

Servitization and digitalization in manufacturing: the influence on firm performance

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Abstract

Purpose – This paper aims to present a comprehensive framework that integrates the emerging trends of servitization and digitalization in manufacturing. The influence between digitalization and servitization is defined and quantified. Their contribution to firm performance is analyzed.

Design/methodology/approach – This paper presents a theoretical model that captures the relationships between the analyzed variables. Drawing on the Spanish Business Strategy Survey, hypothesis testing is conducted using data on 828 Spanish industrial firms. Linear regression models are built to capture the effect of each variable on firm performance and the type of interaction between the variables.

Findings – Servitization and digitalization are positively related to firm performance. Digitalization positively mediates the relationship between servitization and firm performance. The mediating effect of digitalization contributes to differentiating between the direct and indirect effects of servitization on firm performance.

Practical implications – The paper provides a useful analysis framework for firms to evaluate servitization and digitalization as success strategies. It is proposed that firms must simultaneously commit to digital transformation and the incorporation of services to create value, especially in business-to-business settings. Servitization and digitalization interact to exert a greater influence on performance.

Originality/value – The paper contributes to the theory on service strategy by providing an analysis model that includes digitalization as a mediator of the relationship between servitization and firm performance. Digitalization may provide a mechanism to unlock the benefits of servitization and thereby enhance firm performance.

Keywords Performance, Manufacturing firms, Servitization, Mediation, Digitalization

Paper type Research paper

1. Introduction

The current economic environment, characterized by globalization, uncertainty and the pressure of competition, has led many manufacturing firms to seek personalized solutions for customers. Thus, achieving greater customer satisfaction involves a shift toward the provision of integrated solutions (Storbacka, 2011; Kohtamäki *et al.*, 2013). This process is referred to in the literature as *servitization*, which can be understood as the process of increasing value by adding services to products (Vandermerwe and Rada, 1988). Servitization can provide customers with complete product-service systems (Visnjic and Van Looy, 2013).

At the same time, in the industrial sector, the emergence of digital technology has resulted in notable changes and has led to specialization in the value chain and connectivity between different actors. Digitalization refers to the growing use of digital technology in manufacturing (Hsu, 2007). Digital technology can provide value-creating and revenue-creating opportunities (Sklyar *et al.*, 2019). The digital transformation in industry creates new ways of competing to meet the needs of

the most demanding customers who seek personalized solutions. It has also meant that many companies have shifted from producing and selling a single product to offering integrated solutions focused on addressing customers' needs (Davies, 2004).

In this context, industry should tackle the challenges of digitalization and servitization in the interests of increasing competitiveness. In business-to-business (B2B) settings, digital technologies and servitization provide a valuable opportunity to help develop business models (Raddats and Easingwood, 2010; Brown *et al.*, 2011). Servitization and digitalization have a mutual influence and a joint effect on the transformation of business models and thereby facilitate the emergence of digital business models (Martín-Peña *et al.*, 2018).

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Despite this mutual influence, the research domains of servitization and digitalization have evolved in isolation. Only recently have synergies between the two been acknowledged. The implementation of digital technologies to enable servitization remains an important yet understudied area of research (Paschou, et al., 2017). Lightfoot et al. (2012) reported inadequate awareness of the usage of digital technologies that enable firms to deliver product-centric service offerings. Servitization and digitalization together provide significant opportunities to boost firms' performance and profitability (Schroeder et al., 2016).

To fill this research gap, the aim of this study is to analyze the relationship between servitization, the adoption of digital technologies in manufacturing, and their effect on firm performance. Specifically, the objective is to determine the type and intensity of interaction between servitization and digitalization and the mechanism through which this is transferred to firm performance. To achieve this aim, we present a comprehensive framework that integrates the emerging trends of servitization and digitalization in manufacturing.

This framework shows how servitization and digitalization appear to be related through new product-service systems and how they contribute to value creation within the firm. Therefore, a theoretical model is presented to describe the relationships between the three variables in the conceptual framework (i.e. servitization, digitalization and performance).

This paper is organized as follows. The next section outlines the conceptual framework. The theoretical model and hypotheses are then introduced. Following this, we present the methodology, the results of the empirical study, and our findings. Finally, we discuss the findings and managerial implications. We also highlight opportunities for research in the future.

2. Conceptual framework

The development of a servitization strategy by firms promotes the adoption of digital technologies because such a strategy requires more information and control in new product-service systems (Eloranta and Turunen, 2016; Coreynen et al., 2017; Frank et al., 2019). Digitalization can be considered an enabler and a driver of servitization.

