The order of the factors matters

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The Order of the Factors Matters: How Digital Transformation and Servitization Integrate More Efficiently

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Abstract

This article draws on existing debates on standardization versus adaptation to propose two possible pathways for digital servitization. On the one hand, the standardization pathway posits that digital transformation enables servitized firms to make their service-based business model more standardized, and as a result, scalable. On the other hand, the adaptation pathway advocates that servitization enables highly digitalized firms to make their digital offerings more adaptable to heterogeneous customer needs, and as a result, customizable. We investigate which of these two paths integrates more effectively, and which one is thus likely to prevail in the long run. We use a purpose-built survey of 127 Spanish product firms to test these relationships using partial least squares structural equation modelling (PLS-SEM), and test single- and multi-mediation models. The results corroborate the existence of both pathways, but also suggest that the standardization pathway contributes more to performance than the adaptation pathway. This is consistent with historical transitions in adoption (services existed before digital transformation) and services being dependent on digital technologies delivered remotely. These findings suggest the benefits of customization in digital servitization are lower than previous studies seem to imply, and provide important managerial implications.

Keywords. Servitization; Digital transformation; Digital servitization; Standardization, Adaptation; Operational performance.

1. Introduction

Digital servitization unites two contemporary business trends: digital transformation and the integration of products and services into a unified offering, known as servitization, in order to propose an enhanced business model (Coreynen, Matthyssens, & Van Bockhaven, 2017; Vendrell-Herrero, Bustinza, Parry, & Georgantzis, 2017). This has become an increasingly accepted concept in academia (Paschou, Rapaccini, Adrodegari, & Saccani, 2020). For example, approximately 50% of firms in OECD countries are engaged in digital servitization, which has recorded a consistent annual growth rate of over 4% globally over the past decade.[1]

While extant research has extensively documented successful instances of the convergence of these trends (Gebauer, Paiola, Saccani, & Rapaccini, 2021; Kamalaldin, Linde, Sjödin, & Parida, 2020; Paiola & Gebauer, 2020; Tronvoll, Sklyar, Sörhammar, & Kowalkowski, 2020), there is a notable gap in the literature concerning a critical and comprehensive pathway analysis on how the synergistic interplay of servitization and digital transformation contributes to operational performance. Notably, the literature predominantly focuses on a specific pathway originating from digital transformation, leaving the alternative route, commencing with servitization, largely unexplored. This differentiation carries substantial managerial implications, as we contend that the efficacy of digital servitization is, to some extent, contingent on how these two activities are amalgamated in terms of sequence and approach. This pivotal point is underscored in a recent editorial by Opazo et al. (2024), which, as a platform for future research on the

[1] The authors have estimated these figures utilizing the OECD Going Digital toolkit, with a specific focus on the proportion of businesses purchasing cloud services. Further details can be found here https://goingdigital.oecd.org/indicator/25

origins, progress, and challenges in digital servitization, poses the following questions: "*Do companies typically develop digital servitization from inception, or do they start with digital capabilities followed by service integration? Alternatively, is the process reversed, beginning with the addition of new services and subsequent integration of digital capabilities? Additionally, do these different routes create the same value, or is there an optimal approach?*" Altogether, the primary objective of our study is to provide answers to these questions.

To date, all empirical articles that have attempted to discern the optimal pathway for the integration of digital servitization have put forth a narrative of customization.[2] In other words, companies employ services to tailor their digitized offering to their customers. From an empirical standpoint, servitization is often regarded as a mediating variable (Abou-foul, Ruiz-Alba, & Soares, 2021; Davies, Bustinza, Parry, & Jovanovic, 2023; Harrmann, Eggert, & Böhm, 2023; Colin Schulz, Sebastian Kortmann, Frank T. Piller, & Patrick Pollok, 2023; Yang, Zhang, & Zhang), or in some cases, a moderating one (Kohtamäki, Parida, Patel, & Gebauer, 2020; Li, Zhang, Yang, & Wei, 2023), between digital transformation and firm performance. However, we posit an alternative perspective. Servitized companies may choose to incorporate digital functionalities into their offerings as a strategy aimed at enhancing standardization and scalability within their product-service portfolio. Empirically, this standardization narrative implies that digitalization could mediate the relationship between servitization and firm performance.

[2] Some papers, such as those by Zhou, Yan, Dai, and Feng (2021), have explored the interaction effect between digitalization and servitization, but do not provide guidance on the sequence or order of these factors.

Hence, the alignment of these two apparently contradictory paths regarding digital servitization—standardization versus customization—accords with a central tenet in the management literature (Katsikeas, Samiee, & Theodosiou, 2006). On the one hand, subscription-based business models such as Spotify are an example of the customization pathway, through which a company transforms a product (e.g., a CD) into a digital token (e.g., downloads), but later offers it as a service (e.g., stream) to better accommodate consumers' needs (Parry, Bustinza, & Vendrell-Herrero, 2012). Similarly, autonomous vehicle solutions would fit into the customization pathway, as the process starts with digitalization of resources (e.g., vehicles) and continues with the addition of customized solutions (e.g., services) (Leminen, Rajahonka, Wendelin, Westerlund, & Nyström, 2022). On the other hand, business models based on the shared economy (e.g., Uber) would be an example of the standardization pathway. A service (e.g., a ride) becomes more efficient with more digital technologies (Reuschl, Tiberius, Filser, & Qiu, 2021). Another example of standardization is advanced service models (e.g., Rolls Royce's Power-by-the-hour) in which manufacturing companies monitor and escalate their services through digital technologies, i.e., data obtained from sensors enable a more efficient service delivery (Bigdeli, Baines, & Kapoor, 2022).

In this study, we propose two mediation models. In both cases the dependent variable is operational performance (P), but in each of these models the role of servitization (S) and digital transformation (D) is reversed, i.e., the roles of the independent variable and mediating variable are reversed, which allows us to associate the models with the pathways specified above. When servitization is the mediating variable (DSP) we refer to the customization pathway; conversely, when digital transformation is the mediating variable (SDP), we refer to the standardization pathway.

With this approach we can determine which pathway offers the highest complementarity between servitization and digital transformation – the one that starts with servitization (SDP – standardization pathway) or the one that starts with digital transformation (DSP – customization pathway).[3] We test these models with a purpose-built survey of 127 Spanish companies through partial least squares structural equation modelling (PLS-SEM), and find that the standardization pathway seems to be more effective in deploying integrated digital servitization business models.

