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Structuring Servitization-Related Capabilities: A Data-Driven Analysis

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Abstract: The existing literature investigates organizational capabilities for servitization in exploratory studies based predominantly on interviews with managers. This has led to classification frameworks that tend to reflect managerial perceptions regarding key capabilities (rather than actual firm capabilities) and in which associations and connections between capabilities remain anecdotal. This study examines the servitization-related capabilities existing in manufacturing firms that have taken strategic service initiatives and adopts a data-driven approach to explore their underlying structure. A quantitative study based on secondary data from annual report narratives is used to assess the servitization-related capabilities of 79 firms from the aerospace and defense sector and to identify the underlying factors through exploratory factor analysis. The study identifies seventeen capabilities structured into five factors: (i) management of production/delivery operations; (ii) development of valuable and sustainable offerings; (iii) identification of incentives; (iv) planning for uncertainty and change; and (v) relationship management. The study provides evidence of servitization-related capabilities in practice. By examining gaps between existing (current) capabilities and the capabilities identified in our five-factor model, business managers of aerospace and defense firms can assess the status of servitization-related capabilities at their firms and set objectives to develop such capabilities further. The study contributes to the systematic development of a reasonable and parsimonious representation of organizational capabilities for servitization, which is statistically supported and validated through empirical data.

Keywords: servitization; capabilities; framework; structure

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1. Introduction

As product technologies continue to grow in sophistication and complexity, it will be almost impossible to maintain a competitive edge through product differentiation alone. For this reason, many manufacturing firms have shifted their business to services in addition to products—a trend often referred to as servitization or service transition [1–3]. The servitization approach involves manufacturers exploring service opportunities in the customer activity chain, expanding the boundaries of their activities and taking over service activities previously performed by the customers and/or third parties, such as product maintenance, operation, spare part management, process optimisation, certification, system integration, and financing. Based on recent surveys, 95% of B2B manufacturing companies plan to increase their service revenues [4] and 75% of those based in Europe expect delivering services to become a significantly bigger part of their business over the next few years [5].

However, despite servitization is regarded as playing a key role in the competitive stance and survival of manufacturing firms, individual firms may fail to take advantage of such opportunities due to insufficient organizational capabilities (e.g., [6]). Capabilities are widely interpreted as the foundation for the achievement of business success through the creation of value from the deployment of available resources [7]. They reflect a firm's ability to coordinate activities and make use of its resources to achieve desired goals. Implicit

in this interpretation is a recognition that, in order succeed in their service endeavors, manufacturing firms need to have the right capabilities [8]. The existence of specific organizational capabilities, or their development, is what allows firms to perform and manage the organizational processes necessary for their service business in ways that create customer value and confer competitive advantage [9].

The need to understand firm capabilities has been increasingly evident in the literature on servitization, becoming more explicit in the recent works of Raddats et al. [10] and Valtakoski and Witell [11]. A number of exploratory studies have discussed the capabilities required by manufacturing firms to successfully provide services, with several studies developing theoretical frameworks of servitization-related capabilities. With very few exceptions, most of these studies are exploratory in nature [11,12] and use case studies and interviews with managers to identify categories and typologies of organizational capabilities that are relevant to developing, selling and delivering services. Hence, while they represent managerial perceptions about different factors that influence service activities [10], prior works do not capture the capabilities existing within firms [13]. Moreover, the suggested theoretical frameworks tend to include a large number of capability items which are defined in isolation from one another [14], leading to the question about associations and connections among the identified capabilities. In view of these research gaps, the present study was set out to:

- Provide insights into the servitization-related capabilities existing within manufacturing firms that have taken strategic service initiatives;
- Contribute to a better understanding of the underlying structure of such capabilities.

These issues are investigated in a quantitative approach that aims to contribute to the systematic development of a parsimonious representation of servitization capabilities. To this end, the study adopts an existing framework which identifies a fairly comprehensive set of capabilities supposedly relevant to the provision of services by manufacturing firms. A subsequent quantitative study based on secondary data from annual report narratives is used to assess the presence of these capabilities within 79 publicly listed servitized firms from the aerospace and defence sector and to identify the underlying factors through exploratory factor analysis. This study thus addresses the call for deeper sample-based, empirical research into servitization-related capabilities (e.g., [11]).

The remainder of the paper is structured as follows. Section 2 reviews key literature on servitization-relevant capabilities and introduces the study's focus on activity-related capabilities. Section 3 outlines the data collection method, together with the theoretical framework adopted for the empirical study. Section 4 details the methodological approach taken to analyze the data and presents the results. Lastly, Section 5 discusses theoretical and managerial contributions of the study, limitations and potential directions for future research.

2. Background Literature

As discussed, the idea of capabilities has often been used as theoretical lens to explore how manufacturers achieve the transition to services. Drawing on established notions from the resource-based view, several studies have sought to identify sets of resources and capabilities that should underpin service endeavors. The underlying assumption is that capabilities determine a firm's level of efficiency and effectiveness in providing services [15]; that is, the more of them a firm possesses and is able to deploy, the greater the chances for successful service activities [16].

Early studies that drew attention to servitization-related capabilities focused on manufacturing firms wishing to become solution providers, offering integrated combinations of products and services as 'hybrid offerings' [17] that are tailored to address customers' specific needs. Davies [18] singled out four types of capabilities required to compete in the provision of solutions: system integration, operational services, business consulting, and financing. Few years later, Ceci and Prencipe [19] explored firm-related and environment-related contingency factors that may affect the relative importance of these capabilities.

Similarly, Ceci and Masini [20] addressed the fit between the aforementioned capabilities and three types of heterogeneity in the firm's operating environment. These early studies, then, referred to capabilities as well-specified destinations to be achieved in creating servitized offerings. Capabilities would concern the firms' abilities to deliver the constituting elements of a solution package (i.e., finished product, operation, consulting and financing), and developing novel combinations of such capabilities would create a differentiation advantage [18]. Subsequent research delineated the particular 'productive activities' [9] (p. 61) involved in the deployment of hybrid offerings, conceptualizing service capabilities as skill elements that help manufacturers perform those activities competitively. Storbacka [21] drew on a four-step solution process (develop—create demand—sell—deliver) to categorize relevant capabilities in the solution business. Huikkola and Kohtamäki [22] identified seven key capabilities that occur in different phases of solution development and deployment, whilst Ulaga and Reinartz [17] discussed critical capabilities along the categories of: data processing and interpretation, risk assessment and mitigation, design-to-service, hybrid offering sales, and hybrid offering deployment.