Scholars have acknowledged that the development of digital technologies is an enabler of servitization strategies (Oliva and Kallenberg, 2003; Neu and Brown, 2005; Brax and Jonsson, 2009; Kryvinska et al., 2014; Coreynen et al., 2017). As an enabler, technology can be adopted as a tool to fill a specific need (Kryvinska et al., 2014). Information and communications technology (ICT) enables the delivery of services and the improvement of a service-oriented strategy (Antioco, 2006), allowing industrial firms to adopt new business models based on the ability to use and rapidly process real-time data. This opportunity is particularly important for products with long life cycles (Belvedere et al., 2013). Digital technology not only enables servitization through the provision of product-service systems but also allows firms to reduce costs, improve internal efficiency, and increase service orientation (Kowalkowski et al., 2013).

Other scholars have described the development of digital technologies as a driver of servitization (Persona et al., 2007; Peppard, 2011). As a driver, technology can actually spur changes that would previously have been impossible (Peppard, 2011). In doing so, change drivers facilitate paradigm shifts in the firm (Parida et al., 2015). Regarding the drivers of servitization, the literature reveals a consensus that the primary ambition that drives servitization is the desire to address the shrinking margins of manufacturing and selling goods (Gebauer et al., 2005). Digital technology can contribute substantially in this regard.

The interactive effect of servitization and digitalization means that manufacturers progress along a transition path that is influenced by both digitalization and servitization. They develop a servitization-digitalization transformation model that has four generic stages (Lerch and Gotsch, 2015): manufacturer, information technology-based services, pure digital services and digitalized product-service systems. Thus, the level of servitization can be linked to the level of digitalization. Frank et al. (2019) established a conceptual framework for the convergence of servitization and digitalization.

The literature examines factors that encourage the digitalization of services in manufacturing. For example, the complexity of services in manufacturing is related to the level of digitalization (Gebauer et al., 2011; Lerch and Gotsch, 2015). Likewise, the complexity of the product to be servitized influences the digitalization of the incorporated service (Herterich et al., 2015).

New technology that facilitates automation and optimization is a driver and an enabler for many firms to move toward solutions (Windahl, 2015). The evolution of digital technologies has thus been truly transformational across industries and has created new opportunities for revenue generation (Iansiti and Lakhani, 2014). In B2B settings, this phenomenon can really be appreciated. The trends of servitization and digitalization are converging, radically disrupting value chains and forcing companies to rethink how they can secure future revenues and profits (Porter and Heppelmann, 2014). Furthermore, servitization creates strategic advantages in terms of differentiation and even resolves marketing issues by locking customers in, which ultimately yields monetary benefits for the company (Kryvinska et al., 2014).

Digitalization provides new value-creating and revenue-generating opportunities (Sklyar et al., 2019), and it goes hand in hand with the adoption of servitization (Parida et al., 2015). Digitalization entails the decoupling of information and technologies that can potentially reshape the nature of service activities (Lusch and Nambisan, 2015). In sum, servitization and digitalization are related through new product-service systems, and they contribute to value creation within the firm. It can be argued that the creation of opportunities to introduce advanced services gives digitalization a key role in the relationship between servitization and performance.

3. Theoretical model and hypotheses

The conceptual framework suggests that services incorporated into manufacturing entail the deployment of digital

technologies. The framework also suggests that, as servitization becomes more complex, more digital technologies are employed. Finally, the framework suggests that digitalization and servitization contribute to boosting firm performance.

3.1 Relation between servitization and digitalization

Many manufacturing firms increasingly look to digitalize to provide advanced services and develop servitization strategies (Kowalkowski *et al.*, 2013). As industrial products become more advanced and complex, the role of key support services becomes more important (Yang *et al.*, 2011). The development of servitization in terms of volume and complexity calls for more intensive use of digital technologies. Simultaneously, ICT can have an enabling effect on firms' servitization (Matthyssens and Vandenbempt, 1998; Penttinen and Palmer, 2007). The influence on firms' service business orientation should be positive (Kowalkowski *et al.*, 2013).

Business opportunities (business pull) and the push of digital technology (ICT push), create different scenarios for the adoption of technology-based solutions (Kryvinska *et al.*, 2014). Servitization is a business innovation that entails changes in digital technology needs.

Manufacturers use ICTs that enable the monitoring of product features, location, conditions, use, and so on. This enables specific actions to develop services for maintenance, repair, and process and product design improvements (Baines and Lightfoot, 2013). Lightfoot *et al.* (2011) examined the ICTs that support the delivery of advanced services. Grubic and Peppard (2016) identified the benefits of using remote monitoring technology to support servitized strategies.