This study makes several notable contributions to the existing literature. Firstly, to the best of our knowledge, this article stands as the inaugural work employing widely recognized management frameworks, specifically focusing on standardization versus customization, to conduct a comprehensive analysis of the theoretical pathways leading to digital servitization. This approach mitigates the escalating prevalence of arguments favoring the customization path and accentuates the critical role of standardization in the context of digital servitization. Secondly, the study addresses numerous calls for quantitative investigations that scrutinize the interconnection between servitization and digital transformation (Shen, Sun, & Parida, 2023). Lastly, the article introduces a straightforward methodology with broader applicability to diverse industrial and geographic contexts. In this respect, we propose a solution involving a comparison of reverse mediation models, wherein the focus is on evaluating the ratio of the partial

[3] It is important to highlight that we are not comparing two models of the same equivalence class to determine which is best to explain operational performance (see Thoemmes, 2015). Rather, we are examining two theoretically plausible relations to determine in which form digital transformation and servitization seem to integrate more effectively into a digital servitization model. As a robustness test, we also consider a model in which both digital transformation and servitization are mediators, and the independent variable is human capital, which is arguably an antecedent of both (see section 5.2 for further details).

mediation effect relative to the full effect. Additionally, we recommend employing multi-mediation models that have a common antecedent as the independent variable and reverse the roles of factors as mediators. As this method advances, it may evolve into a meta-analysis approach, facilitating a comprehensive assessment within the overall research landscape to determine which pathway effectively integrates into a digital servitization model (Nohe, Meier, Sonntag, & Michel, 2015).

2. Background literature

2.1 Digital servitization

Digital servitization refers to the process by which companies integrate digital technologies into their services to create more value for customers (Paschou et al., 2020). In essence, it is the transformation of a traditional product-based business model into a more service-oriented one, with the help of digital technologies (Coreynen, Matthyssens, & Van Bockhaven, 2017).

Digital servitization can be applied to a wide range of industries, including industrial equipment, healthcare, technology, defense, and tourism, among others (Gebauer, Paiola, Saccani, & Rapaccini, 2021). The basic idea is to use digital technologies such as the internet of things (IoT), artificial intelligence (AI), and cloud computing to enhance the value of products by adding services that complement them (Kamalaldin, Linde, Sjödin, & Parida, 2020). For example, a company that sells industrial equipment may offer a digital monitoring service that employs IoT sensors to track the performance of the equipment and provide real-time data to customers (Vendrell-Herrero et al., 2023). This allows customers to optimize the use of equipment and reduce downtime, ultimately improving their productivity and profitability. Similarly, a

healthcare provider may use AI algorithms to analyze patient data and provide personalized treatment recommendations to doctors (Demonaco, Oliveira, Torrance, von Hippel, & von Hippel, 2020). This can improve the quality of care and outcomes for patients, while reducing costs for healthcare providers.

One of the key benefits of digital servitization is that it allows companies to create new revenue streams by charging for digital services that were not previously offered. It also can help companies internationalize their revenue streams, and thus reduce their dependence on home-market sales (Kolagar, Reim, Parida, & Sjödin, 2021; Shleha, Vaillant, & Vendrell-Herrero, 2023). Another benefit is that digital servitization can build stronger relationships with customers and increase customer loyalty and retention by providing valuable services that complement the company's products (Jang, Bae, & Kim, 2021). This can also help to differentiate the company from its competitors and create competitive advantage (Coreynen, Matthyssens, & Van Bockhaven, 2017).

However, implementing digital servitization can also present challenges for companies. For example, it may require significant investments in new technological capabilities, and involve changes to organizational structures and processes (Sjödin, Parida, Kohtamäki, & Wincent, 2020). There may also be important changes in supply chain dominance, and new entrants may be capable of capturing more value than incumbents (Vendrell-Herrero et al., 2017). Despite these challenges, digital servitization is becoming increasingly important for product firms looking to stay competitive in today's digital age. By embracing this approach, companies can unlock new opportunities for growth and innovation while creating more value for their customers.

2.2 Standardization versus customization strategies

The question of standardization versus customization is a major, long-standing, and ongoing debate in the management literature, as this is a strategic choice affecting most areas of a firm, including marketing, production, and human resources (Katsikeas, Samiee, & Theodosiou, 2006). On the one hand, standardization refers to the practice of creating a standardized marketing mix, including product, price, promotion, and place that is identical across all markets (Jain, 1989). On the other hand, customization involves adapting the marketing mix to suit the specific needs and preferences of each customer (Cavusgil, Zou, & Naidu, 1993).

Proponents of standardization argue that it provides a number of benefits, including cost savings, brand consistency, and ease of implementation (Samiee & Roth, 1992). By creating a standardized marketing mix, companies can achieve economies of scale in production, purchasing, advertising, and distribution, which can result in lower unitary costs and increased profitability (Tan & Sousa, 2013). Additionally, a consistent brand image can help build brand awareness and loyalty across multiple markets, thereby driving enhanced revenues (Martinez & De Chernatony, 2004). Standardization also plays a pivotal role in facilitating a company's internationalization endeavors (Tallman & Fladmoe-Lindquist, 2002). By using a standardized approach, product firms can establish streamlined and efficient processes and systems that reduce the time and resources expended in managing multiple markets in business-to-consumer scenarios (Kaynak & Hassan, 2014) and multiple customers in business-to-business (Momeni, Raddats, & Martinsuo, 2023) contexts. This, in turn, enables companies to redirect their focus towards other critical areas of their operations, such as product development.

Opponents of standardization argue that it overlooks important cultural and social differences between markets, and may not effectively address the needs and preferences of consumers in different regions (Verhage, Dahringer, & Cundiff, 1989). They contend that companies must adapt their marketing mix to suit the unique characteristics of each market, including cultural norms, language, and legal requirements (Franke, Keinz, & Steger, 2009). For instance, an automotive company may need to tailor its vehicle models and marketing strategies to align with market-specific preferences, driving conditions, and regulatory requirements. Similarly, a wind turbine manufacturer may need to tailor its product offerings to align with environmental conditions. Furthermore, customization can facilitate the establishment of more robust relationships with diverse stakeholders within business ecosystems (Grönroos, 1994). By demonstrating a comprehensive understanding of customer culture and values, product-centric enterprises can position themselves as reliable collaborators and contributors within broader ecosystems, thereby enhancing the cultivation of enduring customer relationships over the long term (Freixanet & Federo, 2023).

Ultimately, the decision between standardization and customization depends on a number of factors, including the industry, target market, and the relevant company's resources and capabilities (Ansari, Reinecke, & Spaan, 2014). Companies operating in industries with very similar requirements, such as industrial equipment, may benefit from a standardized offer, while those operating in industries that require more cultural sensitivity, such as medical and healthcare services, may need to adapt their marketing mix to suit customers' needs and preferences. Furthermore, companies targeting global consumers may particularly need to find a balance between standardization and customization (Svensson, 2001). Global companies can benefit by selling a standardized

core offering that maintains essential consistency across all markets, while incorporating select features that enable adaptation to specific customer needs and preferences. For example, a global consumer goods company may create a standard product line and packaging that remains consistent across all markets, while also adapting marketing messages and promotions to align with local cultural norms and values. In sum, the standardization versus customization debate is an ongoing and complex discussion that is highly relevant to multinational and exporting firms.