The role of capabilities has been increasingly emphasized also by the general literature on servitization, where existing studies recognize numerous important types of capabilities for successful service offering, such as partnering capabilities [23], network or ecosystem management capabilities [8,11,14,24,25], service development and innovation capabilities [9,13,16,25–28], service customization capabilities [11,14], risk assessment and mitigation capabilities [8,25], customer intimacy capabilities [15,25], culture change capabilities [25], business model design capabilities [24] and capabilities in digital technologies [14,29–32]. Within this literature, several categorization frameworks have been proposed, although most of them focus on only some particular capability blocks. Not surprisingly, given the general concern with ensuring that manufacturers achieve differentiation advantages through services, the predominant focus has been on service innovation capabilities that support the introduction and viability of new services. For example, Kindström et al. [26] suggests a framework of key micro-foundations for the successful realignment of the dynamic capabilities of sensing, seizing, and reconfiguring so as to achieve a better fit with service innovation activities. Kindström and Kowalkowski [16] use a business model framework to examine the unique capabilities that product-based firms should develop and deploy to pursue service innovation. Parida et al. [27] focus on the capabilities that allow manufacturers to develop effective service innovations for global markets, and Lütjen et al. [13] develop a framework of the capabilities that allow firms to leverage their ecosystem for service innovation.

Other research dwells upon the alignment between capabilities and elements of service offerings (that is, the question of what organizational capabilities are required for manufacturers that venture into specific types of services). However, whereas some early studies have sought out to explore the whole spectrum of service elements that manufacturers may include in their offers (e.g., [17,33]), the accounts of the more recent literature have mainly centered on the capability requirement for advanced services, which address complex customer needs and are focused on delivering specified outcomes [34]. For example, Story et al. [25] adopts a multi-actor perspective and identifies categories of complementary capabilities that manufacturers, customers and intermediaries should develop to support the implementation of advanced services. Similarly, in one of the very few quantitative studies in the area, Sjödin el al. [14] use fuzzy-set comparative analysis (fsQCA) to investigate the complementary, enhancing and suppressing effects of four capabilities leading to advanced services. Still more recent works have considered the capabilities that manufacturers should possess as providers of smart services. Hasselblatt et al. [35] identifies five strategic capabilities required for a manufacturer to operate as a provider of IoT solutions. Münch et al. [32] similarly investigate the capabilities required to offer smart product-service systems and adopts socio-technical systems theory to organize them in a structured framework. Likewise, Huikkola et al. [36] examines the dynamic capabilities that facilitate strategic change from selling products to providing smart solutions.

Other recent works have considered the process of capability development. Importantly, these studies have suggested that several dynamic and operational capabilities for servitization can be developed interactively with suppliers and customers [8] and have indicated that a sequential approach to capability development (i.e., first building front-office instead of back-office service capabilities is potentially best suited for both SMEs [11] and global manufacturers) [12].

Undoubtedly, the extant literature proposes a multitude of servitization-related capabilities. Besides the explorative approach, one possible reason for this may be also that research so far has considered servitization capabilities across multiple 'hierarchical levels' [15]. Referring to Grant [37], organizational capabilities can be arranged into a hierarchy based on their level of specialization. This hierarchy spans across various organizational functions and includes several levels, starting with task-specific capabilities (at the bottom of the hierarchy) and continuing upwards with specialized, activity-related, functional and cross-functional capabilities. Lower level capabilities are progressively aggregated and integrated into higher level capabilities. While prior research on servitization tends to discuss capabilities across multiple hierarchical levels [15] (p. 158), we chose to focus exclusively on activity-related capabilities, which are mid-level in the hierarchy. By doing so, we ensure that the studied capabilities, of which we sought to establish associations and connections, do not overlap with each other. Unlike task-specific and specialized capabilities, activity-related capabilities are not specific to particular end products or services. Accordingly, we regard servitization capabilities as abilities that are important to service provision but are not necessarily exclusive to it; that is, they may, at least in principle, apply as well to product activities.

3. Research Method

3.1. Theoretical Framework

The measurement items used in the empirical study are reported in Table 1. They were drawn from an existing framework, which was developed in the context of a multi-year study (by combining insights from the literature with interviews with senior managers at twelve leading servitized manufacturing firms) and adopted in previous research [38]. We selected this framework since it offers a comprehensive list of pertinent capabilities, grounded in research results and in the literature. Nevertheless, the framework could be adapted to develop a list of measurement items aligned with our research goals.

Table 1. Operationalization of servitization capabilities (adapted from Benedettini et al. [38]).

Category	Item Description
ECOSYSTEM AWARENESS—EA	
How well does the company know the members of its ecosystem?	
Customer perspective	Understanding of current/potential customers and their business models—EA1
Partner perspective	Understanding of current/potential partners and the role that they play in the ecosystem—EA2
Influencer perspective	Understanding of groups and institution that influence customers, partners, suppliers and competitors—EA3
How well does the company understand the economics of its ecosystem?	
Value creation perspective	Understanding of who creates value in the ecosystem (and how this is likely to evolve over time)—EA4
Value capture perspective	Understanding of who captures value in the ecosystem (and how this is likely to evolve over time)—EA5
Power perspective	Understanding of where power lies in the ecosystem and what this implies for the ability to capture value—EA6

