explorative product strategies. The third essay (Chapter 4) could be biased by the single case study approach adopted and the specific features of the selected, which prevents the generalization of the findings. Limitations can also derive from the proxies selected to measure the different service dimensions implemented in the customer segmentation method developed. This last limitation can also be found in the last essay (Chapter 5), in which my personal choices regarding both PSS-related and sustainability criteria and classification adopted prevent results generalization.

Besides trying to tackle the abovementioned limitations, future research opportunities could be found in the gaps that were not treated by the empirical chapters of this doctoral thesis. The contributions included in the present dissertation cover just ten out of twenty-nine gaps. Among the gaps that I did not tackle, there is an urgent need for theoretical and practical contributions regarding digitalization and Industry 4.0 technology to overcome servitization barriers and facilitate the design of new services (e.g., smart services) for PSS business model development. Real SME case studies are strongly suggested to facilitate knowledge transfer toward the industrial community. Opposite, as highlighted in the SLR (Chapter 2), there is a lack of studies related to decision-making support systems, territorial servitization, and policymaking. This fact calls for extensive effort on

these two topics to develop related future research directions identified and help SMEs understand servitization aspects through SMEs.

APPENDIX – TEACHING CASE

Escaping the "tortoise shell paradox": digitalization and servitization in the green building construction industry – The case of Marlegno



Appendix Figure A.1 – Positioning of the appendix according to the general research design adopted.

Acknowledgment

This appendix is derived from the article "Gamba, D., Minola, T., Kalchschmidt, M. (2022). Escaping the “tortoise shell paradox”: digitalization and servitization in the green building construction industry – The case of Marlegno" published in "Iandoli, L., Gibaldi, C. (2022). Cases on Digital Entrepreneurship: how digital technologies are transforming the entrepreneurial process in existing businesses and start-ups. Edward Elgar Publishing." I am grateful to Angelo Luigi Marchetti, CEO of Marlegno Srl, his family, and Marlegno's employees for the time they dedicated to the interviews performed in February 2021. They provided input and suggestions for writing this case directly from their experience. Nothing could be possible without their involvement. I recognize that the value of this work gained from the project "Nuove competenze per la Quarta Rivoluzione Industriale" led by the Polytechnic University of Turin (Italy) in collaboration with the INAPP – Istituto Nazionale per le Analisi delle Politiche Pubbliche (Italy). I must thank my supervisors for involving me as coordinator for the Bergamo area in this project, as well as Professor Paolo Neirotti, Professor Alessandra Colombelli, and Lorenzo Marchese from the Polytechnic University of Turin for the opportunity to work with them and the fruitful collaboration.

A. Case

A.1. Learning objectives

By analyzing the case, students will:

1. Comprehend how digitalization could be a source of entrepreneurial opportunities and competitive advantage.
2. Understand servitization and servitized business model enabled by digital transformation.
3. Introduce open innovation strategies that cope with new skills and capabilities needed to exploit digital entrepreneurial opportunities.

The case would like to summarize some of the concepts treated by the empirical chapters of this thesis. In addition, it covers the literature gaps related to the need to address empirical cases from family businesses and extend empirical research to other sectors from capital goods manufacturing, both in B2B and B2C industries.

"We would like to be a laboratory of excellence able to bring the best of our sector to customers. When we develop a new building, we want it to represent the most updated technology application in structure, systems, design, and services." (Angelo Luigi Marchetti)

A.2. Introduction

"The company's slogan is its payoff: sustainable innovation. Whatever we do, Marlegno brings state-of-art digital technology inside timber buildings with the utmost respect to the environment. This approach gives value to our customers through comfort and energy performance."

Angelo Luigi Marchetti

The CEO's words clarify the warp that makes up today company's identity, where past and future collide uniquely. On the one hand, wood represents the past. Wood is a raw material that was formerly thought to be a poor expression of building architecture and that today serves as a distinctive signal for environmentally aware customers. On the other

hand, digitalization symbolizes the future through which smart homes are connected to people and objects rather than separate entities from their internal and external environments. It is from the successful management of this trade-off that Marlegno was born.

Marlegno started its business in 2000 as B2B subcontractor of prebuilt timber roofs for local construction companies. These were excellent times for the Italian construction industry, which was racing thanks to the recent introduction of the Euro currency. While on the other side of the world the bankruptcy of Lehman Brothers pointed out the climax of the subprime mortgage crisis, in 2008, Marlegno reached a turnover of 8 M€ and about 20 employees. Unfortunately, Marlegno's customers – usually small and heavily indebted – became insolvent within a couple of years. Due to these facts, in 2010, the company shifted to a B2C target selling directly to final customers. This disruptive business model change allowed Marlegno to survive this financial tsunami maintaining unchanged its turnover over the next three years. At the same time, the percentage of B2C customers in the firm's portfolio constantly increased. Despite everything, surviving was not enough for the Marchetti family. "We lived in a comfort zone where we felt good, almost satisfied just to be alive and not because we have grown up from this experience!" the CEO stated.

