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The relationship between digitalization and servitization: The role of servitization in capturing the financial potential of digitalization

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ABSTRACT

The present study investigates the effect of the interaction between digitalization and servitization on the financial performance of manufacturing companies. We challenge the simple linear assumption between digitalization and financial performance with a sample of 131 manufacturing firms and hypothesize a nonlinear U-shaped interaction effect between digitalization and servitization on financial performance. From low to moderate levels of digitalization, the interaction effect between digitalization and high servitization on company financial performance is negative and significant. From moderate to high levels of digitalization, the interplay between digitalization and high servitization becomes positive and significant, improving companies' financial performance. The results demonstrate the need for an effective interplay between digitalization and servitization, the digital servitization. Without this interplay, a manufacturing company may face the paradox of digitalization. For managers of manufacturing companies, the study provides insights into the complex relationship between digitalization and financial performance, emphasizing the value of servitization in driving financial performance from digitalization. Thus, the study demonstrates how manufacturing companies can become data-driven by advancing servitization.

1. Introduction

Digital servitization is an emerging concept that highlights the interplay between two central constructs in manufacturing and technology companies: digitalization and servitization (Coreynen et al., 2016; Kohtamäki et al., 2019; Opresnik and Taisch, 2015; Paschou et al., 2017). Digitalization is considered to have a profound effect on companies, up and downstream operations, networks and ecosystems (Iansiti and Lakhani, 2014; Jacobides et al., 2018; Porter and Heppelmann, 2014). Companies such as Rolls-Royce, Kone, Caterpillar and Hilti have been moving towards digital business models, data-based value chains, and more flexible organizational forms – even towards more agile operations. This transition towards digitalization, smart products, the Internet of Things (IoT), and the industrial internet has been shifting the capability requirements for manufacturing companies that reportedly struggle in this transition (Iansiti and Lakhani, 2014; Porter and Heppelmann, 2015). In addition to shifting the capability requirements, digitalization may also generate profound changes in interfirm transactions (e.g., blockchain) (Tapscott and Tapscott, 2017), power relationships between companies (e.g., Über and car companies) (Cusumano, 2015), and strategic identities (e.g., manufacturing firms becoming more like software companies) (Lenka et al., 2018). However, manufacturing firms are continuously investing in remote diagnostics, data warehouses, analytics and various methods of data visualization (Grubic, 2018; Jonsson et al., 2009; Tilson et al., 2010) to facilitate improved decision making, business intelligence and business development with limited evidence of real profit gains (Talaoui, 2018).

While it seems evident that digitalization-related capabilities have a profound impact on manufacturing companies, and the positive effect of digitalization seems self-evident, the nature of the effect remains unclear, and serious concerns about the productivity of such IT investments have been raised over time (Brynjolfsson, 1993; Brynjolfsson and McAfee, 2012). The existing empirical research does not provide sufficient evidence on the relationship between digitalization and company financial performance and potential moderating

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factors. Digitalization alone may be insufficient to generate positive financial performance effects in manufacturing companies, and thus, the companies need portfolios of advanced services to ensure value capture from digitalization to achieve positive performance effects.

Studies on servitization to date link digital transition and servitization under the umbrella of digital servitization (Coreynen et al., 2017; Parida et al., 2014a; Vendrell-Herrero et al., 2017) or alternatively integrate products, services and software under the concept of servitization (Baines and Lightfoot, 2014; Cenamor et al., 2017). Although the servitization research has acknowledged the role of software, studies have lacked the necessary emphasis on the role of digitalization (Coreynen et al., 2017; Ng and Wakenshaw, 2017; Rymaszewska et al., 2017). Only recently have we witnessed the conceptualization of digital servitization, with an emphasis on the interplay between digitalization and servitization. However, although the concept of digital servitization has been defined and established, we have very little empirical data on the interplay between its two major dimensions – digitalization and servitization (Kohtamäki et al., 2019). As such, the literature on servitization and product-service systems taps into digital transition by studying how companies utilize remote diagnostics to create value for customers (Brax and Jonsson, 2009; Frank et al., 2019; Grubic, 2018; Hasselblatt et al., 2018). Studies also analyze the role of smart products or smart solutions in digital transition (Kowalkowski et al., 2013; Lerch and Gotsch, 2015; Töytäri et al., 2018). Studies highlight the challenge that manufacturing companies face in value appropriation from investments in digitalization. The digital transformation disrupts all industries, and perhaps for the previously most stable industries, these disruptions emerging from the digital transformation, i.e., blockchain, artificial intelligence, and IoT, are the most difficult. The current evidence reveals that manufacturing companies collect vast amounts of market data but often lack the necessary capabilities to utilize and capitalize on the data (Ehret and Wirtz, 2017; Hasselblatt et al., 2018). All too often, investments in digitalization and big data analytics are made without a clear strategy for how the big data provided by customers would be used to generate greater new business opportunities and improved financial performance for companies. The key to unlocking the value of digitalization may be embedded in advanced services, operational services, and outcome-based services that enable companies to capture the benefits of digitalization (Visnjic, Neely & Jovannovic, 2018). Eventually, the value from the investments in digitalization should be captured through the business model, such as the digital servitization business model. Very little research to date exists on the relationship between digitalization and servitization in the context of manufacturing companies.