Table 1. *Cont.*

Category	Item Description
How well does the company understand the dynamics of its ecosystem?	
Dynamics perspective	Understanding of how the ecosystem is evolving (and who has the potential/interest to influence the direction of evolution)—EA7
Skills and assets perspective	Understanding of which skills and assets are in short supply in the ecosystem (and who controls access to these skills and assets)—EA8
Competition perspective	Understanding of where competition is most intense in the ecosystem—EA9
VALUE PROPOSITION—VP	
How well does the company understand its client's business model and the broader ecosystem?	
Value creation perspective	Understanding of how customers (and other significant ecosystem organizations) create value—VP1
Value capture perspective	Understanding of how customers (and other significant ecosystem organizations) capture value—VP2
Constraints perspective	Understanding of the constraints that customers (and other significant ecosystem organizations) face as they seek to create and capture value—VP3
How clearly can the company articulate its value proposition and the associated benefits?	
Customer recognition perspective	Clearly defined value proposition that customers (and other significant ecosystem organizations) understand—VP4
Internal recognition perspective	Clearly defined value proposition that is accepted and embraced within the organization—VP5
Cost perspective	Value proposition that is demonstrated to provide a cost-effective solution to customer problems—VP6
Has the company clearly and unambiguously demonstrated its delivery skills in relation to the value proposition?	
Customer confidence perspective	Ability to deliver the value proposition recognized by customers (and other significant ecosystem organizations)—VP7
Demonstrated capability perspective	Use of contracts allowing to demonstrate the ability to deliver even richer value propositions—VP8
Pilot capability perspective	Pilot projects allowing to demonstrate the ability to deliver even richer value propositions—VP9
VALUE DELIVERY—VD	
How well has the company defined its value proposition and designed the value delivery system?	
Internal capability perspective	Understanding of the internal capabilities required to deliver the value proposition (and how they are likely to evolve over time)—VD1
Ecosystem capability perspective	Understanding of the capabilities needed by ecosystem partners to support the delivery of the value proposition—VD2
Technology perspective	Understanding of the technologies required to deliver the value proposition (and how they are likely to evolve over time)—VD3
How well has the company identified partners and developed appropriate governance mechanisms?	
Partnership perspective	Ability of ecosystem partners to support the delivery and enhancement of the value proposition—VD4
Trust perspective	Trusted relationships with ecosystem partners involved in the delivery of the value proposition—VD5
Governance perspective	Governance mechanisms in place that encourage cooperation among the ecosystem partners involved in the delivery of the value proposition—VD6
How well does the company coordinate multi-party delivery?	
Incentive perspective	Internal incentives in place that encourage cooperation among those involved in the delivery of the value proposition—VD7
Partnership perspective	Fair and clear dealings with ecosystem partners involved in the delivery of the value proposition—VD8
Cultural perspective	Shared culture within the organization designed to support the delivery of the value proposition—VD9

Table 1. *Cont.*

Category	Item Description
ACCOUNTABILITY SPREAD—AS	
How well does the company understand the risks associated with its value delivery system?	
Performance risk perspective	Understanding of the overall performance risk inherent in the value delivery system—AS1
Financial risk perspective	Understanding of the overall financial risk inherent in the value delivery system—AS2
Long-term risk perspective	Understanding of the dynamic, long-term risk inherent in the value delivery system—AS3
How good are the company's systems for measuring and quantifying risks?	
Measurement perspective	Use of measures for quantifying risk in the value delivery system—AS4
Data access perspective	Access to the data needed to measure risk in the value delivery system—AS5
Data quality perspective	Confidence in the quality of data used to measure risk in the service delivery system—AS6
How well does the company price and flow risk to its ecosystem partners?	
Risk ownership perspective	Understanding of who is the best owner of risk in the value delivery system—AS7
Risk pricing perspective	Use of methods for articulating and pricing the risk inherent in the value delivery system—AS8
Risk mitigation perspective	Understanding of how the risk inherent in the value delivery system can be mitigated—AS9

This adaptation was necessary due to the fact that, as outlined above, our study focuses on activity-related capabilities which are relevant to the service business but may, at least in principle, apply also to manufacturers' product business. More specifically, we did non focus on specialized and task-specific capabilities that deal exclusively with service provision, but on capturing more generic capabilities and skills that firms may also be able to particularize and adapt to the provision of physical products. Therefore, for example, a capability item that in the original framework reads as 'We have a deep understanding of the technologies required to deliver the service value proposition and how these technologies will evolve over time' was changed as 'Understanding of the technologies required to deliver the value proposition (and how they are likely to evolve over time)'. That is, we adapted the original capability item assuming that firms do not need differentiated activity-related abilities in order to identify, implement and exploit the technological options that are available to support the delivery of products and services. If a firm is able to understand and align with technological developments, such ability will likely apply to both product and service provision. As this example also illustrates, the adaptation of the original framework involved the rewording of certain capability items in order to simplify interpretation.

At the highest level, the framework consists of four broad categories of capabilities. It suggests that, when adopting a servitized business strategy, manufacturing firms need to innovate their *value proposition*, creating new or extended value for their customers. They do so in the context of a broader *ecosystem*, that they need to understand and leverage. To deliver the value proposition to the customers, they also often need to engage ecosystem partners, creating networks of firms with shared or pooled resources; therefore, they find it necessary to innovate their *value delivery* system. Importantly, if there is innovation in both the value proposition (offering new or extended customer value) and in the value delivery system (engage ecosystem partners in delivering this value), manufacturers are likely to increase their risk or *accountability spread*; that is, they take on more responsibility for customer outcomes, while at the same time reducing their direct control over the resources needed to deliver these outcomes. These four broad categories of capabilities—value proposition, ecosystem awareness, value delivery and accountability spread—are further detailed into twelve bundles of capabilities and 36 individual capabilities. For example,

the ecosystem awareness category includes three bundles of capabilities, tapping into the firm's knowledge of the members of the ecosystem, the firm's understanding of the economics of the ecosystem, and the firm's understanding of the dynamics of the ecosystem (cf. Table 1). Each bundle is composed of three capability items, for a total of twelve individual capabilities making up the ecosystem awareness category. For example, the firm's knowledge of the members of the ecosystem consists of capability items reflecting the firm's knowledge of customers, of partners, and of other influential actors in the ecosystem.

3.2. Data Collection

3.2.1. Sample Selection

The empirical context for this study is the global aerospace and defense industry. Employing a single industry context minimizes potential confounds across multiple industries (e.g., different ecosystem structures, varying competitive pressures) [39,40]. The aerospace and defense sector represents a leading exemplar of the trend towards servitization, as the complexity, high unit cost, and long life of the manufactured equipment can be exploited to drive robust and smooth revenue streams from advanced forms of customer support offerings [41,42]. Therefore, the aerospace and defense industry provides a research setting in which the development of servitization-related capabilities is likely to be important. The primary industry of operation was used to search in Capital IQ for public firms from the aerospace and defense sector. The criterion of larger than 100 employees in size was used to ensure that the firms had strategized service activities. The resulting sample included 138 US and non-US firms.