We draw on the customization versus standardization dilemma to differentiate two implementation pathways within a digital servitization strategy. Digital servitization has a customization component based on services, and a standardization component based on digitalization. We argue that the order in which these elements are amalgamated is significant. Indeed, the fact that the order of the two elements matters is part of our empirical analysis and a central tenet of our theoretical arguments. In the next section, we elaborate on how the implementation pathway impacts the type of digital servitization being delivered and its underlying value.

3. Hypotheses development

3.1 The standardization pathway

Digitalization has revolutionized the way businesses operate, and one of its most significant benefits is its ability to boost product standardization and scalability (Teece, 2018). By leveraging digital tools and technologies, companies can automate and streamline their production processes, making it easier to maintain consistent quality standards across all products (Sharma & Joshi, 2023). This not only ensures that customers receive a consistent experience, but also allows companies to scale their operations more efficiently (Huang, Henfridsson, & Liu, 2022). Furthermore,

digitalization allows for real-time monitoring and analysis of production data, making it easier to identify areas in which improvements can be made and to make adjustments quickly (Halawa et al., 2020).

Similarly, digital technologies have transformed the ways in which services can be produced and delivered, thus allowing for greater standardization and scalability of services (Sjödin et al., 2020). By using digital tools such as automation, analytics, and AI, companies can streamline their service processes and ensure consistent delivery of high-quality services to their customers (Vendrell-Herrero, Bustinza, & Vaillant, 2021). One way digital technologies can be used to standardize services is by automating routine tasks (Leminen et al., 2022). Automating tasks such as appointment scheduling, data entry, and customer inquiries enables companies to reduce the risk of human error and ensure the same process is followed every time. This improves the quality and consistency of the service, which is essential for building customer loyalty.

Digital technologies also play a crucial role in enabling firms to systematically analyze customer feedback and service-related data, facilitating the identification of areas that require enhancement (Correani, De Massis, Frattini, Petruzzelli, & Natalicchio, 2020; Jovanovic, Sjödin, & Parida, 2022). For instance, companies can harness tools that engage customer feedback surveys and social media monitoring systems to gain in-depth insights into customer preferences (Cartwright, Liu, & Raddats, 2021). This valuable data can then be leveraged to enact targeted improvements within the service offering, including the optimization of service processes or the development of new features aligned with customer needs. Consequently, digitization empowers firms to discern patterns in consumer behavior and deliver services that, while replicable, exhibit a personalized touch (Raddats, Naik, & Ziaee Bigdeli, 2022).

Digital technologies also allow for the use of standardized service platforms, which can be easily replicated and scaled up as needed (Choi, Feng, & Li, 2020). For example, companies can use cloud-based platforms to deliver services, allowing for seamless integration with other software systems and enabling services to be accessed from anywhere in the world. This makes it easier to deliver services to a larger customer base, increasing the scalability of the service offering.

In sum, we argue that digital technologies offer a range of tools and capabilities that can be leveraged to standardize services and increase scalability (Linde, Frishammar, & Parida, 2023), thus enabling companies to follow a standardization pathway. This would consist of adding services to the product offering (servitization) followed by the inclusion of digital technologies that enable higher efficiency in service provision leveraged by standardization. In that way, as Figure 1 illustrates, we posit that digitalization mediates the relationship between servitization and firms' operational performance (Servitization–Digitalization - Performance, SDP route).

Hypothesis 1: Digital transformation mediates the relationship between servitization and operational performance.

- Insert Figure 1 –

3.2 The customization pathway

Servitization enables companies to customize their products according to the specific needs of their customers (Rabetino, Harmsen, Kohtamäki, & Sihvonen, 2018). By providing services tailored to customers' individual needs, companies can increase the value of their products and build stronger relationships with their customers, leading to increased customer satisfaction and loyalty (Baines et al., 2017; Sousa & da Silveira,

2019). By providing customized services, companies can differentiate themselves from their competitors and offer unique value to their customers.

We argue that firms that have undergone digital transformation can leverage servitization to enhance and personalize their offerings to match consumer needs. For example, a highly digitalized firm that produces transport equipment can use IoT sensors to monitor the performance of its equipment in real time (Vendrell-Herrero et al., 2021; Ziaee Bigdeli, Bustinza, Vendrell-Herrero, & Baines, 2018). Such monitoring can subsequently be offered as a service (Ziaee Bigdeli et al., 2018). Consumers will benefit by receiving precise predictions on when maintenance or upgrades will be needed. This service not only ensures that the equipment always performs at its best, but it also provides customers with a more personalized experience tailored to their needs. This argument aligns with multiple recent empirical studies, which have identified services as both mediators (Abou-Foul et al., 2021; Davies et al., 2023; Harrmann et al., 2023; Schulz et al., 2023; Yang et al., 2023) and, in certain instances, moderators (Kohtamäki et al., 2020; Li et al., 2023) in the relationship between the digitalization of offerings and firm performance or growth.

In sum, we argue that servitization offers a range of customization capabilities firms can leverage to better adapt their offering to specific consumer needs, thus following a customization pathway (Colin Schulz, Sebastian Kortmann, Frank T Piller, & Patrick Pollok, 2023). Hence, we contend that a possible pathway of digital servitization can start by investing in digital transformation, and then be followed by a service implementation that enables a more customized offer, which, in turn, leads to more engaged and satisfied customers. This way, as Figure 2 shows, we posit that servitization mediates the

relationship between digitalization and firms' operational performance (Digitalization – Servitization – Performance, DSP route).

Hypothesis 2: Servitization mediates the relationship between digital transformation and operational performance.

- Insert Figure 2 -

3.3 The prevalence of standardization

So far, we have argued that there are two possible routes to take advantage of digital servitization: the standardization pathway (or SDP route), and the customization pathway (or DSP route). In this section, we discuss which of these routes is likely to prevail in the long run.