As the three Marchetti brothers discussed the abovementioned situation, opposing arguments emerged. Marlegno could constantly have a higher percentage of B2C customers year by year, which would help its portfolio differentiation if the current strategy had been pursued as-is. In this first scenario, incremental innovations would be the source of process optimization to develop employees' skills and capabilities effectively. Furthermore, financial exposure could be controlled through this approach. At the same time, however, it would also endanger the company to the "tortoise shell paradox". Angelo Luigi Marchetti coined this term to describe Marlegno's business stalemate: choices that allowed it to survive after the 2008 financial crisis became a burden that hindered business development. "Small companies such as Marlegno usually focused only on their own business, protecting themselves from what happens outside their box, reducing costs and investments to survive.

Nevertheless, this is a tortoise shell that limits growth.", he said. Conversely, Marlegno could change its approach to business investing in R&D to become more competitive and

differentiate itself from competitors. R&D investments represent a challenging path that may shift from a follower role of the market trends to a leader able to shape the green building sector and enter new market niches. Emerging technological trends are based on innovation through digitalizing the building life cycle stages. Thus, it could be expected that this scenario would have potentially disruptive consequences for the entire business according to the innovation model adopted and the outcomes reached.

In 2015, the decision to unravel the business deadlock could not be postponed further. Hence, the Marchetti family had to choose how to let Marlegno grow.

A.3. Business overview

"It seemed natural for us to develop the professional activity of designer, construction manager, and then builder, started in the 60s by our father. Following his footsteps, we focused on wood. In Italy, the green building sector is still a niche market. Following the models of countries such as Austria and Germany, all the practical, aesthetic, and environmental advantages that wood entails are beginning to be appreciated by final customers."

Siro Marchetti

Marlegno is an Italian family-owned company based in Bergamo and founded in 2000 by the Marchetti family. The company operates in the green building sector (NACE rev. 2's code 16.1), designing and manufacturing customized timber houses, buildings, and structures. Revenues steadily increased through the years, reaching € 14.1 million in 2019. Marlegno has been managed since its origins by the Marchetti brothers. Angelo Luigi, the company's CEO, and Siro. Their sister Anna – already a partner since its foundation – joined the company in 2018 as HR manager.

Interestingly, the workforce's schooling rate is exceptionally high due to the operations department's use of a qualified workforce for budgeting, architectural and engineering design, project management, logistics, purchasing, and direction of the building sites. The company plays an active role in the local entrepreneurial community, interpreted as an

opportunity for benchmarking and learning. In particular, the CEO is a member of the board of directors of the local industrial entrepreneurs' association (i.e., Confindustria Bergamo) and the Lombardy Energy Cleantech Cluster. In addition, he is President of Assolegno (the association of primary wood processing and construction industries) and co-founder and president of EDINNOVA. The latter is a network for the construction industry's innovation management and knowledge transfer among professionals.

Marlegno has an engineering-to-order production strategy, a typical feature of the construction industry's firms. Marlegno buildings differ from the competition for the high degree of quality and customization pursued thanks to the numerous interactions with the customer. Every building project starts by drafting about three hundred requirements' specifications. Currently, each project is managed by a project manager who is the point of touch between Marlegno and the final customer and is responsible for the correct order implementation.

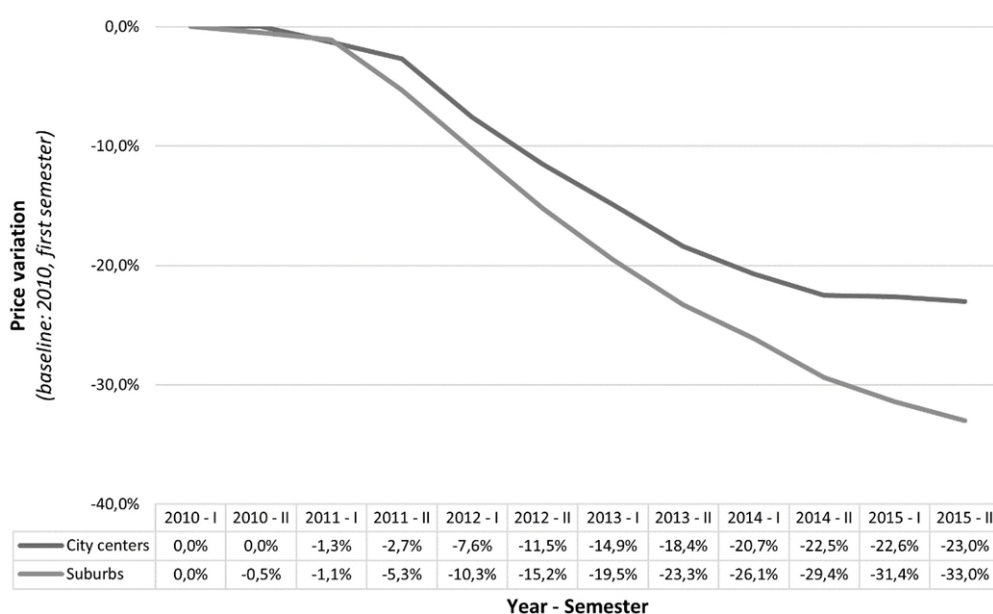
A.4. Industry overview

Since its establishment, Marlegno has operated in the building construction industry. It refers to the branch of manufacturing and trade concerned with the construction, maintenance, and restoration of residential, public, industrial, and commercial buildings. Knowing the economic and technological scenarios that characterized the building construction industry is essential to understanding the Marchetti family's dilemma.