3.2.2. Data Collection Methodology

Information was sought about the framework capabilities by content analyzing the firms' 10-K or annual report narratives. The 10-K filing or annual report provides a comprehensive overview of a firm's undertakings, achievements and performance during the fiscal year and is a primary source of information for shareholders, investors and other observers. Investors and financial analysts, in particular, study and analyze 10-Ks and annual reports to understand the business strategies, resources and future prospects of the firm. Annual reports are considered an objective, accurate and reliable source of information [43]. Thus, any reference to service-related capabilities in the 10-K or annual report is likely to be important to the firm [41]. However, 10-K and annual report narratives are often unstructured, and extracting information from them is time-consuming and difficult. Therefore, a systematic content analysis was adopted to identify servitization-related capabilities in an accurate and effective way.

This technique helps researchers convert empirical content into theoretical concepts [22] and make 'inferences by objectively and systematically identifying specified characteristics of message' [44,45]. As a methodological approach, it gained legitimacy in management research during the 1980s for systematic evaluation of the information contained in corporate documents [46] and for drawing inferences from the textual communications of managers [47]. Although rarely used in service research, the content analysis method has become increasingly popular in various fields of supply chain and logistics research. Other business disciplines, including strategy, organizational behavior and marketing, have also leveraged content analysis tools and techniques to examine various research topics [48], such as the modification of marketing and innovation activities in response to past stock returns and volatility (e.g., [49]), discursive legitimation in merger processes (e.g., [50]) and management of media reaction after firms' wrongdoings (e.g., [51]). Given its ability to uncover evidence embedded in textual documents [45,48], content analysis was a logical choice for converting annual report narratives into the data needed for the present study.

3.2.3. Data Collection Execution

Although multiple sources were consulted (Capital IQ database, SEC website, company websites, email/telephone contact), the annual report was not available for all compa-

nies. Some companies simply didn't have an English version of their annual report, or only reported financial data. This reduced the sample size from 138 to 94 companies.

Capital IQ long business descriptions were then examined to understand if the companies were servitized. Benedettini and Neely [41] identified 15 categories of services that aerospace and defense companies may offer. The companies were classified as servitized if their business description provided explicit evidence that they offered one or more of these service categories to end customers. For some companies, for which Capital IQ did not provide the long business description, the information was gathered from corporate websites. At this stage, it became evident that the sample included eight companies that offered no services, (i.e., eight non-servitized manufacturers). These were removed from the sample. Nevertheless, seven companies were identified as pure service providers (i.e., companies with no manufacturing operations) and therefore also eliminated.

The content analysis was conducted with the coding software Wordstat 7 (Provalis Research, Montreal, Canada). When supported by a software tool, the content analysis methodology entails developing and applying a 'concept dictionary' of search terms, on the basis of which words are extracted from the text and presented to the analyst [52]. A wide range of search terms was selected to enable the location of the servitization-related capabilities in the companies' annual reports. These included identifiable synonyms and alternative terminology/spelling for each search term. Appropriate 'rules' were defined based on closeness of key terms within documents so as to get more accurate hits. The complete concept dictionary included 994 specifications of search terms, organized into 119 rules. The content analytic software identified the occurrences of the search terms in the annual reports. These were manually reviewed to confirm the contextual meaning, removing all irrelevant uses and occurrences relating to forward looking statements, risk factors, duplicates and negative connotations. Examples of hits that were retained after this screening are:

> "*We anticipate increasing competition in our core markets as a result of continued defense industry consolidation, including cross-border consolidation of competition, which has enabled companies to enhance their competitive position and ability to compete against us*".

(Safran SA) for capability EA7: Understanding of how the ecosystem is evolving (and who has the potential/interest to influence the direction of evolution);

> "*Taranis was designed to demonstrate the Group's ability to create a system capable of undertaking sustained surveillance, marking targets, gathering intelligence and carrying out strikes in hostile territory*".

(BAE Systems plc) for capability VP9: Pilot projects allowing to demonstrate the ability to deliver even richer value propositions;

> "*Our success also depends on our ability to provide the people, technologies, facilities, equipment and financial capacity needed to deliver those products and services with maximum efficiency*".

(Northrop Grumman Corporation) for capability VD1: Understanding of the internal capabilities required to deliver the value proposition (and how they are likely to evolve over time).

> "*We believe that we have adopted appropriate measures to mitigate potential risks to our technology and our operations from these information technology-related and other potential disruptions*".

(United Technologies Corporation) for capability AS9: Understanding of how the risk inherent in the value delivery system can be mitigated.

While qualitative content analysis would examine reference vs. non-reference to each servitization-related capability, quantitative content analysis requires to consider the frequency of reference to each capability; i.e., the number of times the capability is

referred to in the text [53–55]. In line with the quantitative approach, the content analysis identified the frequency of reference to each servitization-relevant capability. Previous applications of quantitative content analysis on annual report narratives have deemed the frequency of reference to a specific concept to be a true indicator of the intensity of that concept at the firm (e.g., [56]). Therefore, we assumed that the number of mentions of each servitization-related capability indicates the level of that capability possessed by the firm.

4. Results

4.1. Exploratory Factor Analysis (EFA)

The analysis began with the original 36 items. Three items (EA6, VD8 and AS6) were excluded since the content analysis found no reference to them in the annual reports of the sample companies. Two items (VD2 and AS5) were further excluded due to there being no correlations with other items in excess of |0.3| [57,58]. An exploratory factor analysis was performed on the remaining items. Principal axis was employed as an extraction method to allow for departure from multivariate normality in the data [59,60]. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy did not achieve the recommended threshold of 0.5 for all items [61]. Thus, the items with the smallest MSA values were deleted one at a time and the factor analysis was rerun until all items achieved MSA values above the threshold of 0.5 [57]. This led to the deletion of twelve items (VD5, VP1, VP2, EA8, VP3, EA1, AS8, EA4, EA2, AS3, EA9, EA3). The remaining set of items demonstrated acceptable KMO values for the overall test (0.579) as well as each individual item. Examination of partial correlations—equal to 0.404 and 0.340 for items VP4 and AS1, respectively, and below 0.3 for all other items—also indicated that 'true' factors existed in the data [57,58]. In addition, the result of the Bartlett's test of sphericity (Chi-Square = 412.235, $p = 0.000$) [62] confirmed that the use factor analysis was appropriate [57,58].