Advanced manufacturing technologies also have the ability to simultaneously standardize and personalize a product or service (Koc and Bozdog, 2009). The redesign of operating processes as a result of investment in digital technology is necessary to implement a servitization strategy. Ardolino *et al.* (2018) identified 11 digital capabilities that are important for enabling servitization strategies and provisioning product-service solutions. The use of digitalization can aid a range of service innovations (Gago and Rubalcaba, 2007).

In a context characterized by digital innovation, firms are committed to providing personalized solutions, which require collaborative innovation as well as integrated supply chains and interconnected means of production. Continuous product monitoring and analysis of product operating data can help increase the efficiency of existing service processes and create new hybrid business models based on intelligent, interconnected products (Porter and Heppelmann, 2014). Accordingly, servitization and digital technology are directly related. Based on this reasoning, we propose the following hypothesis:

H1. Servitization is positively associated with digitalization.

3.2 Digitalization and firm performance

The literature acknowledges that digital technologies affect firm performance through different variables because of improvements in both product offer and operating processes (Brynjolfsson and Hitt, 2000, 2003; Kryvinska *et al.*, 2014). These technologies include ICTs and advanced manufacturing technologies.

Belvedere *et al.* (2013) proposed a conceptual structure to link value creation to ICTs through variables such as improvements in product offer, process standardization and response capacity. They showed that ICTs can exert a major influence on value creation. Among others, Koc and Bozdog (2009), Moshiri and Simpson (2011), Cardona *et al.* (2013), and Enriquez *et al.* (2015) have also proposed a positive relationship between ICTs and performance. The association at the sector level between the use of ICTs and productivity growth seems to be positive in all examined industrial sectors (Gretton *et al.*, 2004). Despite reasonable evidence of a strong association between ICT and firm performance, causality has not been convincingly demonstrated (Draca *et al.*, 2006).

Advanced manufacturing technologies are technologies that relate to the application of mechanical, electronic and computer-based systems to operate and control production (e.g. CAD, robots, flexible systems and numerical control systems). They have the ability to simultaneously standardize and customize. Effective deployment of such systems has been cited as a way of building a sustainable competitive advantage (Koc and Bozdog, 2009). Therefore, these systems can themselves positively influence firm performance (Monge *et al.*, 2006; Swink and Nair, 2007; Theodorou and Florou, 2008; Koc and Bozdog, 2009). Porter and Heppelmann (2014) analyzed the impact of digitalization on competitive advantage using Porter's Five Forces. Based on this reasoning, we propose the following hypothesis:

H2. Digitalization is positively associated with firm performance.

3.3 Servitization and firm performance

The main reasons that companies give for undertaking a servitization process primarily consist of economic and financial arguments, strategic rationale (i.e. gaining a competitive advantage), and commercial motivations (Oliva and Kallenberg, 2003; Gebauer and Friedli, 2005). Gebauer *et al.* (2012) presented an interesting literature review that tracks the progress of research on the effect of servitization on firm performance.

In the literature, studies have investigated service-based strategies as sources of competitive advantage in manufacturing firms. Servitization can lead to greater competitiveness (Miller *et al.*, 2002; Davies, 2004).

Other studies of the performance of industrial services have considered the effect of servitization on sales growth (Kohtamäki *et al.*, 2013). Analysis of a servitized manufacturer has shown how the firm can reap revenues and profit by servitizing (Visnjic and Van Looy, 2013). Pawar *et al.* (2009) argued that servitization strategies can create value, with a need for firms to redesign their products, services, and organization (i.e. their product-service-offering triangle). It is also necessary to consider the impact of servitization on a firm's market value (Fang *et al.*, 2008). Ruiz-Alba *et al.* (2019) shown in a B2B context from a customer's perspective that when the level of co-creation of the design of services is high, there are significant effects of servitization on firm performance.

Finally, the effect of servitization translates into profit. Firms with competitive advantages can improve their performance

(Neu and Brown, 2005). Some studies of the performance of industrial services have considered the impact of servitization on firm profitability (Neely, 2008; Gebauer et al., 2011) and the positive effects of service strategies on performance (Antioco et al., 2008). Other studies have shown a more complex relationship between servitization and firm performance (Suárez et al., 2013; Visnjic and Van Looy, 2013; Eggert et al., 2014).

Studies that have shown the positive effect of servitization on firm performance highlight three effects (Ambroise et al., 2016). First, in industries with a high-installed product base (automotive, aerospace, etc.), there is higher profit growth potential from introducing services (Gebauer et al., 2006). Second, services seemingly become a stable source of revenue that can offset the fall in profits from products because they are more resistant to economic cycles (Gebauer et al., 2007). Third, services are less sensitive to price competition and can therefore generate higher rates of profits than pure product offerings. Thus, the main reason for industrial businesses to adopt a service orientation is economic (Oliva and Kallenberg, 2003).