The purpose of the study is to answer the calls for research on the financial impact of digitalization and the enabling role of servitization. By doing so, we extend the existing literature on digital servitization (Kohtamäki et al., 2019; Sklyar et al., 2019) by examining the moderating role of servitization on the nonlinear (inverted U-shaped) relationship between digitalization and financial performance. We hypothesize that servitization mitigates the nonlinear and negative effect of digitalization on a company's financial performance. For managers in manufacturing firms, the study provides needed evidence on the complex relationship between digital servitization and financial performance, emphasizing the important role of servitization in the journey towards digitalization. To carve out the value from a higher level of digitalization, the manufacturer should invest in servitization capabilities, particularly on service offerings that support value capture from digitalization.

2. Theory and hypotheses

2.1. Digitalization and performance

Digitalization is transforming ecosystems and value chains in manufacturing companies, changing how these companies interact across the firm boundaries upstream or downstream, improving supplier and customer interactions, and enhancing data acquisition, warehousing, big data analytics, and implementation (Porter and Heppelmann, 2015). Digitalization not only potentially provides new business opportunities but also increases efficiencies. Digitalization of manufacturing companies and industries is discussed from different perspectives, including concepts such as IoT, the industrial internet, industry 4.0, digitization, and digitalization, among others. In the present study, we use the term "digitalization," by which we refer *to digitalization of downstream activities at the front end of the manufacturing company's value chain, where the company is collecting, warehousing, analyzing, and using market data for improved value co-creation and appropriation.*

Investments in digitalization can be vast, with challenging implementation and integration with various subsystems, e.g., various decision-making platforms and visualization tools. IT investments should improve data usage at the front end and eventually at the back end, improving value chain activities as a whole (Porter, 2001; Porter and Heppelmann, 2015). Manufacturing companies invest in digitalization to enable the reduction of data processing costs by automatizing data collection, warehousing and diagnostics (Wamba et al., 2017). The improved use of data digitalization improves customer engagement and the development of product-service systems, including improvements in remote diagnostics and fleet management (Jayachandran et al., 2005). Although some evidence regarding the direct relationship between digitalization and performance has been presented, the relationship is complex, possibly nonlinear and moderated by other variables (Kohtamäki et al., 2019). This view is in line with scholars who have previously demonstrated opposing evidence, claiming that the value of IT may be questionable (Brynjolfsson, 1993; Brynjolfsson and Hitt, 1998; Kettinger et al., 1994), at least if not supported by complementary capabilities (Kim et al., 2005). Hence, despite the significant financial potential, companies struggle regarding value appropriation from digitalization. Mere technological investments are not sufficient, but often, the greatest challenges are faced regarding the organizational practices and capabilities – practices that must be developed to take advantage of the systems.

Thus, why manufacturers struggle with capturing value from digitalization and what we know about this issue are revisited in terms of the digitalization paradox (Brynjolfsson, 1993; Brynjolfsson and McAfee, 2012). For the digitalization paradox to occur, we find three main requirements. First, vast investments in digitalization require significant increases in value creation and value appropriation to generate the needed returns. With easy-to-implement systems, the integration of product-service-software systems has become simpler and less costly, with systems adding simpler features that increase customer value, such as early warning signals for maintenance, automatically generated reports, and easy-to-document customer leads. With easy-to-implement and integrated systems, investments in digitalization may produce direct financial impacts, as these investments focus on critical features related to improved financial performance, customer service and solution delivery that directly improve the effectiveness of customer co-creation and the efficiency of solution delivery, thus also decreasing transaction costs (Sjödin et al., 2019). With more complex systems, investments in new digital architectures require significant integration and, hence, often lengthy, heavy and costly integration projects (Haynes and Thompson, 2000; Landauer, 1995). Moreover, some IT systems may have overengineered features that are costly but do not produce significant business value to the servitized manufacturer or the manufacturer's customer. However, ex ante, the value of large-scale IT systems is very difficult to determine.

Second, the implementation of digitalization requires investments in other capabilities as well. For instance, investments in the digitalization of value chains are known to shift routines and capabilities throughout the organization, from solution sales to project management, R&D, supply chain and solution delivery, not forgetting the support activities, such as finance and human resource management (Kim et al., 2005; Porter, 2001; Porter and Heppelmann, 2015). With easier systems to implement, the lower investment costs enable decreased payback times and higher financial performance. Instead of moderate to high levels, investments in digitalization require a significant reconfiguring of value chain activities (Porter, 2001), creating costly and radical organizational transformation projects that are difficult to implement. The development of organizational structures and new operational processes requires development work, new capabilities and activities, increasing implementation costs and project payback times and leading to missing returns (Wamba et al., 2017).