A.4.1. Building construction and real estate industries' economic trends during the 2008 financial crises

The building construction industry in Italy and other countries is strictly linked to real estate. After decades in which relatively easy Access to credit destined for the purchase of houses by households allowed the building construction industry's constant development, starting from 2008, a first setback occurred. The latter was due to the crisis in the sub-prime mortgage market, which made credit institutions very cautious in granting loans raising interest rates. All this was reflected in the building construction industry. In fact, during 2009, the credit crunch continued, and categories of potential buyers (e.g., immigrants, singles, and temporary workers) could no longer access credit.

Consequently, the buildings' prices and transactions dropped down. The latter recorded a reduction of about 15% compared to the previous year. It was the first significant signal, the prelude to the negative trend that occurred during 2010 and 2011: the country's unemployment increased exponentially, while business and consumer confidence decreased along with the willingness to buy a house. 2012 was the "annus horribilis" of the Italian real estate and building construction markets. The most critical price contraction was recorded (Appendix Figure A.2), and sales volumes began to plummet (-25.8% compared to 2011). In addition, the tax burden that affected second homes determined an increase in the real estate offer. The minimum peak of transactions was reached in 2013, but prices were still falling. Inside the credit market, there were the first signs of a recovery in demand for household loans, which seem to be regaining confidence despite the not brilliant trends in the consumption and labor market. In 2014, mortgages restarted thanks to the European Central Bank's injection of liquidity into the financial markets through the so-called Quantitative Easing. Transactions increased, while prices have not yet taken off. Last, real estate demand continued to grow during 2015 shyly. All this still did not transfer to prices, which continued to decrease less than before and headed towards stability. This scenario imposed a radical rethinking of the Italian building construction industry through new approaches based on sustainable and circular business models, renovation of the existing real estate assets, and new technologies.



Appendix Figure A.2 – Real estate Italian price trends in 2010-2015 (Monitor Immobiliare, 2021).

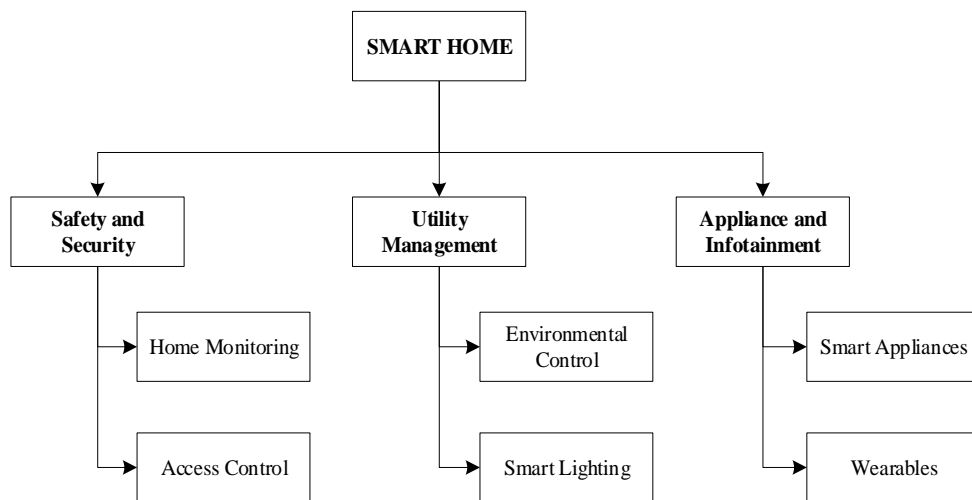
A.4.2. Building construction industry's technological trends

In 2015 building construction industry was influenced by digitalization as a driver of the green building concept. By definition, a green building reduces or eliminates adverse impacts on climate and the natural environment through its design, construction, or operations while also having the potential to create positive effects.

Digitalization's first viable option to reach these sustainable goals is represented by process innovation, namely introducing a new or considerably improved manufacturing or delivery method, including significant changes in techniques, equipment, or software. As the CEO said: "Our goal is to create increasingly eco-sustainable elements considering the costs of any life cycle phase.". In that sense, digitalization can hugely benefit existing business processes and workforce efficiency. Digitalization also favors the servitization of the producer's business model, especially for the building life cycle's use stage. Servitization refers to the transition in an enterprise's business model from products (i.e., buildings) to a combination of products and services, the so-called product-service systems (hereafter PSS). Servitization generates higher use-value, value-based pricing, and capabilities to support co-creation. Servitization is not a recent trend in the industry. What is changed over the last years is the sense of urgency perceived by managers caused by customers' pressure and competition within manufacturers' commoditized markets. This situation encourages proactive action to capitalize on technological advancements such as digitalization to capture customer relationship value and expand the market potential. In that sense, there are two categories of building services from the end user's perspective: primary services and smart home services.

Primary services are represented by energy (i.e., electricity and gas), water (i.e., supply, drainage, and adequate plumbing), escalators, elevators, security, alarm systems, fire detectors, and safety systems. They are designed and integrated into the early building design and construction stages, following strict standards and building codes. Such services can benefit from the digitalization of the product (e.g., alarm system control through digital devices). On the other hand, the so-called smart home services generate more and more interest among building construction industry entrepreneurs. The term smart home has many connotations (Appendix Figure A.3). For example, the smart home in the healthcare industry is employed as a residential space that improves illness prevention by monitoring residents' health, habits, and life patterns. In the energy

business, technological advancements and research in smart homes are centered on the efficiency of energy facilities, including demand-oriented energy production and utilization. In our context, it refers to house components with various internet and mobile applications related to the internet of things (from now on, IoT) and artificial intelligence (from now on, AI). IoT and AI allow the analysis of data collected by sensors and translate them into information and services, performing monitoring and predictive activities. For example, sensors capable of detecting the state of health of the building, diagnosing consumption and anomalies in real-time, adapting the internal comfort in relation to the people present, adjusting ventilation, humidity, and temperature.