The common Latent Root Criterion (Guttman-Kaiser rule) suggested retaining four factors for rotation (eigenvalues > 1) [57,58,63,64]. However, this technique has been found not to be always reliable [60,63,65,66]. In particular, as noted by Hair et al. [57], if the number of variables is less than 20, the tendency is for this technique to extract too few factors. Examination of the scree plot [57–60] indicated the presence of five factors in the data. The five-factor solution also coincided with the minimum number of factors that achieved a cumulative percentage of total variance explained exceeding 100 per cent (due to the use of principal factor extraction, some negative eigenvalues were generated) [67]. Combining these results together [57,60,65,66] led to the decision to retain five factors for interpretation.

An oblique rotation method (oblimin) was applied to foster the interpretability of the extracted factors. Oblique rotation has been proven to outperform orthogonal rotation in avoiding that potential inter-correlation among the factors may produce a solution that distorts factor loadings away from simple structure [59,63,65]. Further to the rotation, item VP8 and item VD7 were excluded from the analysis due to loadings on all factors below the minimum requirement of 0.4 [68–71] All of the remaining items loaded onto a factor with a minimum factor loading of 0.464. Also, there were no cross-loading items that loaded at 0.4 or higher on more than one factor [59]. Communalities of all items were at acceptable levels ($\geq$0.3) [58,72,73]. The final factor solution, which comprises a respectable 17 of the original 33 items, is presented in Table 2.

As shown in Table 2, the five factors demonstrated satisfactory internal consistency. Cronbach's alphas ranged from 0.628 to 0.7, exceeding the generally agreed lower limit of 0.6 for exploratory research [57,74–77]. Similarly, the factor solution resulted in adequate item-total correlations and inter-item correlations. For all items, the item-total correlation surpassed the recommended cut-off value of 0.3 [78] whereas the mean inter-item correlation was larger than the recommended minimum of 0.2 [79].

Table 2. Results of the exploratory factor analysis.

Item	Factor and Item Description	Factor Loading	Communality	Cronbach's Alpha	Item-Total Correlation	Mean Interitem Correlation
	Factor 1: MANAGEMENT OF PRODUCTION/ DELIVERY OPERATIONS			0.673		
VD9	Shared culture within the organization designed to support the delivery of the value proposition	0.745	0.560		0.623	0.242
AS4	Use of measures for quantifying risk in the value delivery system	0.464	0.310		0.378	0.389
AS7	Understanding of who is the best owner of risk in the value delivery system	0.537	0.450		0.307	0.437
AS9	Understanding of how the risk inherent in the value delivery system can be mitigated	0.637	0.480		0.534	0.292
	Factor 2: DEVELOPMENT OF VALUABLE AND SUSTAINABLE OFFERINGS			0.700		
VP6	Value proposition that is demonstrated to provide a cost-effective solution to customer problems	0.643	0.419		0.525	0.344
VP7	Ability to deliver the value proposition recognized by customers (and other significant ecosystem organizations)	0.737	0.555		0.577	0.313
VD1	Understanding of the internal capabilities required to deliver the value proposition (and how they are likely to evolve over time)	0.613	0.468		0.478	0.373
AS1	Understanding of the overall performance risk inherent in the value delivery system	0.472	0.320		0.368	0.446
	Factor 3: IDENTIFICATION OF INCENTIVES			0.699		
EA5	Understanding of who captures value in the ecosystem (and how this is likely to evolve over time)	0.639	0.437		0.466	0.502
VP4	Clearly defined value proposition that customers (and other significant ecosystem organizations) understand	0.754	0.577		0.621	0.307
VP9	Pilot projects allowing to demonstrate the ability to deliver even richer value propositions	0.568	0.498		0.466	0.502
	Factor 4: PLANNING FOR UNCERTAINTY AND CHANGE			0.628		
EA7	Understanding of how the ecosystem is evolving (and who has the potential/interest to influence the direction of evolution)	0.488	0.460		0.429	0.370
VD3	Understanding of the technologies required to deliver the value proposition (and how they are likely to evolve over time)	0.644	0.442		0.531	0.243
AS2	Understanding of the overall financial risk inherent in the value delivery system	0.477	0.400		0.358	0.467

Table 2. *Cont.*

Item	Factor and Item Description	Factor Loading	Communality	Cronbach's Alpha	Item-Total Correlation	Mean Interitem Correlation
	Factor 5: RELATIONSHIP MANAGEMENT			0.638		
VP5	Clearly defined value proposition that is accepted and embraced within the organization	0.539	0.300		0.440	0.378
VD4	Ability of ecosystem partners to support the delivery and enhancement of the value proposition	0.596	0.377		0.473	0.337
VD6	Governance mechanisms in place that encourage cooperation among the ecosystem partners involved in the delivery of the value proposition	0.615	0.432		0.428	0.394

4.2. Confirmatory Factor Analysis (CFA)

A confirmatory factor analysis was conducted to validate the factor model [60]. Although the *p*-value for the model was below the threshold of 0.05, other fit indexes suggested that the model provided an adequate fit to the data (χ^2 (d.f.) = 155.64 (109), RMSEA = 0.074, SRMR = 0.086) [57,63]. Specifically, the normed χ^2 (χ^2/d.f.) was less than 3 [57,80,81], RMSEA was less than 0.08 [57,82–85], and SRMR was less than 0.1 [57,85]. Additionally, CFI and TLI were satisfactorily close to one (CFI = 0.820, TLI = 0.775), again suggesting an adequate model fit [58,83].