Third, the implementation of new digital systems requires development of human skills and competencies at the micro level – personnel need to learn how to use the new systems, which requires training, coaching and the development of new IT skills (Brynjolfsson and McAfee, 2012; Wamba et al., 2017). Sociomaterial perspectives have emerged in information systems and organization science, emphasizing the interplay and entanglement between material technologies and social practices and the interaction between material technologies and human actors. In these instances, at the micro level, the usability of IT systems and interfaces is emphasized, as well as competence development and other micro-level social factors (Orlikowski, 2007; Orlikowski and Scott, 2018). When the complexity of socio-technical systems increases, so do the requirements regarding competence development. From the competence perspective, the implementation of new systems is costly and obviously takes time, increasing investment payback times.

Thus, manufacturers seem to struggle with the deployment of digitalization. They implement investments but struggle with creating and appropriating value from these investments. Mere technological investments are insufficient to generate financial performance; complementary capabilities, such as servitization, are required.

2.2. Digital servitization

By servitization, current research refers to the transition from products to services and integrated solutions (Lightfoot et al., 2013). Servitization is often described as a transition, where the company moves from providing pure stand-alone products and add-on services to maintenance contracts, operational services and, finally, to outcome- or performance-based offerings (Huikkola and Kohtamäki, 2018; Kowalkowski et al., 2015; Parida et al., 2014b; Visnjic et al., 2017). This transition has been coined as servitization, service infusion, service transition, or service transformation (Kowalkowski et al., 2017; Rabetino et al., 2018; Raddats et al., 2019). As such, servitization is a fully fledged transformation from product to service orientation, which often manifests in integrated solutions, including customized products, and advanced services (Windahl and Lakemond, 2010). In time, products and services are integrated by using the product lifecycle (Artto et al., 2015; Rabetino et al., 2015). Servitization studies tend to see IoT, digitalization and IT capabilities as inherently related to servitization – full-fledged servitization would not exist without effective data acquisition, warehousing, analytics and utilization, through a variety of sensors, data warehouses, big data analytics and user interfaces, that enable servicing the installed base effectively or increasing customer value by improving the usage of the product fleet being operated (Ardolino et al., 2018; Martín-Peña et al., 2018). The concept of servitization is considered to capture the digital technologies related to IoT and remote monitoring, and studies have also begun using the concept of digital servitization to underline the role of digital service technologies. Studies highlight the interplay between digitalization and servitization (Martín-Peña et al., 2019; Opresnik and Taisch, 2015; Rymaszewska et al., 2017). Digitalization enables new innovative services, business models and pricing models, which are required to capture the value from digitalization (Adrodegari et al., 2017; Kohtamäki et al., 2019).

Servitization studies tend to operationalize the level of servitization through offerings (Gebauer et al., 2010; Partanen et al., 2017). The scope of service offerings provides a good reflection of the company's servitization, the industrial services bundled with customized products. The scope of service offerings is particularly relevant for companies and researchers, as it captures and communicates the company's solutions strategy, business model and the tactic utilized to create and appropriate value from the company's innovations or capabilities (Lenka et al., 2017; Rabetino et al., 2015; Töytäri et al., 2015), such as digitalization. Moreover, as service offerings vary less than products, service offerings can be used to measure servitization by a rather general scale capturing the scope of the offerings, in other words, the broadness of the offerings (Partanen et al., 2017). Hence, the scope of service offerings provides a valuable tool for researchers to capture the key component of servitization. During the evolution of the servitization literature, studies have developed multiple measurement methods, which tend to use service offerings as a reflection of the level of servitization (Coreynen et al., 2018; Kohtamäki et al., 2013). Studies have found that service offerings tend to reflect the quality and level of servitization reasonably well. The solution provider's strategy materializes into offerings and hence can be used to measure servitization (Gebauer et al., 2010; Kohtamäki et al., 2013). For instance, Gebauer et al. (2010) utilized an interesting combination of dimensions to measure service strategy, such as the number, broadness, and emphasis on services for different service strategies. Kohtamäki et al. (2013) used the scope of industrial service offerings to study the effect of servitization on sales growth, finding a nonlinear direct effect and a positive moderating role of network capabilities. Using a reflective measurement model, Kohtamäki et al. (2013) measured three dimensions of service offerings: maintenance services, R&D services, and customer services. In the use of the reflective measurement model, the items and dimensions reflect the latent construct, which, in their case, were service offerings or, in other words, servitization strategies. Later, Partanen et al. (2017) validated the measurement method for the scope of industrial services in a customer relationship – their argument was that offerings are often co-created in customer relationship, and hence, the customer relationship can be used as a unit of analysis in servitization research (Kohtamäki and Partanen, 2016). Using a typological approach, Forkmann et al. (2017) also focused on servitization at the relational level. Recently, Coreynen et al. (2018) developed their tool to measure servitization capacity by three main dimensions and multiple subdimensions. Their main dimensions were service development, service deployment, and service orientation. In the present study, we utilize the concept of servitization, considering that the scope of advanced service offerings, such as operational services, R&D services, and consulting services, provide a good reflection of the level of servitization.