Appendix Figure A.3 – Smart home segments.

Both potential scenarios (i.e., process innovation and servitization) would impact Marlegno's organizational structure. New re-engineered processes and servitized business models need critical resources and capabilities to succeed in such significant changes as data processing and interpretation skills.

A.5. Escaping the "tortoise shell paradox"

"Innovation is a mindset, a mental approach that must lead you not to sit down after reaching a goal. It leads you to question your certainties."

After a series of all-night-long meetings and analyses, the Marchetti family decided to change the firm's approach to their business starting to invest in R&D about 3% of its yearly turnover. Marlegno began collaborating with external research centers and organizations, such as universities and start-ups, adopting an open innovation approach. These collaborations started recognizing that processes and servitized business model innovation capabilities were not present in Marlegno. At the same time, the company introduced new professional figures, while the existing ones were upskilled. Digitalization represented a driver toward the green building concept. In addition, it is an integrated part of the new corporate culture set up, at the root of that integration concept of information, data, processes, and the entire business organization.

A.5.1. Process innovation

Thanks to the participation in the four-year Level-Up project, a research and development initiative funded by the international research call Horizon 2020, Marlegno has begun to digitize its production processes in partnership with SCM Group. This challenge's technological and digital heart is the "Oikos x" machining center. Oikos x has an innovative six-axis machining head unit capable of processing elements up to 18 meters long and 1.25 meters wide with millimeter precision. Thanks to the Maestro beam&wall program, which is wholly integrated with the most popular CAD systems on the market, a digital twin of the processes can be created, which benefits productivity and cost. Vibration sensors installed on "Oikos x" allow checking and measuring machine operations to detect real-time problems, leading to predictive maintenance. Alessandro Greppi, Marlegno's innovation manager, pointed out that all the company's machinery will benefit from implementing SCM's IoT Maestro connect platform. The latter will allow for data collection about performances and the status of the various technologies, creating a digital register. The project allowed a shift from unstructured operations and maintenance activities to a fully digitized system. This innovation impacted the production time and the operating costs of the process.

A.5.2. *Servitization of the business model*

Marlegno decided to start to servitize its model by developing a set of services in the pre and aftersales phases. These services aim to address customers' needs through a long-term-oriented relationship that seeks to optimize the total cost for the customer. As stated by the CEO, the company stopped selling "just cubic meters of wood", adding sales based on the value transferred to the final customers. The B2C services provided are listed in Appendix Table A.1.

Appendix Table A.1 – List of Marlegno's offered B2C services.

Phase	Service	Digital technologies used
Presales	Cost budgeting.	CPQ
	Architectural design.	BIM and VR
	Building practices management.	-
	Dialogue with banking and insurance institutions (not brokerage).	-
Aftersales	Ordinary maintenance.	IoT
	Predictive maintenance.	AI

Digitalization represented a key factor in the delivery of these services. For example, architectural design is based on a BIM platform. At the same time, cost budgeting was performed by developing a CPQ system that simplifies generating an offer for customers, who can receive a cost estimation of the desired building directly through the step-by-step tool accessible through Marlegno's website. The most innovative project started by the company is founded on the cognitive building concept, which opens for an even more advanced scenario compared to smart building. In this case, homes can self-learn and regulate themselves proactively from data collected through sensors installed within the structural package of the timber frame walls. In that sense, a building is transformed into an actor able to auto-regulate itself, enhance people's comfort, and send information about its health status to Marlegno's customer care department. In such a way, maintenance will be performed just if needed. Customers can monitor the building's performance through a smartphone app. This project was possible thanks to the partnership that Marlegno developed with IoTty, a local start-up specialized in IoT systems development. "The goal is to create houses capable of self-organizing and assisting those who live there, in the name of energy efficiency and structural protection.", the CEO said. Last, Marlegno started using virtual reality (from now on, VR) in pre-sales services. VR allows the

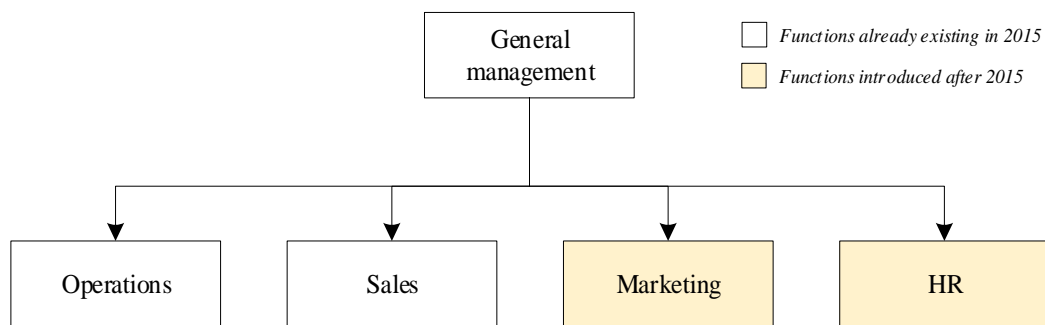
customer to see and "be immersed" in the house starting from the design phase. As well as machinery for advanced prefabrication, this innovation reduced errors and production times.