We argue that the standardization route will prevail for two reasons. First, there is a historical reason. The servitization literature emerged in the last two decades of the twentieth century with two seminal articles (Vandermerwe & Rada, 1988; Wise & Baumgartner, 1999). That literature presented servitization as a downstream move that was difficult to scale. This trend continued with a series of conceptual (Cusumano, Kahl, & Suarez, 2015; Oliva & Kallenberg, 2003; Tukker, 2004) and empirical (Kastalli & Van Looy, 2013; Neely, 2008) studies. But it was only after 2017 when digital servitization emerged (Favoretto, Mendes, Oliveira, Cauchick-Miguel, & Coreynen, 2022; Kohtamäki, Rabetino, Parida, Sjödin, & Henneberg, 2022). Digital technologies make it possible to scale services, and in recognition of this, digitalization and servitization seemed to be inseparable terms in the servitization literature. But this is not the case in the digitalization literature, which seems to have its independent line of research (Gong & Ribiere, 2021). This argument seems to indicate that servitization cannot be separated

from digitization, but digital transformation can be seen as independent from servitization.

Second, we argue that the success of servitization depends on firms' digital capabilities. If the services are limited, despite their capacity to generate added value for customers, they are unlikely to be scalable, which limits firm growth (Gebauer et al., 2021). We consider that this is the fundamental value of digitalization for companies. Through digitalization, services can be offered remotely and more efficiently (Opazo-Basáez, Vendrell-Herrero, & Bustinza, 2022). This dependency does not happen the other way around. Digitalization can benefit from the value of customization on sporadic occasions, but it is not a necessary condition for implementing scalable digital business models (Mithani, 2023).

In sum, as Figure 3 illustrates, we argue that the standardization pathway (SDP route) will be more effective in improving firm performance than the adaptation pathway because of historical and dependency reasons, thus prevailing in the long run. Based on these arguments, we propose the following hypothesis:

Hypothesis 3: The mediation role of digital transformation in the SDP route is stronger than the mediation role of servitization in the DSP route.

- Insert Figure 3 –

4. Data, method and measures

4.1 Data collection and sample

Our research focuses on product firms that have established a digital transformation department as the population of interest (Kretschmer & Khashabi, 2020). To identify these firms, we leveraged LinkedIn to identify managers whose role descriptions

emphasized the presence of a digital transformation department or similar entities. Then, we visited the companies' websites to confirm that they offered both products and services. Further details about these companies were retrieved from the SABI database. Based on this information, we ensured that these firms employed more than 20 full-time equivalent individuals and that their primary industries aligned with those typically encountered in digital servitization research (e.g., Vendrell-Herrero et al., 2021). In particular, we used the Spanish Clasificación Nacional de Actividades Económicas (INE, 2009) industrial classification system to narrow our analysis to firms operating primarily in either manufacturing (two-digit CNAE codes between 19 and 32) or technological services (two-digit CNAE codes 72). This approach acknowledges the potential for business hybridity, as previous research has noted that technological service firms may also offer products (Aquilante & Vendrell-Herrero, 2021; Harkonen, Haapasalo, & Hanninen, 2015; Wirtz, Fritze, Jaakkola, Gelbrich, & Hartley, 2021).

A total of 349 Spanish companies constitute the study population. Many of these companies are engaged in international activities, while others belong to international companies or groups of companies. To ensure respondents were acquainted with the survey questions, we limited participation to managers in one of the following positions: operations or production manager, digital transformational manager, human resources manager, and innovation or marketing manager. These managerial positions are distinguished by their profound understanding of the company and its products, enabling them to effectively assess the four constructs under examination in the empirical analysis. These constructs encompass the central elements for testing the hypotheses, which

include servitization, digital transformation, and operational performance. Additionally, we incorporated human capital for the purposes of conducting a robustness test.

We formulated a questionnaire that underwent scrutiny by four senior scholars who specialize in the fields of digital transformation and/or servitization. We also conducted a pre-test on four companies, using interviews to improve the clarity of the questionnaire and ensure effective, accurate, and unambiguous communication with the respondents. Data collection started by sending a private message on LinkedIn to targeted managers, encouraging them to participate in the study. This message explained the purpose of the research, data collection procedures, and confidentiality policies. Once the members targeted agreed to participate, we sent them a link to the electronic questionnaire. Typically, respondents self-reported their completion of the questionnaire. In cases where no response or confirmation was received within two weeks, we followed up once, but beyond that point, no further follow-up was conducted. Data collection took place between May and July 2022.

Finally, we received 127 complete answers, representing a response rate of 36.4% of the study population. This response rate is similar to the ones obtained by other survey-based studies in the management field (Chidlow, Ghauri, Yeniyurt, & Cavusgil, 2015). Table 1 shows the individual-level characteristics of respondents, which indicate they occupy significant positions within their respective companies and possess substantial experience in managerial roles. For example, 73.2% have more than 10 years of experience in such positions. The table also provides data on the age and educational background of the respondents.

- Insert Table 1 -

Respondent and non-respondent companies were compared in terms of general characteristics and model variables. These comparisons did not reveal any significant differences, suggesting no response bias. The study design aimed to ensure representation in terms of size, sector, age, and annual volume of sales.

Common Method Bias (CMB) may manifest when the same method or respondent is used to assess multiple constructs, potentially leading to the emergence of spurious correlations. As a preemptive measure against CMB, we implemented specific strategies. First, we ensured that our respondents were familiar with the study's subject matter, which pertained to service implementation and digital transformation (MacKenzie & Podsakoff, 2012). As Table 1 shows, the data reveal that 91% of respondents are responsible for functions such as operations, production, marketing, or digital transformation. Moreover, we conducted a standard validity assessment employing the unmeasured latent method factor (ULMF) procedure, which is designed to address potential ex-post CMB (Min, Park, & Kim, 2016). This procedure involves a confirmatory factor analysis (CFA) wherein all variables of interest in the study, including the dependent, independent, and moderating variables, are loaded onto a common method factor. The results from this model demonstrated poor fit and yielded insignificant outcomes. To further eliminate the possibility of CMB in our data, we performed a comprehensive collinearity test (Kock & Lynn, 2012), which assesses both vertical and lateral collinearity simultaneously. This procedure generates variance inflation factors (VIFs) for all latent variables in the model. A VIF value exceeding 3.3 is considered indicative of problematic collinearity and a potential sign of common method bias contamination. Our analysis revealed that none of the VIF values exceeded this threshold, thus reinforcing the assertion that our dataset is not affected by CMB.

4.2 Measures

We drew on extant literature for the design of the measurements, and used five-point Likert scales for all of them. To test the hypotheses, three variables were measured as multi-dimensional constructs, as we explain below.

Digital transformation comprised four dimensions: digital leadership, organizational agility, digital strategy, and transformational capabilities (e.g. see AlNuaimi et al., 2022) stem from adaptations of scales proposed by Chen and Chang (2013), Cegarra-Navarro et al. (2016), Li et al. (2021), and Nasiri et al. (2020). These scales facilitate the measurement of digital transformation across these four dimensions, offering a more comprehensive and representative assessment of the construct. In this study, digital transformation is treated as a unified reflective construct consisting of the four mentioned dimensions, encompassing a total of 16 items[4] (refer to Table A1 in the appendix for a detailed list of items).