The literature also describes different types of linear and nonlinear relationships between servitization and performance (Bustinza et al., 2018).

H3. Servitization is positively associated with firm performance.

The mechanisms through which the benefits of servitization efforts translate into firm performance are not always evident. Digitalization might be one mechanism that unlocks the benefits of servitization to enhance firm performance. We have posited the direct effect of servitization on digitalization (hypothesis 1) and the direct effect of servitization on firm performance (hypothesis 3).

Technological innovation plays a key role in enabling service innovations (Miles, 2005). It is gaining prominence as a key contributor to service productivity and therefore performance. A substantial part of this technological innovation is based on digital technology. Kindström and Kowalkowski (2014) found that digitalization aids the development of cost-efficient operations and is an enabler of service quality through better resource allocation. Exploitation of digital technologies also improves the efficiency and effectiveness of service operations such as the collection and processing of real-time data (Kowalkowski et al., 2013). Adrodegari et al. (2017) showed that manufacturers introduce digital technologies to increase the efficiency of service delivery and raise the value of their product-service system offerings.

Capabilities enable value co-creation with customers when implementing servitization strategies. Digitalization capabilities actually enable the interaction of resources, processes, and outcomes between manufacturing firms and customers to co-create value (Lenka et al., 2017). Penttinen and Palmer (2007) showed that digital technology enables stronger relationships with customers and more extensive service offerings such as integrated solutions. Coreynen et al. (2017) found that different digitalization options enable manufacturing companies to follow distinct servitization pathways when supported by a unique dynamic resource configuration.

From the value chain perspective, digitalization-aided servitization enables organizations to extend their value chains to better serve customers, potentially resulting in greater profitability (Rymaszewska et al., 2017). Belvedere et al. (2013) analyzed the moderating effect of ICT on the linear relationship between product service innovation (servitization) and performance through the redesign of operating processes. However, empirical studies that have analyzed the effect of mediation on firm performance are practically nonexistent. Based on this reasoning, we propose the following hypothesis:

H4. Digitalization positively mediates the relationship between servitization and firm performance.

3.4 Theoretical model

Figure 1 summarizes the theoretical model. Drawing upon the literature on servitization and digitalization (Porter and Heppelmann, 2014; Parida et al., 2015; Eloranta and Turunen, 2016), we hypothesize that servitization influences digitalization and that servitization and digitalization positively affect firm performance with interaction between the two variables. More specifically, digitalization positively mediates the relationship between servitization and firm performance.

4. Methodology

4.1 Sample selection

We used a cross-sectional sample for the period 2014–2017. The sample comprised Spanish manufacturing companies covered by the Business Strategy Survey. This survey is conducted by the Public Business Foundation (*Fundación Empresa Pública*), which operates under the supervision of the Spanish tax authority (*Ministerio de Hacienda*). The survey population consisted of companies with 10 or more employees engaged in one of the activities described in Divisions 10 to 32 of the CNAE-2009 classification (i.e. the Spanish official version of NACE rev.2). Division 19 (activities related to oil refining and fuel handing, except nuclear fuel) was excluded. The geographical scope was the whole of Spain. The Business Strategy Survey aims to define and maintain a representative

Figure 1 Theoretical model

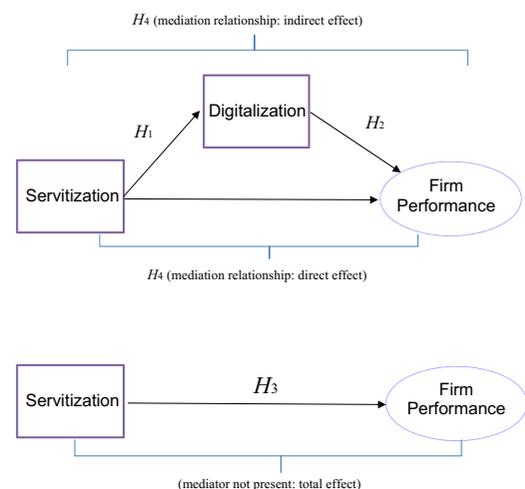


Table I Number of firms by sector

Sectors included in the study	No. of firms	% of total
CNAE-2009 C17: Paper and paper products	69	8.3
CNAE-2009 C20 and 21: Chemicals and chemical products	112	13.5
CNAE-2009 C22: Rubber and plastic products	80	9.7
CNAE-2009 C24: Basic metals	51	6.2
CNAE-2009 C25: Fabricated metal products	195	23.6
CNAE-2009 C28: Farming and industrial machinery and equipment	94	11.4
CNAE-2009 C26: Computer, electronic, and optical products	26	3.1
CNAE-2009 C27: Electrical equipment	55	6.6
CNAE-2009 C29: Motor vehicles	75	9.1
CNAE-2009 C30: Other transport equipment	31	3.7
CNAE-2009 C32: Other manufacturing	40	4.8
Total	828	100.0

sample of industrial manufacturing firms. Thus, as long as the specific characteristics of this representativeness are accounted for, the inferences derived from the analysis of this sample can be taken as valid for the reference population.