As Table 3 shows, all individual items' standardized coefficients from the measurement model were highly significant and 15 of the total 17 coefficients where greater than 0.5, in support of convergent validity of the factor structure [57,70,86]. The correlation matrix (Table 4) shows that none of the correlations between factors exceeded the 0.85 threshold, thus indicating that the factor model achieved adequate discriminant validity [63]. In addition, the square root of the average variance extracted (AVE) for each factor was larger than the correlations with other factors, confirming that the factors shared more variance with their measuring items than with other factors in the model [86–88]. Finally, the composite reliability scores of all factors (Table 3) were higher than the recommended value of 0.6, demonstrating internal consistency [57,89].

4.3. The Final Factor Model

The empirical findings suggest that the profile of servitization-relevant capabilities in manufacturing companies from the aerospace and defense sector encompasses five core dimensions. The first dimension includes four capabilities, i.e., (i) development of an organizational culture supporting the delivery of the value proposition, (ii) assessment of risk inherent in the value delivery system, (iii) understanding of who is the best owner of such risk, and (iv) of how such risk can be mitigated. As this dimension covers capability items referring to the firm's ability to plan and manage operational activities, we label it as 'management of production/delivery operations'. The second dimension includes such capabilities as: (i) development of a value proposition providing a cost-effective solution to customer problems; (ii) achievement of external recognition for the ability to deliver the value proposition; (iii) understanding of internal skills and resources required to deliver the value proposition over time; and (iv) of the overall performance risk inherent in the value delivery system. As this dimension covers the content and viability of the value offering, we labelled it as 'development of valuable and sustainable offerings'. The third dimension incorporates three capabilities, referring to: (i) understanding of current/future value capture mechanisms within the company's ecosystem; (ii) clarity of the value proposition for customers and other significant ecosystem organizations; and (iii) running pilot projects

to demonstrate the company's ability to provide even richer value propositions. As these capabilities focus on outlining incentives for customers and other ecosystem organizations involved with the firm's service activities, we classified them as 'identification of incentives'. The fourth dimension incorporates (i) understanding of how the ecosystem is evolving and who may influence the direction of evolution; (ii) understanding of the technologies required to deliver the value proposition and how they are likely to evolve over time; and (iii) understanding of the overall financial risk inherent in the value delivery system. We classified these capabilities as 'planning for uncertainty and change'. Finally, the fifth capability dimension incorporates: (i) acceptance and embracing of the value proposition within the organization; (ii) ability of ecosystem partners to support the delivery and enhancement of the value proposition; and (iii) introduction of governance mechanisms to encourage cooperation among ecosystem partners involved in the delivery of the value proposition. Such capabilities focus on coordinating efforts of internal and external actors and were thus defined as 'relationship management' capabilities.

Table 3. Results of the confirmatory factor analysis.

	Factor	Item	Standardized Coefficient	Average Variance Extracted (AVE)	Composite Reliability (CR)
Factor 1	MANAGEMENT OF PRODUCTION/ DELIVERY OPERATIONS	VD9 AS4 AS7 AS9	0.735 *** 0.521 *** 0.348 ** 0.753 ***	0.589	0.689
Factor 2	DEVELOPMENT OF VALUABLE AND SUSTAINABLE OFFERINGS	VP6 VP7 VD1 AS1	0.646 *** 0.774 *** 0.619 *** 0.413 ***	0.613	0.712
Factor 3	IDENTIFICATION OF INCENTIVES	EA5 VP4 VP9	0.591 *** 0.782 *** 0.641 ***	0.671	0.679
Factor 4	PLANNING FOR UNCERTAINTY AND CHANGE	EA7 VD3 AS2	0.669 *** 0.583 *** 0.547 ***	0.599	0.642
Factor 5	RELATIONSHIP MANAGEMENT	VP5 VD4 VD6	0.571 *** 0.652 *** 0.602 ***	0.608	0.638

** $p < 0.05$, *** $p < 0.01$. Fit indices: χ^2 (d.f.) = 155.64, d.f. = 109, RMSEA = 0.074, SRMR = 0.086, CFI = 0.820, TLI = 0.775

Table 4. Discriminant validity of the factor model.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Factor 1	(0.767)				
Factor 2	−0.172	(0.782)			
Factor 3	−0.007	−0.086	(0.819)		
Factor 4	−0.507	0.233	0.626	(0.773)	
Factor 5	−0.205	−0.053	−0.118	0.262	(0.779)

Diagonals in parentheses are square roots of the average variance extracted from observed variables (items); Off diagonals are correlations between factors.

4.4. Interpretation of the Factor Model

Figure 1 illustrates the factor model.

Issues concerning the organization and management of service operations are mentioned frequently in the servitization literature [90,91] and several studies have highlighted that manufacturing firms need operations management capabilities in order to improve the quality and reduce the costs of service operations and processes (e.g., [11,17,92]). The first dimension in our model identifies relevant operations management capabilities in two areas. The first area refers to the organization's culture. Corporate culture influences the

values and behaviors of employees [93]. A service-oriented culture has been frequently discussed in the literature as key to encourage service personnel to adapt service processes to the needs, problems and issues of individual customers [94]. A service-oriented culture also facilitates the strong integration among back-office and front-office service units necessary for achieving cost-efficiency without compromising the ability to offer service excellence and customization [90]. The second capability area captured by the operations management dimension of our model refers to risk management. The presence of three capability items in this area strongly reflects the aerospace and defense context of the study sample. Typically, aerospace and defense customers ask for availability-based service contracts where through-life support of high-technology, complex and long-life products/equipment is contracted out on an availability basis [42]. Such contracts involve significant operational risks that service suppliers need to take on and manage as an integral part of the offering [95]. The capability items in this area indirectly capture also the complexity of service delivery operations in the aerospace and defense sector [96], which requires servitized manufacturers to co-operate with service partners, and hence to elaborate ways to share and distribute operational risks.