We measured *servitization* following Bustinza et al. (2019), Kohtamäki, Parida, Oghazi, Gebauer, and Baines (2019) and Kohtamäki et al. (2020). We measured this variable as a unique reflective construct and used 41 items pertaining to clients' satisfaction and their participation in product development, the alignment of the product or service with clients' tastes, and IT outsourcing (refer to Table A2 in the appendix for a detailed list of items).

[4] Previous literature predominantly discusses the minimum number of items required to form a construct measuring a latent variable. However, research on the existence of an upper limit remains limited. Nevertheless, there is some evidence suggesting there may be no upper limit for reflective constructs, particularly those utilized in SEM-PLS methodology (Cheah, Sarstedt, Ringle, Ramayah, & Ting, 2018). Garson (2016) further suggests that an increased number of items per construct can mitigate bias in SEM-PLS analysis. Notably, any potential limit on the maximum number of items in SEM-PLS appears to be driven primarily by theoretical considerations (Lohmöller, 2013). Our reanalysis of the data, focusing on the five items with the highest relevance in the literature, produced qualitatively similar results. In some cases, the results became more statistically significant. The results of this analysis are available from the authors upon request.

Operational performance: To measure company effectiveness, extant research usually employs self-explanatory measures of performance, such as a change in market share, new product success, growth, and profitability (e.g., Freixanet & Rialp, 2022(Han, Kim, & Srivastava, 1998). As previous tests have demonstrated (Dess & Robinson, 1984), subjective and objective performance outcomes are highly correlated. We included subjective measures of the usual indicators of performance, i.e., change in the quality of products, market share, growth, and profitability. Thirty-one items comprised the final scale, and this construct was processed as reflective (see Table A3 in the appendix for a detailed list of items).

For a robustness test, we also consider *Human Capital*, which comprises its value and uniqueness. Value signifies the capacity to enhance firm efficiency and exploit opportunities, while uniqueness emphasizes specific routines and knowledge developed within the firm (Coff & Raffiee, 2015; Morris, Alvarez, Barney, & Molloy, 2017). In competitive environments, human resources and talent management are crucial for enhancing a firm's competitive advantage (Wright, McMahan, & Mcwilliams, 1994). Therefore, it is important to identify the knowledge, skills, and abilities necessary for job roles to select and train teams that contribute to a company's success (Krumm, Kanthak, Hartmann, & Hertel, 2016). Using the previously cited empirical literature, we have developed a 12-item construct to evaluate human capital. The construct fits with the reliability and discriminant validity conditions, and a detailed list of items is shown in Table A4 in the appendix.

Control variables: Two control variables were incorporated into the analysis. The first variable, *industry*, distinguishes between companies operating in the manufacturing industry and those in the technological services industry. This variable is binary in nature

and takes a value of 1 for technological services, and 0 for manufacturing. Roughly two thirds were in manufacturing and the rest in technological services. We measured the second variable, *firm size*, by the number of employees.

4.3 Confirmatory factor analysis

We calculated the reliability of the measures with Bagozzi and Yi's (1998) composite reliability index, and with Fornell and Larcker's (1981) average variance extracted index (see Table 2). For all the measures, both indices are higher than the evaluation criteria of 0.6 for the composite reliability and 0.4 for the average variance extracted (Bagozzi & Yi, 1998). Furthermore, all items load on their hypothesized factors, and the estimates are positive and significant (the lowest t-value is 2.06), which provides evidence of convergent validity (Bagozzi & Yi, 1998).

- Insert Table 2 -

We then assessed the discriminant validity of the measures. First, we analyzed that the confidence interval (± 2 S.E.) around the correlation estimate between any two latent indicators never includes 1.0 (J. C. Anderson & Gerbing, 1988). Second, we verified, as Fornell and Larcker (1981) suggest, that the AVE for each construct is greater than the correlations of squared latent factors between pairs of constructs. In addition, Table 3 shows that the Heterotrait-Monotrait Ratio (HTMT) values (elements above the diagonal) are below 0.8, except for control variables. The results of these three tests provide strong evidence in support of discriminant validity among the constructs.

- Insert Table 3-

5. Analysis and results

5.1 Main analysis

We employ partial least squares structural equation modelling (PLS-SEM) methodology to test the hypotheses. We use maximum conventional likelihood estimation techniques to test the empirical model depicted in Figure 4 (Jöreskog & Sörbom, 1996), which shows that the nomological network of relationships fits the data.

- Insert Figure 4 -

Beginning with the SDP pathway, which we developed in Hypothesis 1, we have identified the direct links between servitization and operational performance (referred to as DL_1 in Figure 4) and between servitization and digital transformation (referred to as DL_3 in Figure 4). First, we have obtained evidence supporting a direct relationship between servitization and operational performance ($\beta_1 = 0.199$, $p < 0.001$). As we have previously argued, servitization leverages customers' knowledge to provide products and services that align with their needs. By embracing servitization, organizations can better address customers' demands, thus positively impacting their operational performance. Furthermore, the relationship between servitization and digital transformation is also apparent ($\beta_3 = 0.450$, $p < 0.01$), which is consistent with the findings presented in the literature review. This reinforces the notion that servitization and digital transformation are interconnected, with servitization acting as a catalyst for organizations to embark on their journeys of digital transformation.

Once the direct relationships have been examined, we can proceed to analyze the indirect relationships, specifically addressing Hypothesis 1. In relation to the SDP path, we have calculated a parameter $\beta_{SDP} = 0.195$, with a p-value < 0.001. The confidence intervals for the mediating effect pertaining to SDP range from 0.101

(lower limit at 2.5%) to 0.257 (upper limit at 97.5%), which support Hypothesis 1 (see Table 4). Hence, our results support the existence of a standardization pathway towards digital servitization.

- Insert Table 4 -

The pathway referred to as DSP, which serves as the basis for Hypothesis 2, establishes a direct relationship between digital transformation and operational performance (DL_2), as well as a link between digital transformation and servitization (DL_4) (see Figure 4). The PLS-SEM methodology used in this study reveals values of $\beta_2 = 0.430$ with a p-value < 0.001 for the direct relationship of digital transformation with operational performance, and a parameter $\beta_4 = 0.422$ with a p-value < 0.001 for the relationship between digital transformation and servitization. These findings are consistent with the current state of the art, and provide substantial evidence for our assumptions.