A.5.3. Organizational structure change

Marlegno started to pay great attention to the innovation of its organizational structure accordingly to the new products developed and the servitized business model introduced. Anna Marchetti began the first HR manager, emphasizing enhancing both employees' hard and soft skills. Digital training (e.g., data interpretation and use of software tools) crossed all company's departments, with a particular focus on the operations department following the introduction of the new technologies. As mentioned by Marlegno's innovation manager: "I believe that our job has always been in constant change. In recent years, there has been a great interest in digitalization and improving production and managerial processes. The reasons are the greater search for efficiency given the increase in globalization and competitiveness between companies.". In general, resources reskilling and upskilling have used both the training provided by consultancy companies for staff training and the opportunities offered by the network created by Marlegno's CEO. The HR department guided Marlegno in introducing the first non-family manager – who comes from a multinational IT company – and launched the first objectives-based incentive plan for its employees. In addition to the HR department, the marketing function was introduced (Appendix Figure A.4), representing an unconventional choice in a traditional industry such as building construction. This department, composed of four internal people and several external agencies, was created to actively contribute to the company's growth by continuously improving the relationship with Marlegno's customers and prospects, especially B2C ones. Prospects were appropriately clustered into communities to strengthen corporate brand recognition.

Each potential or current customer was profiled and reached through marketing campaigns to create long-term relationships and allow Marlegno to respond immediately to requests. Simona Lovati, Marlegno's CMO, mentions how marketing activity has educational and cultural implications, both internally and externally. For example, Marlegno curates "Percorsi sostenibili", a series of webinars 15 minutes long during which experts, suppliers, and customers of the green building sector are interviewed to

deal with specific issues. Topics treated are not turned exclusively to the products but also all the services offered by Marlegno. The goal is to reinforce the community's identity to address the webinar, intercept new potential members, and collect needs in a bottom-up logic. The attention to the data and its interpretation to transform it into practical actions is very high. As stated by the CMO: "Initially, the social networks' reports highlighted a predominantly male audience. Our posts had a high technical imbalance, with a tone of voice that needed to be completely redesigned. Brand awareness does not only involve technicalities but also emotions. The customer chooses Marlegno for his unique selling proposition. Therefore, we have rethought communication to balance the messages conveyed and optimize investments by creating value and a constructive and transparent relationship with our followers."



Appendix Figure A.4 – Marlegno's organization chart.

A.6. Epilogue: a new thin and elastic shell

The advances mentioned above are just an overview of the initiatives implemented by Marlegno. In conclusion, it is valuable to note that significant product innovations were introduced. One example is Tavego – a range of eco-sustainable structural floors and load-bearing walls assembled without glues and made by certified wood – and AdESA. The last is a dry prefabricated system designed according to the building's morphology to extend its useful life. It consists of insulated timber panels connected to the structure, with the triple function of an energy coat, an anti-seismic shell, and a layer for architectural restyling. Both innovations' development had benefited from the partnerships between Marlegno and local universities, confirming that open innovation represents a weapon

SMEs can use to catch skills and resources from outside. Talking about what happened since 2015, Marlegno CEO synthesized:

"Through digitalization and servitization, we escaped the tortoise shell [paradox], making it thinner and more elastic."

Angelo Luigi Marchetti

These few words are empirically proved in the long list of prizes that Marlegno received for its entrepreneurial initiatives, including a first prestigious "Prize of the Prize" for innovation in 2016 and a second in 2019. The three strategic milestones the company has experienced are summarized in Appendix Table A.2.

Appendix Table A.2 – Marlegno's lifecycle strategic milestones.

Year	Milestone	Outcome
2000	Building constructions industry's good times.	Marlegno was founded.
2010	Customers' insolvency.	The business model shifted from B2B to B2C.
2015	Business stalemate (a.k.a., "tortoise shell paradox").	Investment in R&D

A.7. Student challenges

1. How would you describe the SME strategy before the financial crisis? What were the drivers that led the SME to innovate its business model? Can this business model innovation be replicated in other industries?
2. How does digitalization influence process innovation in a traditional industry' SME? What were the factors that played a fundamental role in the innovation process?
3. How does the servitization of the business model gain from digitalization? What are the main challenges SMEs face in adopting such a business model?
4. How does digitalization shape the company's organizational transformation and corporate culture? Is employees' reskilling and upskilling a consequence of technologies adopted, or, vice versa, a propaedeutic factor to innovation?

5. What do you think the company should do in the future to stay ahead and maintain an edge in the digitalization of its business?

B. Instructor notes

B.1. Case summary

Marlegno S.r.l. is an Italian small and medium-sized family firm that operates in the green building construction industry, designing and manufacturing customized timber houses, buildings, and structures. The case can illustrate the importance of digitalization as a driver for process innovation, servitization of the business model, and organizational change by analyzing the adoption of digital innovations by a company in a traditional industry. In addition, the case demonstrates how open innovation approaches can boost the innovation process. Finally, it is a learning resource that helps understand the evolution of the green building construction industry and real estate from the financial crises in 2008 to the advent of smart homes.