Digital servitization is defined as a transition process from pure products and add-on services to smart product-service systems. Product-service systems also include software, as defined by the first servitization study (Vandermerwe and Rada, 1988). As stated, in the context of servitization and product-service systems, a variety of concepts have been utilized, such as digital servitization, smart product-service systems, digitalized product-service systems, smart products, IoT, and the industrial internet, with various definitions. For a long time, studies have seen the opportunities that digitalization is generating for solution provider companies, suggesting that these industrial firms need to develop capabilities to seize these opportunities (Huikkola and Kohtamäki, 2017). As such, digital technologies should provide a platform for improved interactions with customers, enhancing data acquisition, data warehousing, big data analytics, and implementation (Cenamor et al., 2017; Eloranta and Turunen, 2016; Jayachandran et al., 2005). Hence, digital technologies should directly enhance the rationale of decision making by providing richer and more reliable data and analytics for decision making about customers and their fleets (Grubic and Jennions, 2018; Hasselblatt et al., 2018;

Jonsson et al., 2009). Digital technologies should therefore integrate effectively with fleet management, providing opportunities for improved product lifecycle management, servicing the lifecycle, optimizing the fleet, consulting the customer regarding new investments, and even selling outcome-based services instead of products (Visnjic et al., 2018). For instance, Visnjic et al. (2018: 46) argued that companies *"evolve the market strategy from provision of pure products to provision of services and then outcomes, in order to achieve a better fit with customer needs and to grow their service businesses."* However, this step requires an evolving capacity to understand customers and develop capabilities to find a better fit between customer needs and offerings.

In this study, digital servitization is viewed as the use of digital technologies to create and appropriate value from product-service offerings; thus, digital servitization is understood as the interplay between digitalization and servitization. Servitization is required to appropriate value from digitalization for higher financial performance of a manufacturing company. Hence, for the present study, service scope provides a vehicle to study the interaction between digitalization and servitization, e.g., to what extent the interaction between digitalization and servitization explains the financial performance of manufacturing companies.

2.3. Research model and hypotheses

Fig. 1 describes the research model, main constructs and hypotheses, and the controlled relationships for company financial performance. In the study, the direct effect of six variables was controlled, such as the direct effects from digitalization and servitization, and then the effects of four control variables such as total assets, cash flow, number of patents, and company size. The following sections provide the rationale for our nomological model, the main hypothesis arguing for the nonlinear interaction effect of digitalization and servitization on company financial performance.

2.3.1. The interaction between digitalization and servitization

In transition to digital servitization, solution providers develop their service offerings to strengthen their scope of product-service systems, integrated solutions, or hybrid offerings (Rabetino et al., 2015). As such, digitalization provides capable technologies in the form of hardware and software to be utilized for improved value creation and appropriation (Porter, 2001; Wamba et al., 2017). In the deployment of advanced digital technologies related to data acquisition, warehousing, analytics and implementation, technological capabilities are insufficient to generate financial value, and instead, sufficient organizational resources and processes are required to create and appropriate value from digitalization (Cenamor et al., 2017; Coreynen et al., 2017; Kim et al., 2005). Here, we hypothesize how servitization, reflected by the scope of service offerings, enables coping with the so-called digitalization paradox.

The scope of service offerings provides a reflection of the company's servitization strategy and business model (Partanen et al., 2017). The company business model defines how the company intends to create and capture value in the markets – the strategy is required to create and appropriate value from the company systems, processes, resources and competencies. A broader scope of offerings provides a larger capacity to customize solutions offerings for higher prices. However, the offerings should fit with the technological capabilities (Frank et al., 2019). Often, the modularity of solutions plays a key role (Hellström, 2014; Kohtamäki et al., 2018; Rajala et al., 2019). The potential value of digitalization must be captured by the solutions offerings sold for industrial customers. These offerings embed smart solutions and services, such as R&D, optimization, operational and performance services. *"Only when the information technology is embedded into organizational processes (e.g., strategy making) is it expected to offer sustainable benefit"* (Kim et al., 2005: 170). Thus, to carve out the value from IT investments, those investments must align with the company strategy and business model.

The present study suggests that servitization could mitigate the value leakage related to higher levels of digitalization. We hypothesize a nonlinear, U-shaped effect of the interaction between digitalization and servitization on company performance. From a low to moderate level of digitalization, we hypothesize a negative effect of the interaction between digitalization and servitization. Despite the increases in digitalization, servitization, from a low to moderate level of digitalization, fails to produce a positive financial impact. At a low level of digitalization, there is not much value to be captured, and hence, the overly expensive development-related capabilities, without the necessary strategic emphasis of digitalization in the company strategy, may consume the potential value. Instead, value capture requires extensive commitment to the development of digitalization and servitization to generate financial value from their interplay (Kohtamäki et al., 2019). At higher levels of digitalization, servitization enables improved capacity to appropriate value from digitalization, as value can be appropriated by effective pricing of advanced services. Moreover, a broader portfolio of services (e.g., service scope) increases the opportunity to serve diverse customer segments that may benefit from highly customized offerings, while digitalization provides the backbone to implement this with lower coordination and implementation costs. Thus, increases in digitalization should be supported by the servitization and scope of service offerings to capture the financial benefits of digitalization, i.e., data acquisition, analytics and implementation.