Once the direct relationships have been examined, we can now move on to studying the indirect relationships and, consequently, our second hypothesis (H_2). For the DSP path, we have calculated a parameter $\beta_{DSP} = 0.083$ with a p-value < 0.001. The confidence intervals for the mediating effect of H_2 (DSP) range from 0.027 (lower limit at 2.5%) to 0.158 (upper limit at 97.5%), thus supporting Hypothesis 2 (see Table 5). Therefore, the findings support the existence of a customization pathway towards digital servitization.

- Insert Table 5 -

To verify the third hypothesis of our research, we measured the direct and mediating effects of hypotheses 1 and 2 as a percentage, by means of the parameters β. For the SDP path, we compared the percentage represented by β_{SDP} versus the sum of

β_{SDP} and β_1, while for the DSP path, we considered β_{DSP} and β_2, and compared the percentage representing β_{DSP} versus the sum of β_{DSP} and β_2. Panel A in Table 6 presents the findings, illustrating the study's values before subjecting them to a robustness analysis that involves the inclusion of the Human Capital variable as an independent variable.

- Insert Table 6 -

These findings show that the mediating effect of digital transformation between servitization and operational performance (SDP) is greater than the effect of servitization between digital transformation and operational performance (DSP). Specifically, in the SDP pathway, 49.4% of the total effect is attributed to the mediation of digital transformation between servitization and operational performance, while the remaining 50.6% represents the direct effect of servitization on operational performance. Conversely, in the DSP pathway, the direct effect of these two constructs accounts for 83.7%, while the mediating effect of servitization between digital transformation and operational performance amounts to only 16.3%. These two results validate our third hypothesis, highlighting that the mediation role of digital transformation in the SDP pathway (49.4%) is considerably stronger than the mediation role of servitization in the DSP pathway (16.3%). Figure 5 displays a summary of the results obtained for each hypothesis of the study, along with the direct connections between the constructs.

- Insert Figure 5 -

5.2 Robustness tests

To ensure the validity and consistency of our analyses, we conducted two additional robustness tests: (i) employing a simplified version of the constructs, and (ii) introducing a common antecedent as an independent variable in a multi-mediation model.

Regarding the first robustness test, we acknowledge that while there is no upper limit on the number of items to form a construct as long as they combine appropriately, our constructs represent an amalgamation of several smaller elements found in the literature. To verify the robustness of our results when using these smaller constructs, we conducted a series of combinational models. The results are qualitatively consistent with those presented in the tables and figures, indicating that the number of items in our constructs does not significantly impact the results.

Regarding the second robustness test, we addressed a comparability issue between the YMX and MYX mediation models (Thoemmes, 2015). The proposed solution is to add a new independent variable and consider variables X and M as mediators. This implies moving to a four-construct model with an independent variable (X), two mediating variables (M_1 and M_2), and a dependent variable (Y). That is, the XM_1M_2Y with XM_2M_1Y models are comparable. Our chosen independent variable that can influence servitization (M_1) (Buenechea-Elberdin, Sáenz, & Kianto, 2023), digital transformation (M_2) (Lang, Behl, Phuong, Gaur, & Dzung, 2022), and operational performance (Y) (Bag, Pretorius, Gupta, & Dwivedi, 2021; Nicolás-Agustín, Jiménez-Jiménez, & Maeso-Fernandez, 2021) is Human Capital. By using human capital as the independent variable, we can run the models stated in Figure 3 again, but considering that now both digital transformation and servitization will be mediators in a multiple mediation model, as presented in Figure 6.

- Insert Figure 6 -

The inclusion of human capital as an independent variable contributes to an increase in the R^2 values across all cases, as demonstrated in Table 7. Results with and without

human capital for central variables are graphically synthesized in Figure 7. While some coefficients differ in size, the findings of the model including human capital align qualitatively with the previously reported results without human capital. This indicates that, after this adjustment, the results continue to support the existence of both the standardization pathway (now referred to as HSDP) and the adaptation pathway (now referred to as HDSP). Furthermore, Panel B in Table 6 presents the direct and mediating effects for the standardization (SDP) and customization (DSP) pathways when human capital is included. The mediating effect increases in both cases. Specifically, for the SDP model, the mediation effect increases from 49.4% to 53.2%, while for the DSP model, the mediation effect moves from 16.3% to 32.8%. Overall, it is evident that the standardization pathway exhibits greater strength, as the mediating role of digitalization in the HSDP route is significantly stronger (49% without human capital and 53% with human capital) than the mediating role of servitization in the HDSP route (16% without human capital and 32% with human capital).

- Insert Table 7 and Figure 7–

6. Discussion and conclusion

6.1 Theoretical and empirical contributions

Previous studies have achieved consensus in identifying digital servitization as an element that enhances firms' competitive advantage (e.g., see Gebauer, Paiola, Saccani, & Rapaccini, 2021; Kamalaldin, Linde, Sjödin, & Parida, 2020; Paiola & Gebauer, 2020; Tronvoll, Sklyar, Sörhammar, & Kowalkowski, 2020). However, the current body of literature has not comprehensively investigated the mechanisms by which servitization and digital transformation collaboratively improve operational performance. This gap in knowledge carries substantial theoretical implications concerning the strategic

motivations that underpin the success of digital servitization (Opazo et al., 2024). In contrast to previous empirical research, which primarily advocated a customization narrative (Abou-Foul et al., 2021; Davies et al., 2023; Harrmann et al., 2023; Kohtamäki et al., 2020; Li et al., 2023; Schulz et al., 2023; Yang et al., 2023), our study presents an alternative perspective rooted in standardization.

Our framework can be approached as if it were akin to a causality question, reminiscent of the classic "chicken or egg" dilemma. To investigate this, we formulated and empirically tested two symmetrical mediation models. We assessed these models using a custom-designed survey administered by Spanish product firms. In empirical terms, while both variables can mediate the relationship between the other variables and operational performance (SDP in Hypothesis 1 and DSP in Hypothesis 2), the role of digital transformation as a mediating variable is significantly more pronounced (49% vs. 16%). This implies that companies engaged in servitization and incorporating digital technology into their services tend to benefit more from digital servitization than highly digitalized companies that introduce services in their offerings (Hypothesis 3). Furthermore, for robustness purposes, two models of multiple mediation exhibit qualitatively similar results (53% vs. 32%). In summary, our results suggest that while both customization and standardization pathways are present, the standardization pathway exhibits significantly greater strength.

Our theoretical arguments and empirical findings point to two related conceptual implications for the digital servitization literature. First, this article extends the discourse on product standardization versus customization, transitioning it from the domain of international and general management to the more specific realm of technology management. By taking this approach, the research addresses a recognized need within

technology management for more investigations that establish connections between flexibility and standardization (Shalley & Gilson, 2017). This study establishes that attributes commonly ascribed to product standardization, such as scalability, are applicable to digitalization. Conversely, attributes traditionally associated with product adaptation, such as customization, align with servitization. Consequently, the study delineates two distinct implementation pathways for digital servitization: standardization and adaptation. This contribution enhances our comprehension of the intersection between technology and management practices.