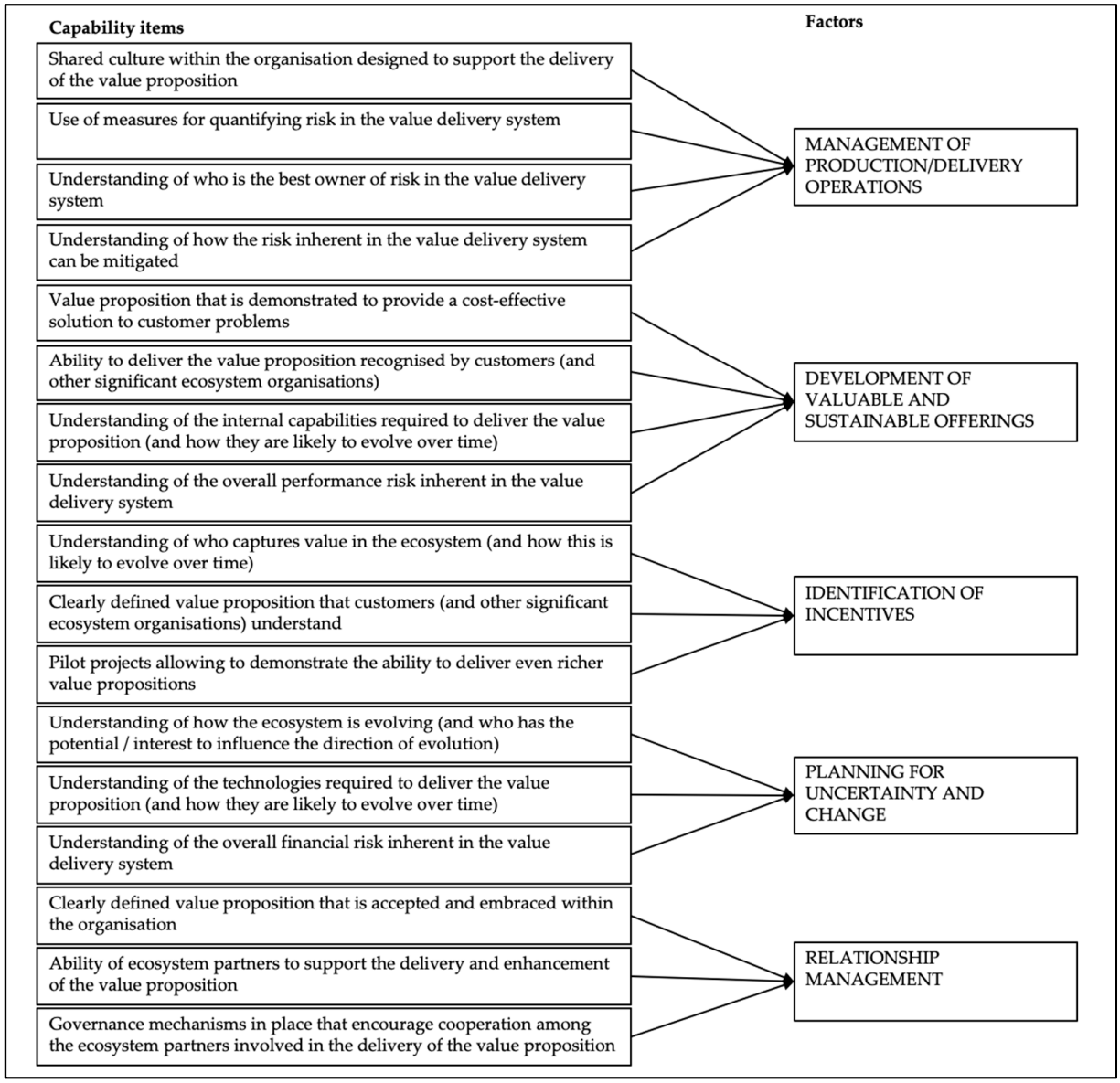

Figure 1. Illustration of the factor model.

The importance for a company to devise value propositions that provide effective customer value is not a new insight. The second dimension in our model, focusing on capabilities related to the design of value offerings, confirms this importance for servitized firms. As observed by Johnstone et al. [97], aerospace and defense manufacturers especially need to understand value through the eyes of the customers so as to develop products and services as seamless, comprehensive and largely customer-specific propositions. Intriguingly, this dimension further includes three capability items that point to the firm's capacity to sustain or "afford" the delivery of the value proposition. As previously outlined, in the aerospace and defense industry, servitized manufacturers often have to take responsibility for complex service performance, as well as providing high-technology products. Achieving standardization and efficiency is particularly difficult in such circumstances, and lack of specific competences and resources may jeopardize the firm's ability to deliver the contract value proposition [97]. Nevertheless, it is worth noting that one of the three capability items refers to a perceptual dimension of value [98]; that is, the firm's ability to gain the trust of customers (and of other actors in the service network) in the viability of its value proposition. Penttinen and Palmer [99] identify this ability as playing an important role in the transition from product sales to total-service contracts such as those that are often implemented in aerospace and defense [96].

The capability items collectively constituting the third dimension of our model point to alignment of incentives. Prior research underscores that servitized manufacturers struggle with differences between service-based value creation and traditional sale of products [100]. Scholars have highlighted that, as a consequence, servitized manufacturers need to explicitly define and demonstrate how their offerings would create value for customers and other relevant actors in order to incentivize them to embrace such offerings [72]. In aerospace and defense contracting, incentives are used to ensure that the objectives of the actors involved are aligned [95]. In this respect, the capability to establish pilot projects may help develop and sustain customer trust and similar relationships with other parties. Likewise, pilot projects and clearly defined value propositions may encourage customers and other actors to experiment with new offerings and approaches [101].

The fourth dimension in our model, concerning issues of uncertainty and change, conveys the notion that servitized companies from aerospace and defense operate in complex and dynamic environments, and need explicit capabilities to deal with this. According to our model, three factors are responsible for the capability challenges in this area. The first factor concerns the high technological requirements and technological commoditization that characterize the sector [97]. Technological developments in both products and service technologies can increase the capabilities of servitized providers and, if adequately exploited, can positively influence their operations and value delivery strategies [95]. However, they also introduce risks of rapid obsolescence of products and digital services. The second factor reflects the complex and highly regulated business environment. Servitized companies need to be proactive and flexible in order to keep up with such things as changes in procurement policies of military and commercial clients, regulatory requirements, demand trends, and changes in availability of productive resources [97]. The third factor recalls the service delivery uncertainty that may be driven by service operations that are difficult to standardize and require input from multiple parties [95]. Since service performance depends on the outcome as well as the process of service delivery, understanding this uncertainty plays a key role in the formulation of the service strategy.