B.2. Teaching objectives

The main objectives of the case are listed from now on.

1. Show how digitalization was the source of innovation opportunities and competitive advantage in an SME that operates in a traditional industry. The story provides application cases of digital technologies such as the internet of things, artificial intelligence, and virtual reality in the green building construction industry.
2. Introduce students to servitization strategies in small-medium manufacturers. Compared to large companies, SMEs lack internal financial and managerial resources, capabilities, and experience helpful for a compelling servitization journey.
3. Present innovations enabled by open innovation strategies, following Chesbrough's theory (Chesbrough, Vanhaverbeke, & West, 2006).

B.3. Target audience

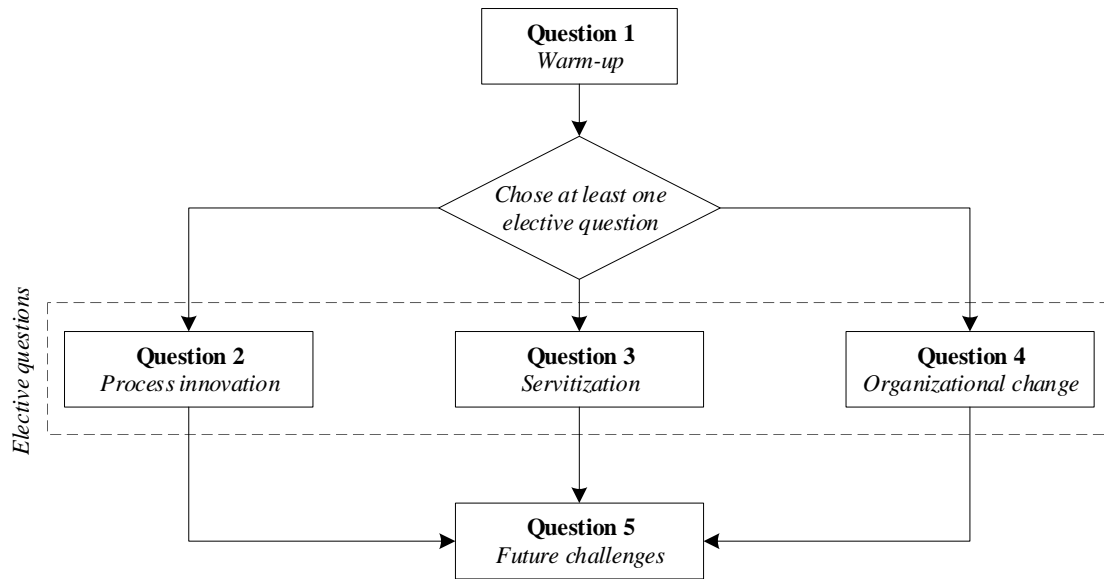
Authors recommend the case for undergraduate students at an advanced stage (third year), master's students, and executive classes of various courses, including innovation management, strategic management, and entrepreneurship. The case also makes a good fit for operations management students, especially for service management classes. The case can be of interest also for an audience without or limited previous knowledge in business modeling.

B.4. Teaching strategy

Appendix Table B.1 provides a recommended instructional sequence that includes necessary and optional elements. If students read the case before class, the teaching case can be given in a regular three-hour lecture. The analysis should be confined to two or three questions among the ones provided for the sake of time and based on the instructional objectives. The first question can be considered a warm-up stage of the teaching strategy, which should be answered by mostly analyzing the teaching case's content. The authors suggest selecting this question jointly with one or more of the following three according to the student audience and the pursued teaching goal. The last question can be used to conclude the class by probing students to forecast future challenges that the company will face (Appendix Figure B.1).

Appendix Table B.1 – Suggested teaching strategy.

Step	Suggested duration [mins]	Execution
Preparatory activity	-	<ul style="list-style-type: none">• Students read the case before class.• Create teams of 3 or 4 students each.• Depending on the educational objectives and the type of audience, the instructor will select a couple of discussion questions for the in-class discussion.
Introduction	10	<ul style="list-style-type: none">• The instructor creates slides with a list of the steps and questions that have been chosen.
Students discuss the case in groups and develop responses to the questions	45	-
Groups' answers definition	15	<ul style="list-style-type: none">• Ask groups to prepare a presentation to illustrate their conclusion. The instructor should stimulate non-standard presentation methods.
Discussion	90	<ul style="list-style-type: none">• Ask each group to present answers in 5 minutes, adopting an elevator pitch approach.• Class discussion.



Appendix Figure B.1 – Suggested questions selection process.

B.5. Suggested answers to student

B.5.1. How would you describe the SME strategy before the financial crisis? What were the drivers that led the SME to the decision to innovate its business model? Can this business model innovation be replicated in other industries?

Marlegno started as B2B subcontractor of prebuilt timber roofs for local construction companies. Due to the 2008 financial crisis, customers became insolvent towards Marlegno, which shifted to a B2C target selling directly to final customers. The instructor can ask students to reflect on the transaction from a B2B to a B2C strategy through the business model canvas (Osterwalder & Pigneur, 2010). A suggested solution is presented in Appendix Table B.2.

The financial crisis started as an endogenous factor that impacted the building construction industry in 2010, serving as a driver to the business model shift.

Other industries can replicate the shift from a B2B to a B2C, mainly thanks to digital transformation and servitization opportunities. A couple of good examples to stimulate reflections are listed after this.