Second, this study contributes to the digital servitization literature by responding to several calls for research that show how digitalization and servitization are intertwined (Gebauer et al., 2021; Kohtamäki et al., 2019). The prevalence of digitalization as a mediating variable suggests that contrary to the conclusions of previous studies (Abou-Foul et al., 2021; Davies et al., 2023; Harrmann et al., 2023; Schulz et al., 2023; Yang et al., 2023), most successful digital servitization seems to be a story of service scalability and not of product customization. This is an important contribution as it suggests it is more efficient to begin with servitization in heading towards digital servitization. This is consistent with the historical process of adopting service and digital business models (Kohtamäki et al., 2022; Favorite et al., 2022) and the fact that services depend on digital capabilities to be delivered remotely, and thus be standardized and scalable (Gong and Ribeiro, 2021; Linde et al., 2021).

This article employs the theoretical standardization versus customization framework (Katsikeas et al., 2006) to contribute to the strategic sequencing of digital servitization implementation. At the same time, the identified mechanisms prompt additional reflection and reconsideration of the standardization versus customization

paradigm, which predominantly focuses on the capacity of multinational companies to develop a transnational strategy (London and Hart, 2004). In such a strategy, processes and products are standardized, but there is room for subsidiaries to be responsive and adjust their offerings to the specific needs in the markets they serve. A noteworthy observation emerges: technology not only enables the scaling of offerings but, more crucially, facilitates market adjustments without predetermined offerings, allowing local demand to dictate specific needs. This phenomenon is particularly evident in platforms, where it serves as a distinct mechanism for the global expansion of service-based businesses (Garcia-Canal et al., 2024). We contend that in this context, artificial intelligence plays a pivotal role and may be the glue that enables a more systematic integration of customization and standardization (Sullivan and Wamba, 2024). We deem imperative future research on this domain.

Our analysis also makes a significant methodological contribution by introducing a methodology that focuses on an examination of reverse mediation models, with a specific emphasis on assessing the ratio of the partial mediation effect relative to the full effect. Furthermore, we support the recommendations Thoemmes (2015) to apply multi-mediation models that incorporate shared antecedents as the independent variable while reversing the roles of factors as mediators. Collectively, we envision these approaches as particularly relevant in contexts characterized by the interaction of two interrelated continuous variables, providing essential insights into the mechanisms governing the flow of value and its impact on profitability or growth. This implies that, moving forward, the proposed empirical approach may help disentangle the puzzle of 'what comes first, the chicken or the egg?' and address the work-family conflict (Nohe et al., 2015), export-

productivity (Vendrell-Herrero, Darko, Gomes, & Lehman, 2022), or entrepreneurial orientation–firm performance (B. S. Anderson, Schueler, Baum, Wales, & Gupta, 2022).

6.2 Managerial implications

This study offers two valuable managerial implications. First, our findings suggest managers should view servitization as the initial step in the journey toward digital servitization. To achieve the highest level of operational performance, the focus should be on leveraging standardization rather than customization. In practical terms, this implies that while digital technologies can be integrated, they should not take precedence until the service offering and its boundary conditions are clearly defined. Following this approach can help product firms ensure the scalability of their services. However, it is essential to acknowledge that digitalization may have limitations when it comes to global scalability (Verbeke & Hutzschenreuter, 2020) and that services may not be viable in markets that lack territorial value spaces (Zolkiewski et al., 2023). These limitations involve issues such as assuming that a company's digital assets can function universally, or not recognizing the importance of integrating new digital resources with the analog resources and networks the company already possesses.

Second, in line with the outcomes of our robustness test, it is evident human capital plays a pivotal role as a precursor to both servitization and digital transformation. Therefore, managers aspiring to implement digital servitization within their organizations should prioritize the development and maintenance of an adequate level of human capital before proceeding with further investments. This strategic approach will help ensure the successful execution of digital servitization initiatives.

6.3 Limitations and further research avenues

While we are convinced of the relevance of the topic, this study is not without limitations. For instance, our approach is cross-sectional, and hence lacks longitudinal capacity to determine the order of adoption of servitization and digital transformation. Also, the database focuses on a specific context (i.e., Spanish product firms) and therefore may not be generalizable to other industries and countries. These limitations point to exciting opportunities for new lines of inquiry. For instance, the inclusion of necessary items to measure servitization and digital transformation in well-established surveys stored in public repositories (e.g., Community Innovation Surveys) would enable a longitudinal analysis of digital servitization. With this type of data, it would be possible to implement more sophisticated empirical designs with lagged variables. Moreover, this data would enable the identification of the most common order of adoption (SDP or DSP), as well as an analysis of industry- and country- level contextual heterogeneities.

Another interesting point from our analysis is that it shows an alignment of various items within a single construct, indicating a significant convergence of different elements identified in the literature into a general idea. For example, we find that within the field of servitization, the scales of Kohtamaki et al. (2019, 2020) for servitization and Bustinza et al. (2019) for product-service innovation converge in meaning. We believe this opens up a promising avenue for future research, where attempts are made to standardize different constructs into higher-level multidimensional scales, rather than considering simple scales in isolation.

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Table 1. Individual-level characteristics of respondents

Position in the company	**% of responses**	**Age**	**% of responses**
Operations or Production Manager	43.3%	<34	17.3%
Digital Transformational Manager	36.2%	35-44	31.5%
Human Resources Manager	8.7%	45-54	29.1%
Innovation or Marketing Manager	11.8%	>55	22.0%
Higher level of education	**% of responses**	**Managerial experience**	**% of responses**
Secondary school	3.9%	<10 years	26.8%
Undergraduate degree	37.8%	11-20 years	40.2%
Master's degree	52.0%	21-30 years	26.0%
Doctorate	6.3%	> 30 years	7.1%

Table 2. Descriptive statistics

	Q^2	R^2	*Cronbach's Alpha*	*rho_A*	*Composite Reliability*	*AVE - Average Variance Extracted*
Servitization	0.188	0.634	0.966	0.973	0.967	0.430
Digital Transformation	0.229	0.592	0.921	0.934	0.932	0.472
Operational Performance	0.346	0.795	0.966	0.968	0.968	0.499
Industry	1.000	1.000	1.000	1.000	1.000	1.000
Size	1.000	1.000	1.000	1.000	1.000	1.000

Table 3. Correlation matrix

	P	*D*	*S*	*SECTOR*	*SIZE*
Operational Performance (P)	*0.706*				
Digital Transformation (D)	0.426	*0.687*			
Servitization (S)	0.202	0.415	*0.656*		
Industry	0.029	0.193	0.033	*1.000*	
Size	-0.175	-0.024	-0.035	-	*1.000*