Consistent with the aims of this research, we selected 11 sectors that were representative of B2B settings. Finally, 828 firms belonging to these sectors were analyzed (Table I).

4.2 Variable measurement

Several items were used to measure each construct. These items, which are described below, were taken from the literature.

Level of servitization was measured as the proportion of the firm's sales that service offerings account for (Santamaría et al., 2012; Suárez et al., 2013; Crozet and Milet, 2017). This is the most standard way of measuring servitization using the available data from secondary sources.

Level of digitalization was measured as a combination of different items that capture the use of ICTs and advanced manufacturing technologies. The use of ICTs was measured using the following items: information technology programming services, online sales to firms, online sales to end consumers, online purchases from suppliers, and owning an Internet domain (Thong, 1999). The use of advanced manufacturing technologies was measured using the following items: use of

CAD, use of robotics and use of flexible manufacturing systems (Grant and Yeo, 2018).

Each item was coded as a binary variable, where 0 indicates that the firm does not use the technology and 1 indicates that the firm uses the technology. The items were then summed. A value of 0 indicates that the firm uses none of these technologies. A value of 8 means that the firm uses all of these technologies. Values closer to 8 indicate higher levels of digitalization by the firm. This approach is used to compute the Digital Economy and Society Index (DESI), a composite index that summarizes relevant indicators on Europe's digital performance. The resulting variable had a high level of internal consistency (Cronbach's alpha = 0.902). Although this set of items is not fully comprehensive, it is extensive. It reflects a range of elements in digital technologies, including ICTs and advanced manufacturing technologies.

Firm Performance was measured using total sales (Patterson et al., 2004; Crozet and Milet, 2017; Fang et al., 2008). It was operationalized using the logarithm function.

The model included several *control variables* to rule out alternative explanations to those that were formally hypothesized. Firm age was measured as the number of years hypothesized. Firm age was measured as the number of years between the foundation of the firm and the observation year (Bikfalvi et al., 2013; Benedittini et al., 2015; Vendrell-Herrero, et al., 2017). Firm size was measured as total liabilities (Crozet and Milet, 2017). We also used sector as a control variable (Patterson et al., 2004). The CNAE-2009 classification was used to define the firm's sector. Dummy variables were used in the regressions to reflect whether a firm belonged to a given sector. Thus, each item was coded as a binary variable, where 0 indicated that the firm did not belong to the sector and 1 indicated that the firm belonged to the sector.

Descriptive statistics and correlations of all variables are shown in Table II.

5. Results

5.1 Analysis techniques

The proposed model and the associated hypotheses were tested using regression analysis. Ordinary least squares estimation was used. The assumptions of normality of the distribution of error terms and normality of the individual variables were confirmed. We studied the consistency of the possible relationships between the variables associated with the mediation models, using statistical criteria to detect and test the mediators based on multiple regression models. The dependent variable in equation (1) was digitalization. The dependent variable in

Table II Descriptive statistics and correlations

	Performance	Level of servitization	Level of digitalization	Firm age	Firm size
Performance	1	0.106**	0.359***	0.238***	0.494***
Level of servitization		1	0.111**	0.065	0.149***
Level of digitalization			1	0.095**	0.144***
Firm age				1	0.12**
Firm size					1
Mean	16.265	8.359	3.719	36.168	86.779.123.413
Standard deviation	1.970	14.934	1.591	17.851	340.192.707.191

Notes: ***Significance level ($p < 0.001$); **significance level ($p < 0.01$); *significance level ($p < 0.05$)

equations (2) and (3) was firm performance. The equation (3) also included the mediating effect of digitalization. Correlation analysis provided a starting point to explore the relationships, which were then confirmed with multiple regression analysis to test and interpret the interactions. The control variables were included in all the equations used in the regression analysis to prevent the effect of size, age, or sector altering the relationships between the studied variables. Regressions associated with the hypotheses are shown in Table III.

The relationship between level of servitization and level of digitalization (*H1*) was positive, this result was confirmed using multiple regression analysis [equation (1)]. The relationships between level of digitalization and firm performance (*H2*) and between level of servitization and firm performance (*H3*) were also positive. These results were confirmed using multiple regression analysis [equations (2) and (3)].