- Volvo started to sell its cars directly to final customers without dealerships through the program Care by Volvo (Volvo, n.d.) in the automotive industry.
- HP started to sell ink for its printers directly to final customers through the Instant Ink (Hewlett-Packard Company, n.d.) program in the computer hardware industry.

The instructor can then ask students to suggest other cases, especially in manufacturing.

Appendix Table B.2 – Suggested analysis of Marlegno's transaction from B2B to B2C.

Building block	B2B strategy	B2C strategy
<i>Value proposition</i>	<i>Price leadership.</i>	<i>Sustainability, differentiation, innovation.</i>
<i>Revenue strategy</i>	<i>Prebuilt timber roofs one-off sale.</i>	<i>Buildings one-off sale; services sold through long-term contracts.</i>
Customer segments	Construction companies.	Households.
Customer relationships	Discrete.	Continuous (i.e., loyalty).
Channels	Direct contact.	Internet channels, events (e.g., open house).
<i>Cost structure</i>	<i>Production and operations activities; workers and employees; raw materials.</i>	<i>Production, operations, design, R&D, and marketing activities; employees; raw materials.</i>
Key resources	Production workers.	Designers, project managers, and production machinery.
Key activities	Production and on-site operations.	R&D, design, on-site operations, marketing, customer service, and aftersales.
Key partners	Raw materials supplier	Raw materials suppliers; tech and institutional partners.

B.5.2. How does digitalization influence process innovation in a traditional industry' SME? What were the factors that played a fundamental role in the innovation process?

The instructor should start guiding the class by reflecting on Industry 4.0 practices and technologies that the teaching case does not explicitly mention (e.g., 3D printing) to stimulate possible other digitalization applications for process innovation. Digitalization impacts the manufacturing process through Industry 4.0's technologies by introducing novel fabrication methods that allow more flexibility while granting low-cost low-volume production (Savastano, Amendola, Bellini, & D'Ascenzo, 2019). Because SMEs have fewer resources than large companies, managing the innovation process is the most challenging task. Digitalization necessitates a mental change in how current processes

and re-engineered activities are seen based on facts rather than appearance. The shift from a process-oriented to a data-oriented emphasis underlies the transformation from data scarcity to data abundance, which transformational technologies like IoT and AI may facilitate. As in the case of "Oikos x", new datasets based on replicated and distributed structures enable innovative processes to enhance competitive advantage.

In most cases, SMEs are not "early adopters", mainly because of the fear of investing in the wrong technologies or adopting inapt practices. Due to the lack of hard skills related to the technology adopted and the potential risk of failure, institutions can incentivize SMEs' process innovation through partnerships and inter-firm collaborations based on open innovation strategies. In that sense, the teaching case describes the EU's Level-Up project in which Marlegno collaborated with SCM to adopt "Oikos x" in its production plant.

B.5.3. How does the servitization of the business model gain from digitalization? What could be the main challenges SMEs face in adopting such a business model?

The instructor can encourage students' reflection by calling back answers about the transaction from a B2B to a B2C business model provided to question 1. Product-centric SMEs adopt servitization to gain a competitive advantage, as well as improved flexibility, cost and time savings, product reliability, increased sales and profitability, and improved customer satisfaction (Kaňovská & Tomášková, 2018b). Digitalization and technology usage plays an essential role in new service creation. The teaching case shows that adopting technologies such as the IoT, VR, and AI can create opportunities or completely transform the features of delivered services, such as Marlegno's preventive maintenance system developed with a local start-up. At the same time, SMEs need an appropriate management information system as a base to exploit data collected from customers. Data collected from products can be the input for developing new, value-adding services and optimizing the existing ones.

Unfortunately, SMEs usually experience a shortage of skilled personnel and a lack of organizational mindset. These barriers are also present in large enterprises, but they are perceived more intensely in SMEs because of their smaller size and lack of resources. On the other hand, a lack of hard skills related to technology can be insourced through partnerships and collaborations based on an open innovation strategy. In addition, SMEs

could face significant financial barriers to servitization, the so-called service paradox (Gebauer et al., 2005). The latter says that companies that invest heavily in extending their service business enhance their service offerings and incur higher costs (e.g., because of digital transformation implementation), but this does not result in the expected correspondingly higher returns.

B.5.4. How does digitalization shape the company's organizational transformation and corporate culture? Is employees' reskilling and upskilling a consequence of technologies adopted, or, vice versa, a propaedeutic factor to innovation?

Digitalization shapes a company's organization through the introduction of new roles. In fact, along with technology advancements, the organizational structure undergoes numerous significant changes, helping businesses to become more adaptable in the face of rapidly changing markets. The teaching case illustrates as Marleno introduced HR and marketing functions. Each of them is horizontal with respect to the existing ones. This horizontal coordination mechanism allows new interactions between different functional areas for continuous improvement (both formal and informal). Data favors and enables interaction between departments. The HR department can use data to analyze all workers' and employees' performances to manage resources' reskilling and upskilling.

On the other hand, the marketing department uses data from external sources to help the sales function in the lead acquisition and commercial opportunity processes. De-facto, the organizational structure of Marleno assumed a matrix configuration with the introduction of the two above-mentioned cross-functional departments, as shown in Appendix Figure B.2. Hence, the firm experiences a passage from a hierarchical structure to an organic and adaptive one. Digitalization guides businesses toward more flexible organizational structures that allow continuous adaptation (Hanelt, Bohnsack, Marz, & Antunes Marante, 2021).