To have a significant positive influence on financial performance, the manufacturing company has to invest enough in digitalization and servitization, so-called digital servitization. Significant investments in

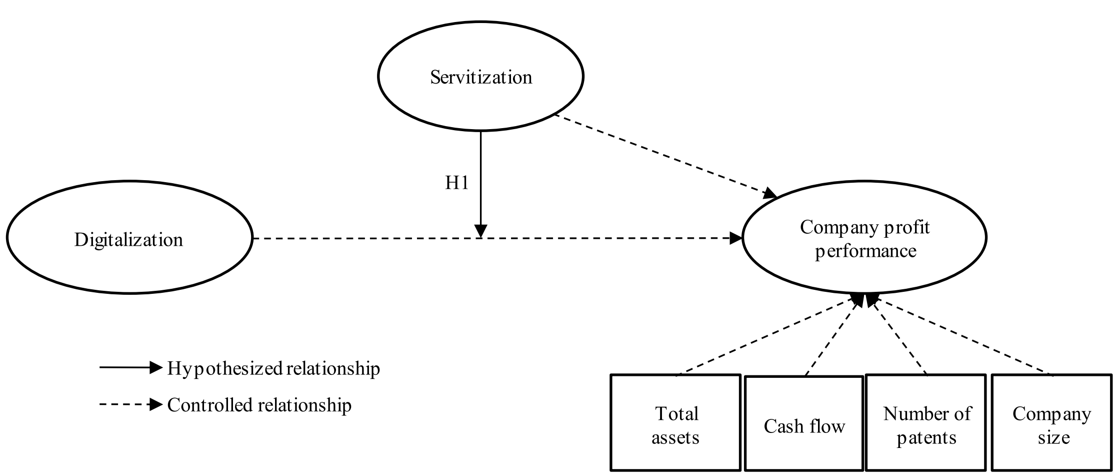

Fig. 1. The research model.

digital servitization bring these new innovations to the forefront, making digital servitization visible for R&D, solution sales and delivery. Similar findings have been previously made in servitization research, where researchers have found that the visibility of service offerings plays a significant role in their performance impact – thus, a company should pay enough attention to strategic initiatives to make an impact (Fang et al., 2008; Kohtamäki et al., 2013). Particularly strong strategic emphasis is needed in a traditional manufacturing firm operating in a relatively conservative sector; this has been demonstrated by some high-profile CEOs arguing how manufacturing companies should become software firms (Porter and Heppelmann, 2015) – a transition that has recently been coined as digital servitization, where not only the services but the software in particular play a significant role. Thus, to implement digital servitization to an extent that it has an impact on company financial performance, significant strategic emphasis is required.

Finally, the combination of digitalization and servitization may provide the best configuration for operating in a complex and uncertain “joint sphere” of customized, integrated solutions, where a broad scope of offerings enables this customization to fully explore and utilize the value of digitalization (Kohtamäki et al., 2019). This situation is related to the explorative innovation stage of digitalization, where manufacturing companies significantly expand software competencies but also continue to explore how to exploit the software capabilities for improved value creation and capture. In this context, servitization provides valuable support when carving out the value from investments in digitalization. Companies geared towards servitization may be more capable of adapting new digital technologies. Thus, servitization capabilities enable manufacturing companies to avoid the learning trap created by the digitalization paradox.

H1: Servitization mitigates the inverted U-shaped relationship between digitalization and company financial performance. Moderate to high levels of digitalization combined with high levels of servitization lead to increased financial performance in manufacturing companies.

3. Methods

3.1. Sample and data collection

To test for the proposed hypotheses, a survey study targeting Swedish manufacturing firms was conducted in 2014, and the outcome data (i.e., performance data) were derived from archival sources to lower common method bias. The digitalization and servitization literature has focused predominantly on understanding the transformation of manufacturing firms from product providers to digital service providers (Baines et al., 2009). Therefore, consistent with prior studies, we investigate the influence of digitalization on firm performance moderated by the servitization of manufacturing firms. The survey focused on four manufacturing sectors: machine and equipment manufacturing, computer, electronics, and optical product manufacturing, electrical equipment, and telecommunications manufacturing.

Two additional filters were used to identify the sampling frame. First, our sample consists of manufacturing companies with more than 10 employees to ensure that we exclude microenterprises (as per European Union (EU) definition), as they have a limited ability to offer portfolios for services (Kohtamäki et al., 2013). Second, to ensure that the firms have ongoing business activities, firms with sales lower than USD 150,000 were excluded. Based on these criteria, we randomly selected 1000 manufacturing companies from the ORBIS database.

A self-administered questionnaire was developed for a postal survey study. The variables and items in the questionnaire were adapted from prior studies and then translated and back-translated (English-Swedish-English) by two researchers to confirm translation equivalence (Brislin, 1970). Moreover, the questionnaire was pretested with four managers from manufacturing companies and four academic experts. Their feedback was incorporated into the questionnaire. To encourage participation, the survey was complemented with a cover letter motivating the purpose of the study. In the cover letter, participants were assured anonymity. The survey was addressed to the CEO or a manager who was responsible for digitalization-based business development (due to their ability to provide an overview of the firms’ operations related to the application of digitalization technologies for business growth) (Cenamor et al., 2017). After the initial mailing, the researchers sent two additional reminder letters to the sample firms.