The relationship between level of servitization, level of digitalization, and firm performance (*H4*) involved different possible interactions. Firm performance was taken as the dependent variable. Because the relationship between level of servitization and level of digitalization was positive, equation (1) rules out the possibility of moderation. However, mediation in the relationship with firm performance was possible. According to Baron and Kenny (1986), four conditions are necessary for mediation:

- 1 the predictor variable (servitization) must significantly predict the outcome variable (performance);
- 2 the predictor variable (servitization) must significantly predict the mediator (digitalization);
- 3 the mediator (digitalization) must significantly predict the outcome variable (performance); and
- 4 the predictor variable (servitization) must predict the outcome variable (performance) less strongly when the mediator (digitalization) is introduced.

If these conditions hold, there is mediation, which may be partial or total as a function of whether the direct path is weaker (or negligible) than the path via the mediator. The results of the regressions, based on equations (1), (2) and (3), confirm these conditions.

In equation (3), level of digitalization and firm performance were positively related, even when level of servitization was included in the regression model; in contrast, the relationship between level of servitization and firm performance became non-significant after level of digitalization was included. Mediation can explain this situation. If we considered the relationship between level of servitization and firm performance in equation (3) to be non-existent, there would be total mediation.

To establish whether the mediation was significant, we calculated the total, direct, and indirect effects of servitization on performance (Model 4 of PROCESS in SPSS, Hayes, 2017). We estimated the indirect effect and provided a bootstrapped standard error and confidence interval. The fact that the confidence interval does not contain 0 means that a genuine indirect effect is likely and that mediation is likely to exist (Field, 2013). The analysis was performed using the three variables in Figure 1.

Table IV displays the three effects: first, the total effect of servitization on performance in isolation; second, the direct effect of servitization on performance when digitalization is included as a predictor; third, the indirect effect of servitization on performance. We provide an estimate of this effect ($b=0.052$) as well as a bootstrapped standard error and confidence interval. We also calculated the completely standardized indirect effect or index of mediation (0.0391) because this measure is useful in that it can be compared across different mediation models that use different measures of the predictor, outcome, and mediator.

Table III Regressions associated with the hypotheses

Regressions	Dependent variables		
	Equation 1 (<i>H1</i>): Digitalization	Equation 2 (<i>H3</i>): Performance	Equation 3 (<i>H2</i> , <i>H4</i>): Performance
Level of digitalization			0.274 (0.000)
Level of servitization	0.094 (0.008)	0.061 (0.032)	0.036 (0.188)
Firm age	0.083 (0.018)	0.163 (0.000)	0.141 (0.000)
Firm size	0.101 (0.005)	0.416 (0.000)	0.390 (0.000)
Paper and paper products	0.042 (0.27)	0.156 (0.000)	0.144 (0.000)
Chemicals and chemical products	−0.033 (0.415)	0.283 (0.000)	0.292 (0.000)
Rubber and plastic products	0.052 (0.181)	0.069 (0.028)	0.055 (0.063)
Basic metals	0.017 (0.656)	0.216 (0.000)	0.211 (0.000)
Fabricated metal products	–	–	–
Farming and industrial machinery and equipment	0.174 (0.000)	0.156 (0.000)	0.108 (0.000)
Computer, electronic and optical products	0.122 (0.001)	0.036 (0.212)	0.003 (0.915)
Electrical equipment	0.105 (0.005)	0.118 (0.000)	0.089 (0.002)
Motor vehicles	0.151 (0.000)	0.270 (0.000)	0.229 (0.000)
Other transport equipment	0.076 (0.043)	0.069 (0.022)	0.048 (0.090)
Other manufacturing	0.019 (0.605)	−0.070 (0.019)	−0.075 (0.007)
Adjusted R^2	0.083	0.402	0.470
F value	6.461 (0.000)	41.669 (0.000)	50.876 (0.000)

Note: The table shows standard coefficients and significance in parentheses

Table IV Total, direct and indirect effects

Type of effect	Level of effect	SE (HC3)	LLCI	ULCI	p
Total effect of X on Y	0.0140	0.0053	0.0035	0.0244	0.0089
Direct effect of X on Y	0.0088	0.0048	−0.0006	0.0182	0.0666
	Level of effect	Boot SE	Boot LLCI	Boot ULCI	
Indirect effect of X on Y	0.0052	0.0017	0.0019	0.0086	
Completely standardized IE	0.0391	0.0128	0.0143	0.0646	

Notes: Confidence interval to 95 per cent; heteroscedasticity-consistent inference HC3 (Davidson-Mackinnon); number of bootstrap samples 5000

Because the confidence interval does not contain 0, there is an indirect effect. Thus, digitalization mediates the relationship between servitization and performance. Moreover, this mediation is total, as explained earlier.