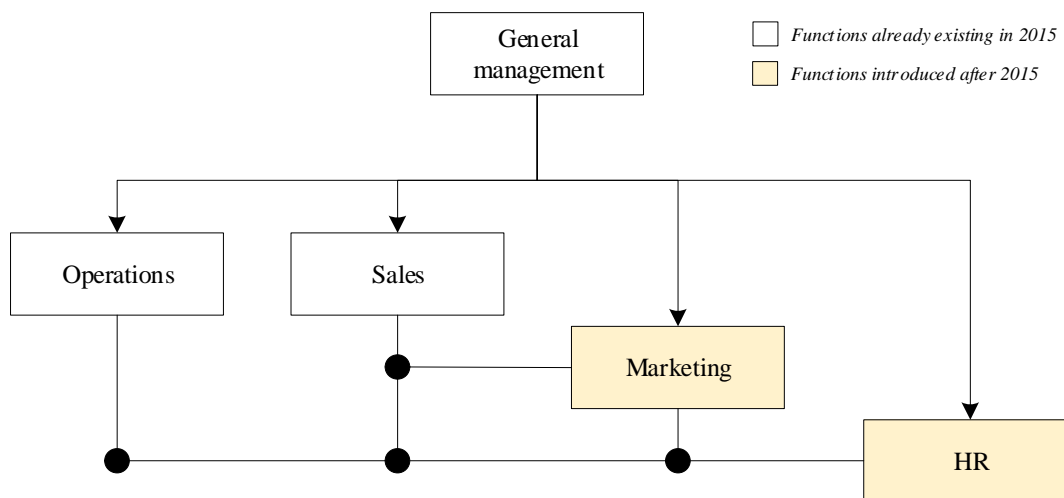
The instructor can stimulate additional analysis at the individual resource level. Possible triggers of discussion connected to digitalization are listed after this.

1. Employees' involvement in the continuous improvement process thanks to data sharing.
2. Collaboration between workers and machines.
3. Single resource and team evaluation as a result of data collected.

By the way, Industry 4.0 is not just a wave of disruptive technical innovation but a cultural shift (Savastano et al., 2019). The instructor can stimulate analysis of digitalization's impact on corporate culture based on the triggers listed hereinafter.

1. Introduce top and middle managers with a strong drive towards digitalization to tackle cognitive inertia.
2. Add an innovation manager who can spread the digital culture within the company and introduce new technologies to older resources. SMEs can select a middle manager with a strong orientation towards digitization to spread digital culture among resources.
3. Share objectives with workers and employees.

Finally, the last question is intentionally open to stimulate class discussion. The instructor should guide the debate by highlighting the different innovations mentioned in the teaching case and the open innovation strategy adopted by the company. Process innovation started with an EU project that allowed the creation of a partnership with SCM Group. The servitization of the business model began by identifying firms that collaborated with Marlegno to implement pre and after-sales technology applications, such as IoT. Hence, it seems that Marlegno started with technology adoption through expert partners; just then, it began to upskill and reskill its workers and employees to cope with technology usage and business implications.



Appendix Figure B.2 – Marlegno's cross-functional organization chart

B.5.5. What do you think the company should do in the future to stay ahead and maintain an edge in the digitalization of its business?

The instructor should guide students to think about future challenges stressing the dimension related to elective questions selected. The authors suggest using easy strategic tools (e.g., SWOT analysis focusing on opportunities and threats quadrants) to stimulate thoughts about possible scenarios. For the benefit of the instructor, the authors suggest a not exhaustive list of three future challenges to stay ahead and maintain an edge in the digitalization of its business (Appendix Table B.3).

The first future challenge regards 3D printers for highly customized components production at accessible costs. Unfortunately, this opportunity led to different design and production processes, requiring new digital capabilities compared to the existing ones. The second challenge refers to insource the production of smart objects (e.g., humidity sensors). This choice can benefit from economy of scale with existing production, enhancing the performances of Marlegno's remote monitoring of their buildings. Investments could be very high for the new production lines required and the new capabilities needed to design these products. Last, students should reflect on introducing c-level managers within Marlegno's organizational chart. The new manager should effectively promote and implement digital opportunities (i.e., CIO, Chief Information Officer). Such a role can enhance product production and service delivery by helping Marlegno understand using new digital technologies. On the other hand, conflicts with Marlegno's owners and existing IT figures could arise.

Appendix Table B.3 – Future challenges

DIGITAL OPPORTUNITIES		DIMENSIONS		
		Process innovation	Servitization	Organizational change
New technologies	Opportunities	Optimization of raw material consumption.	Customized components at accessible costs.	-
3D Printers	Threats	Different design and production processes.	-	New digital capabilities are needed.
New services	Opportunities	Economy of scope.	Enhance remote monitoring.	-
Production of smart objects	Threats	New production lines.	-	New capabilities are needed.
New c-level roles	Opportunities	Enhance existing production processes	Enhance existing services provided	Resources managerialization.

CIO		through a better understanding of the technologies used.	through a better understanding of the technologies used.	
	Threats	-	-	Conflicts with Marlegno's owners and existing IT figures.

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