In total, we received 135 responses from the firms in which we excluded four questionnaires that were incomplete. This final dataset with all the relevant variable information led to 131 responses, representing a 13% response rate. We regard the response rate to be satisfactory given the increased data collection efforts from researchers and similar responses in other management surveys (Baruch, 1999).

4. Variables

4.1. Dependent variable

To complement the survey data, we collated data on the dependent variable through secondary sources. However, as the existing activities related to digitalization and service scope can have a lag effect on firm performance, we focused on three-year returns on assets (ROA) growth (2013–2015). Prior studies have called for inclusion of secondary financial data to be used in the servitization and digitalization literature (Kohtamäki et al., 2013). Table 1 summarizes the constructs and variables used in the study.

4.2. Independent variable

The measurement of digitalization is based on a refined version of the scale of digital technology use for customer relationship management (Jayachandran et al., 2005). Digitalization holds the promise to generate higher value for customers by improving the extent of interaction and communication based on the use of digital technologies for relationship management. We used four subconstructs: digital sales support (e.g., “we use digital technologies for providing the sales force in the field with customer information”) ($\alpha = 0.84$), digital service support (e.g., “we use digital technologies for providing customized service scripts for the particular customer's needs”) ($\alpha = 0.70$), digital analysis support (e.g., “we use digital technologies for providing forecasts on customer preferences and needs”) ($\alpha = 0.79$), and data integration and access support (e.g., “we use digital technologies for integrating customer information from different contact points”) ($\alpha = 0.75$). Each item was measured using a 7-point scale from “1″ = strongly disagree to “7″ = strongly agree. The Cronbach's alpha for the combined construct was 0.89.

4.3. Moderating variable

The scale for service scope is a reflective 22-item scale based on prior studies (Kohtamäki et al., 2013; Partanen et al., 2017). The proposed scale maps and measures the extent to which practical services are offered to the customer based on a seven-point scale (1 = not at all to 7 = to a large extent). The scale includes three subconstructs: operational services (e.g., “managing the customer's maintenance function, service for operating the product sold to the customer, providing performance guarantees and others”) ($\alpha = 0.76$), R&D services (e.g., “prototype design, prototype development and testing, analyses of the product's manufacturability, and others”) ($\alpha = 0.91$), and consulting services (“technical consulting, process-oriented consulting, product user training, and others”) ($\alpha = 0.78$). Here, we focused on measuring the advanced components of servitization, as most companies provide basic services to some extent, and therefore, the basic services do not vary between companies (e.g., “most of the companies provide some form of warranty and spare parts”). Hence, to study the level of

Table 1
Measurement constructs and items.

Main constructs and items
Servitization (Based on Kohtamäki et al., 2013; see also Partanen et al., 2017)
Operational services (OS)
1 Managing the customer's maintenance function
2 Service for operating the product sold to the customer
3 Service for operating the customer's process
4 Outsourcing services
5 Providing performance guarantees
6 Selling performance without selling the actual product
R&D services (RD)
1 Prototype design
2 Prototype development and testing
3 Product design
4 Product development
5 Analyses of product's manufacturability
6 Factory design
7 Process design
8 R&D-oriented support
9 Feasibility studies
Consulting services (CS)
1 Technical consulting
2 Business consulting
3 Process-oriented consulting
4 Product user training
5 Product demonstration
6 Customer seminars
7 Writing informal material
Digitalization (based on Jayachandran et al., 2005)
Digitalization of sales support -
1 Provides sales force in the field with customer information
2 Provides sales force in the field with competitor information
3 Assigns leads and prospects to appropriate sales personnel
4 Provides customized offers to salespeople in the field
Digitalization of service support
1 Allows customer support personnel to access data on customer interactions with all functional areas
2 Provides customers access to a knowledge base of solutions to commonly occurring problems (e.g., frequently asked questions)
3 Schedules and tracks service delivery
4 Is able to customize service scripts to particular customers' needs
Digital analysis support
1 Enables assessment of channel performance
2 Enables forecast of customer preferences
3 Measures customer loyalty
4 Calculates customer lifetime value
5 Enables the assessment of service profitability
Data integration and access support
1 Combines customer transaction data with external source data
2 Integrates customer information from different contact points (e.g., mail, telephone, Web, fax)
3 Allows relevant employees access to unified consumer data
Dependent variable
Financial performance (ROA growth 2013–2015)
Control variables
Number of employees
Total assets
Number of patents
Cash flow

servitization, it is more relevant to measure advanced services.