5.2 Discussion

We first hypothesized that servitization positively influences digitalization. Figure 2 shows the associations between level of digitalization and level of servitization, depicting an initial level at which basic services are incorporated, an intensification of these services in the form of support services, and a more developed level of services in the form of advanced services. Digitalization may act as an enabler, facilitating the incorporation of services, mostly in the form of support services. Digitalization may then evolve into a driver, creating an opportunity for the introduction of advanced services.

The analyses confirm that the level of servitization is positively related to the level of digitalization in the analyzed firms, thereby confirming *H1*. These results show that organizations can improve their service offerings by harnessing the potential of digital technologies through digitalization. Digital technology adoption has recently been identified as crucial for manufacturers to shift to product-service system business models (Adrodegari et al., 2017; Ardolino et al., 2018). These findings are consistent with those reported by Coreynen et al. (2017).

The importance of level of digitalization to the success of the firm is supported by the empirical results of this study. More specifically, the results show a positive relationship between level of digitalization and firm performance (test of *H2*). Digitalization relates to all aspects of the use of data, including

how data are monitored, stored and processed throughout the firm and how it affects performance. The disruptive and productive effects of digital technologies on organizational operations have been shown (Kumari et al., 2017). This study thereby confirms the findings reported in the literature in relation to digital technologies' overall contribution to improving operational processes (Kindström and Kowalkowski, 2014; Porter and Heppelmann, 2014).

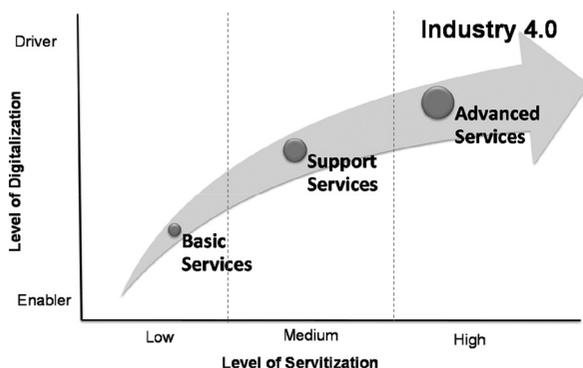
Analyzing the relationships between servitization and firm performance while considering all variables except digitalization, as per equation (2), confirms the positive relationship between servitization and firm performance (test of *H3*). The core of the relationship between servitization and firm performance relates to the strategic approach under which introducing services in manufacturing leads to the creation of capabilities that provide sustainable competitive advantages (Windahl et al., 2004). Not only do firms incorporate services, but they also change their strategies and occupy new positions in the value chain (Davies, 2004). These findings are consistent with those reported in the literature (Miller et al., 2002; Davies, 2004; Gebauer et al., 2005). As proposed by Crozet and Milet (2017), who evaluated industry heterogeneity and the positive effect of servitization on profitability, employment and total sales, the data used in this study corroborate the relationship between servitization and total sales for the group of studied sectors.

In contrast, considering all variables, including digitalization, as per equation (3), shows that digitalization takes the place of servitization in the model, and there is total mediation. The presence of digitalization is necessary for servitization to have a positive effect on performance. This finding implies that there is a complex indirect relationship between servitization and firm performance.

At this point, it is worth noting that empirical studies have highlighted different scenarios, with a positive relationship between servitization and firm performance that is not always linear (Suárez et al., 2013; Kohtamäki et al., 2013). Authors such as Fang et al. (2008) and Cusumano et al. (2015) have suggested that until a critical mass of services is achieved, this relationship will not be positive. Moreover, not all firms achieve this critical mass, which is conditioned by the industry, features of the services, and level of innovation, as well as other factors (Eggert et al., 2014).

Thus, the literature reflects the complexities in the relationship between servitization and firm performance, with a gap between the theoretical arguments and empirical evidence. The role of moderators and mediators in the servitization literature can help explain the relationship between

Figure 2 Servitization and digitalization: levels and associations



Source: Authors' own work

servitization and performance (Bustinza *et al.*, 2018). The equation (3) includes the level of digitalization as a mediator of the relationship between servitization and performance. We tested this hypothesis by analyzing the mechanism that generates the relationship between servitization and firm performance. The theoretical model in Figure 1 illustrates this mechanism. If H3 proposes the total effect, which can be separated into the direct effect and the indirect (or mediating) effect, the entire total effect becomes an indirect (or mediating) effect.