Finally, the fifth dimension in our model captures the well-known issue of managing internal and external relationships. This study's findings align with the literature suggesting that servitized companies need to achieve internal coordination (e.g., [16,102]), for example between the sales and field service departments. Clearly, when employees understand the value proposition as a whole and where they fit into the delivery effort, they are encouraged to think outside their functional role and increase their cooperation and interaction with other functional areas [97]. Likewise, an important managerial challenge is the coordination and prioritization of relationships with external partners contributing

the delivery of the value proposition. Poor decisions regarding partner selection have been previously identified as a potential cause of failed servitization [103–105]. Our findings confirm the relevance of a firm's ability to select partners that complement the firm's own competences in a fruitful way [106]. As one would expect given the aerospace and defense context of the study, and the associated intricate contractual settings of service provision, our model further outlines that relevant external coordination capabilities further involve the ability to establish relationship governance arrangements with business partners. Sjödin et al. [107] remark that these governance arrangements, relying on either structural or social mechanisms, define how service partners should behave in the customer relationship and are crucial to manage service processes for effectiveness, productivity and low transaction costs.

5. Discussion and Conclusions

5.1. Theoretical Contribution

The study makes the following contributions to the literature. First, we extend the existing literature on servitization by providing empirical evidence of servitization-related capabilities in practice. With few recent exceptions using surveys [11,13,14], previous research into the capabilities that are needed by manufacturing firms to effectively manage a service business has been based on case studies and interviews with managers. Previous research, therefore, relies on managerial perceptions about the abilities and skills that should underlie service provision. Our study, instead, assesses capability constructs using secondary data from annual report narratives and hence it captures the capabilities existing within manufacturing firms that have moved into service provision. We found evidence referring to 33 of the 36 capability items in our original framework. Therefore, our results add to the findings of Valtakoski and Witell [11] by showing that servitization capabilities can be operationalized and measured also using secondary data. Second, by exploring the underlying structure of our empirical data, we contribute to prior literature in relation to structuring servitization-relevant capabilities. While the extant literature discusses servitization capabilities comprehensively and provides several classification frameworks, these are based on associations and relationships between capabilities that remain anecdotal. Such frameworks have been extremely valuable in advancing theoretical development, but they tend to be heterogeneous and complex, as they include a large number of capability items which are defined in isolation from one another [14]. A distinct contribution of our study is therefore the achievement of a parsimonious representation of servitization capabilities, which is statistically supported and validated through empirical data. In this representation, servitization capabilities in manufacturing firms are comprised of five factors: (i) management of production/delivery operations; (ii) development of valuable and sustainable offerings; (iii) identification of incentives; (iv) planning for uncertainty and change; and (v) relationship management. We contend that these factors should be considered the backbone of service capabilities for manufacturing firms from the study's industrial sector.

5.2. Managerial Contribution

The results of this study also have managerial implications. The presented five-factor model and its capability items can serve as a managerial navigator to assess the current status of servitization capabilities and prioritize development activities. By examining gaps between existing (current) capabilities and the capabilities appearing in the model, business managers at aerospace and defense firms can analyze the maturity of their firms for services and, more importantly, set objectives to develop their service capabilities further. As prior interview-based studies demonstrate, there are many capabilities that managers within manufacturing firms may think to address in their strategic initiatives for service business development. Our findings indicate on which capability areas managers of servitized aerospace and defense firms should concentrate their attention and resources. In particular, managers should address the management of production/delivery

operations through developing a supportive organizational culture and the ability to assess, allocate and manage operational risks. They should also steer their strategic initiatives towards the achievement of valuable and sustainable offerings through developing an externally recognized ability to build a value proposition that addresses customer needs, in parallel with an ability to understand the internal capabilities and the risks involved in delivering such value proposition. In addition, managers should concentrate on outlining incentives for customers and other ecosystem organizations through developing the abilities to understand current/future value capture mechanisms within the ecosystem, to define a value proposition that is widely understood within the ecosystem, and to run pilot projects demonstrating the viability of even richer value propositions. Business managers should also give attention to planning for uncertainty and change through developing the abilities to understand how their ecosystem and the technologies involved in the delivery of the value proposition may evolve, and to understand the financial risks involved in the value delivery system. Likewise, managers should address the management of internal and external relationships through developing the abilities to disseminate the value proposition within the organization, to involve ecosystem partners that may support the delivery/enhancement of the value proposition, and to set-up governance mechanisms encouraging ecosystem-wide cooperation in value delivery. Second, the five-factor model can help managers of aerospace and defense firms divide servitization-related capabilities into logical groups. This assessment is useful for understanding the rationale for developing, acquiring or maintaining individual capabilities, as well as for evaluating substitutive and complementary relationships among capabilities when service business development activities are strategized.

5.3. Limitations and Future Research Opportunities

As with all research, this study carries some limitations. First, we examine servitization-relevant capabilities in the context of a single industry. Care must be taken in generalizing our results to any servitized manufacturer. Our results are based on a sample of firms from the aerospace and defense industry, where the adoption of digital technologies, outcome-based contracts and multi-party service delivery is taking center stage in service provision, and which may be different from other, for example, less technological and less demanding industries. A natural progression would be a replication in other situations and/or industries yielding different specificities and offering a noteworthy contrast to our empirical context. Hence, firms from other manufacturing industries should be included in future studies to determine whether our model of servitization capabilities is replicable to other settings, or whether different capabilities emerge. Second, based on extant literature, we make the implicit assumption of a causal link between servitization-related capabilities and firm performance. However, future research could test the capabilities in our model to determine whether they actually lead to improved firm performance. Relatedly, by combining capability measures with performance measures, future research could also evaluate which of the capability groups are more important to firm performance. Finally, from a methodological perspective, we followed several previous studies (e.g., [108–110]) and performed the CFA on the same sample as the initial EFA which identified our capability factors. While the limited size of the available data did not permit to adopt a split-sample approach, we acknowledge that it is generally more sensible to use different samples for EFA and CFA.

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