4.4. Control variables

We controlled for the effect of alternate variables on the proposed relationships. We controlled for company size (number of employees), total assets, cash flow, and number of patents. Company size controls for firm stability because more stable firms would commit to increasing their employee base. The cash flow and total assets can influence the relationship between digitalization and higher performance. Finally, property rights protection can give certain firms a favorable advantage because they can mitigate competition and lock-in customers, leading to higher performance; therefore, we controlled for the number of patents granted. Finally, we also controlled for the direct effect of servitization, which we used as the moderating variable. Servitization has been found to affect company performance (Kohtamäki et al., 2015) Table 1.

5. Results

The analyses begin by presenting a correlation matrix. Then, the results of the regression analyses with the plotted curves are presented. Table 2 presents the number of cases, the mean, minimum and maximum values, standard deviations, and correlations between the measures.

The proposed research model was tested using a multilevel speciation, *mixed* routine in Stata 14.0. Industry membership is the level 2 variable. The model was analyzed against the ROA growth variable for 2013–2015. The research model was analyzed in three steps, namely, the effects of control variables in model 1, the direct and nonlinear effects of the main independent variable in model 2, and in model 3, the added direct effect of servitization and, in particular, the moderating effect of servitization on the linear and nonlinear relationships. The results of the multilevel analysis are reported in Table 3.

The present study and model 1 (Table 3) control for the effects of the control variables, such as total assets, cash flow, number of patents, and company size. While total assets, number of patents, and company size demonstrate no significant effects on the dependent variable, the effect of cash flow is marginally significant.

In Model 2 in Table 3, the linear term is positively associated ($\beta = 5.460$, $p < 0.05$), and the squared term of digitalization is negatively associated ($\beta = -0.794$, $p < 0.05$) with ROA growth. Fig. 2 supports the proposed hypothesis.

Hypothesis 1 proposed that the scope of service offerings moderates the inverted-U shape effect of digitalization on performance, such that the decreasing returns from digitalization to firm performance are mitigated by higher levels of servitization. The third model adds servitization as a component to the model and tests the moderating effect of servitization on digitalization. In Model 3 in Table 3, the interaction term of service scope and the squared term of digitalization associated with ROA growth are significant ($\beta = 1.038$, $p < 0.05$). Figure 2 shows that at high levels of digitalization, ROA growth is greater for higher levels of servitization. The results provide support for Hypothesis 1, particularly at higher levels of digitalization, where the marginal effects

Table 2
Correlation matrix.

Variable	Mean	SD	Min	Max	1	2	3	4	5	6
1 Company financial performance	0.088	9.327	−35.726	96.759	1					
2 Digital servitization	3.325	1.350	1	6.083	0.0468	1				
3 Servitization	2.984	1.095	1	5.392	0.0083	0.6102*	1			
4 Number of employees	208.741	842.342	15	9036.000	−0.0049	0.2160*	0.1437	1		
5 Total assets	766,239.700	3,182,556.000	12,643	25,600,000	−0.0037	0.2617*	0.2097*	0.8130*	1	
6 Number of patents	19.985	136.046	0	1530.000	−0.0013	0.1566	0.0956	0.9330*	0.6905*	1
7 Cash flow	8.167	15.293	−64.414	99.546	0.0601	0.2570*	0.1984*	0.064	0.2944*	0.0075

* $p < 0.05$ (two-tailed).

Table 3
Multilevel moderated regression results.

VARIABLES	Model 1 Company profit performance	Model 2 Company profit performance	Model 3 Company profit performance
Digitalization		5.460**	25.01**
		(2.331)	(11.28)
Digitalization squared		−0.794**	−3.789**
		(0.393)	(1.866)
Servitization			9.626***
			(2.583)
Digitalization* Servitization			−7.003***
			(2.703)
Digitalization squared* Servitization			1.038**
			(0.451)
Number of employees	2.12e-05	0.000102	3.33e-05
	(0.000804)	(0.000554)	(0.000702)
Total assets	−1.24e-07	−4.72e-08	−7.74e-09
	(1.06e-07)	(1.23e-07)	(1.65e-07)
Number of patents	0.00172	0.00117	5.49e-05
	(0.00383)	(0.00223)	(0.00291)
Cash flow	0.0418*	0.0238	0.0134
	(0.0221)	(0.0296)	(0.0440)
Constant	−0.120	−7.992***	−33.25***
	(1.011)	(2.260)	(10.82)
P-value	4.752	59.25	103
Chi-squared	0.314	<0.001	<0.001
Observations	131	131	131
Number of groups	18	18	18

Robust standard errors in parentheses.
* $p<0.1$.
** $p<0.05$.
*** $p<0.01$.

demonstrate significance (from approx. 4.9 to 6 on the x-axis). The marginal effect is also significant at intermediate levels of digitalization (from approx. 4.0 to 4.6). Thus, the results demonstrate the significant interaction at a high level of digitalization (see the plotted curves in Fig. 2).