The results show that digitalization mediates the relationship between servitization and firm performance, thereby confirming H4. This result is consistent with the literature showing that digitalization can improve the efficiency and effectiveness of processes, thereby creating value for customers through new opportunities to generate revenue (Iansiti and Lakhani, 2014). This enables the provision of advanced services, promoting synergies between digitalization and servitization. In other words, digitalization efforts to improve the level of servitization translate into greater value created by the firm. Furthermore, digitalization leads to changes in the firm's capabilities and business model, and these changes in turn promote servitization and value creation.

In short, servitization and the evolution of digital technologies have been truly transformational across industries and have created new opportunities for revenue generation and the introduction of services.

6. Conclusions

6.1 Theoretical contribution and managerial implications

The development of digital technologies and the increase in global competition have led many manufacturing firms to seek solutions to meet their customers' needs. In this context, digital technologies and servitization represent a key opportunity for industry. A substantial part of digitalization owes to the introduction of services. Similarly, the design of new product-service systems is driven by digitalization.

For the case of Spain, this study shows that the relationship between servitization and digitalization is positive. The transition from a product-centric model to a service-oriented one is not easy. Firms are often unable to make this transition profitable, thereby failing to exploit the opportunities afforded by the shift toward product-service systems. Complexity, heightened risk, and a lack of digital capabilities explain this situation. Digital technologies are changing the way in which services are provided, and they are becoming enablers or drivers of the servitization process in industrial firms. Therefore, digitalization and servitization must converge, and firms must address the digital transformation of their businesses.

Numerous studies have shown that the relationship between servitization and firm performance is not always positive (i.e. the servitization paradox). Our analysis indicates that this relationship is complex and indirect when digitalization occurs. One of the novel contributions of this study is the fact that digitalization is studied as a mediating variable in the relationship between servitization and firm performance. Digitalization positively mediates the relationship, indicating that servitizing firms can enhance their performance

improvements through digitalization. The relationship between servitization and firm performance that is most widely studied is thereby supported. For the analyzed firms, this study shows that in B2B settings, providing product-service systems with the use of digital technologies can contribute to improving firm performance.

From a theoretical perspective, this study advances research on the relationship between digitalization and servitization. Once the servitization process is initiated, and as each successive level is reached, a greater level of digitalization is necessary. Accordingly, as the level of servitization increases, new needs and service volumes lead to a subsequent increase in the level of digitalization, even if there was already a need for digitalization. This shows the importance of synergies between the two variables to generate positive performance that contributes to improving the competitiveness of industrial firms. Defining whether and under what conditions servitization and digitalization work and improve manufacturing firms' performance is essential to justify such strategies' effectiveness (Kowalkowski *et al.*, 2017).

We also contribute to the empirical literature by clarifying the hitherto mixed results regarding the relationship between servitization and firm performance. This study helps strengthen the consensus regarding the positive effect of servitization on firm performance. The mediating role of digitalization can be seen as a way of overcoming the servitization paradox. By improving digitalization, servitization indirectly increases profits while reducing costs, increasing efficiency, providing integrated packages and strengthening customer relations. Therefore, managers should pay attention to the relationship between the introduction of services and performance, promoting innovative business models to generate positive performance by incorporating services to overcome the servitization paradox (Eggert *et al.*, 2014).

The study of digitalization as an enabler and driver of servitization is of considerable practical relevance for managers. The management of the firm should pay heed to the relationships between the introduction of services and digitalization and develop business models that enable synergies between servitization and digitalization to enhance the positive effect on performance.

6.2 Limitations and future research opportunities

Although this study provides some interesting findings, it has several limitations that in turn provide opportunities for future research. First, the analysis of secondary data prevented us from considering observations besides those included in the pre-established external questionnaire. In addition, the measurement of certain variables could be improved. For example, digitalization was operationalized by summing different technological items. However, items that are more closely linked to Industry 4.0 settings, such as the Internet of things, the cloud, big data, and artificial intelligence, were not considered. Second, like most survey-based studies, our analysis was cross-sectional. Accordingly, the results fail to capture the dynamic processes that underpin the relationships identified between the variables. Third, it would be of interest to use other sampling frames besides Spanish firms to extend the validity of the findings.

This study also raises some interesting challenges for future research. The limitation of performing cross-sectional analysis creates an opportunity for longitudinal analysis that enables the

study of the relationship between servitization and digitalization over time as well as the synergistic effect on firm performance. It would be of interest to consider other approaches to the measurement of digitalization to better understand these dynamics. It would also be of interest to rigorously analyze the mechanisms through which digitalization mediates the relationship between servitization and performance to establish an effective servitization strategy. Finally, other variables related to those analyzed in this study could also be considered. Examples include internal R&D and external R&D. Studying these variables could provide insight and help develop a more complete structural model of relationships.

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