6. Discussion

6.1. Theoretical contribution

The present study set out to challenge the simple linear assumptions underlying the causal relationship between digitalization and company performance to analyze the financial impact of digital servitization, which is the interplay between digitalization and servitization. In particular, we find a significant nonlinear, U-shaped effect of the interaction between digitalization and servitization on company financial performance. Moreover, the study also revealed a nonlinear, inverted U-shaped effect of digitalization on company financial performance; however, due to a lack of significance for the margin's effects for this direct nonlinear effect of digitalization, we do not infer significance. Finally, the results demonstrate a direct relationship between servitization and company financial performance, a relationship that has been much debated in the prior literature. The study provides an alternative explanation for the complex interplay between digitalization, servitization and financial performance (Luoto et al., 2017).

As the main contribution of the study, we find a nonlinear U-shaped interaction between digitalization and servitization on company financial performance. From low to moderate levels of digitalization, the interaction effect between digitalization and high servitization on company financial performance is negative and significant. From moderate to high levels of digitalization, the interplay between digitalization and high servitization becomes positive and significant, improving company financial performance. Thus, the results reveal the need for servitization in carving out positive financial performance from digitalization. In this interplay, the results also emphasize the need for high investments in digitalization. Thus, the results emphasize the need for effective interplay between digitalization and servitization, the true need for digital servitization. Without interplay, manufacturing companies may face the paradox of digitalization.

Based on the results of the empirical study, we conclude that servitization matters for the digitalization of a manufacturing company. The present study provides evidence on the complex relationship

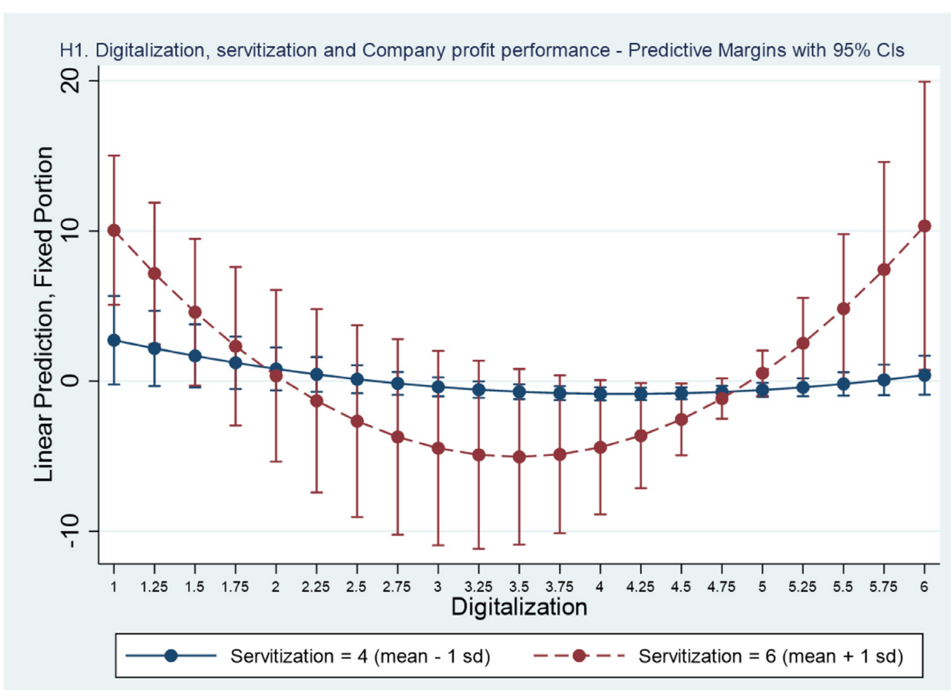

Fig. 2. The moderating effect of servitization on the nonlinear relationship between digitalization and company financial performance.

between digitalization and company financial performance and the existence of a digitalization paradox. Finally, the empirical study also demonstrated the controlled direct effect of servitization on companies' financial performance. This effect is interesting, as it provides further evidence on the direct financial benefits of servitization in manufacturing companies by using ROA growth as an archival measure of companies' financial performance (Wang et al., 2018).

6.2. Managerial implications

The results of this study have significant implications for industrial manufacturing companies implementing digital servitization. Simple, easy-to-implement IT systems seem to produce a direct effect on companies' financial performance if the deployment costs are low. At higher quality and cost levels, IT investments should be supported by other organizational capabilities, making the investments even more difficult and expensive to implement. From moderate to high levels of digitalization, investments should be supported by the development of higher levels of servitization, which materialize as advanced service offerings and possibly other organizational capabilities. It seems that servitization may enable companies to cope with the digitalization paradox. The development of both digitalization and servitization occurs through complex processes of organizational change (Bigdeli et al., 2017; Martinez et al., 2017; Martinsuo and Hoverfält, 2018; Raddats et al., 2017), and the simultaneous evolution of these processes requires ambidextreous innovation capabilities.

6.3. Limitations and suggestions for further research

As with every study, the current study is not without limitations. The present study uses a relatively small sample of Swedish manufacturing companies, which may limit generalizability. Future studies can focus on additional moderators and mediators to further unpack the nonlinear relationship between digital servitization and company performance. Furthermore, as the present study tested the link between digitalization and financial performance, the effects of digitalization should be further studied to a variety of additional outcome variables, such as sales growth and company market value. Finally, in-depth qualitative studies could help develop a more detailed understanding of the needed capabilities, practices and microfoundations.

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