The *italics* numbers on the diagonal are the square root of the average variance extracted. Off-diagonal elements are correlations among constructs

Table 4. Construct structural model: effects for Hypothesis 1 (SDP)

Paths	**Hypotheses**		**Standardized parameter estimates**				***Confidence interval***	
	Number	*Sign*	*Parameter*	*Indirect effect*	*t-value*	*p-value*	*2.50%*	*97.50%*
Servitization (S) → Digital Transformation (D) → Operational Performance (P)	H_1	+	β_{SDP}	0.195	4.646	0.000	0.101	0.257
			Parameter	*Direct effects*	*t-value*	*p-value*		
Servitization (S) → Operational Performance (P)	DL_1	+	β_1	0.199	2.797	0.005		
Servitization (S) → Digital Transformation (D)	DL_3	+	β_3	0.450	6.236	0.000		

Table 5. Construct structural model: effects for hypothesis 2 (DSP)

Paths	**Hypotheses**		**Standardized parameter estimates**				***Confidence interval***	
	Number	*Sign*	*Parameter*	*Indirect effect*	*t-value*	*p-value*	*2.50%*	*97.50%*
Digital Transformation (D) → Servitization (S) → Operational Performance (P)	H_2	+	β_{DSP}	0.083	2.532	0.012	0.027	0.158
			Parameter	*Direct effects*	*t-value*	*p-value*		
Digital Transformation (D) → Operational Performance (P)	DL_2	+	β_2	0.430	8.472	0.000		
Digital Transformation (D) → Servitization (S)	DL_4	+	β_4	0.422	5.425	0.000		

Table 6. Percentage comparison of direct effects and mediating effects of servitization and digital transformation with operational performance. Hypothesis (H_3)

	PANEL A. Without Human Capital		*PANEL B. With Human Capital*	
	Direct effects	*Mediating effects*	*Direct effects*	*Mediating effects*
Servitization (S) → Digital Transformation (D) → Operational Performance (P)	50.6%	49.4%	46.8%	53.2%
Digital Transformation (D) → Servitization (S) → Operational Performance (P)	83.7%	16.3%	67.2%	32.8%

Table 7. Human Capital leverage effect in the model

	R^2 with Human Capital	**R^2 without Human Capital**	**Δ R^2**	**Δ %R^2**
Servitization	0.634	0.533	0.101	15.9%
Digital Transformation	0.592	0.533	0.059	10.0%
Operational Performance	0.795	0.749	0.046	5.8%

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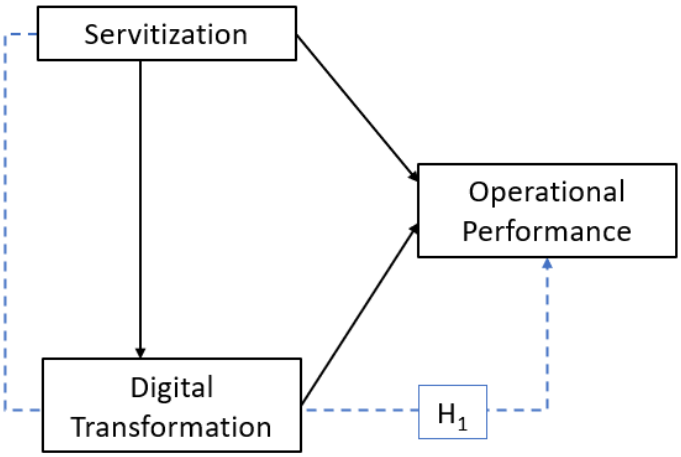


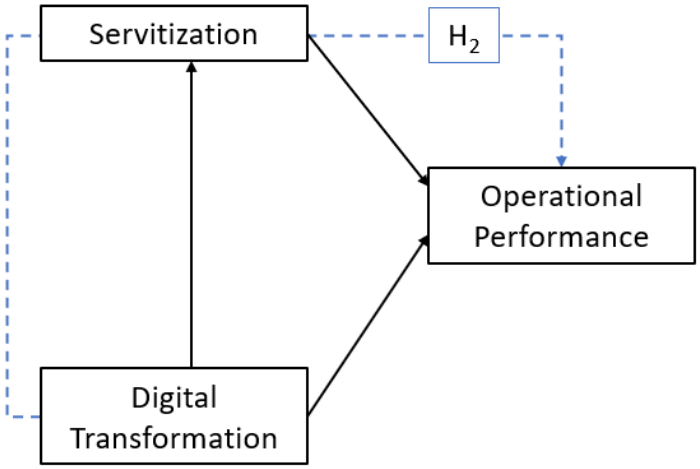


Figure 3. Weighting digital servitization pathways

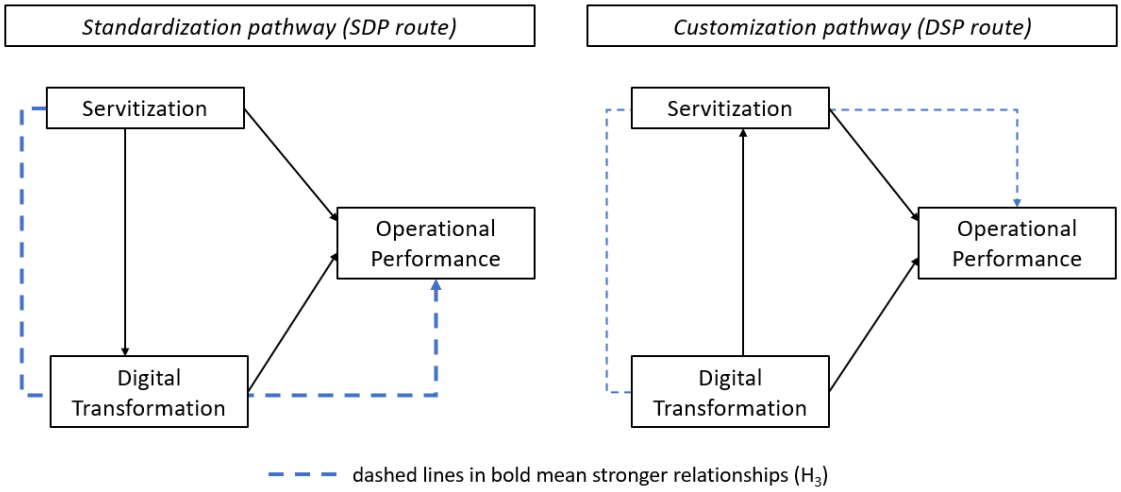


Figure 4. Empirical model with direct and mediation relationships

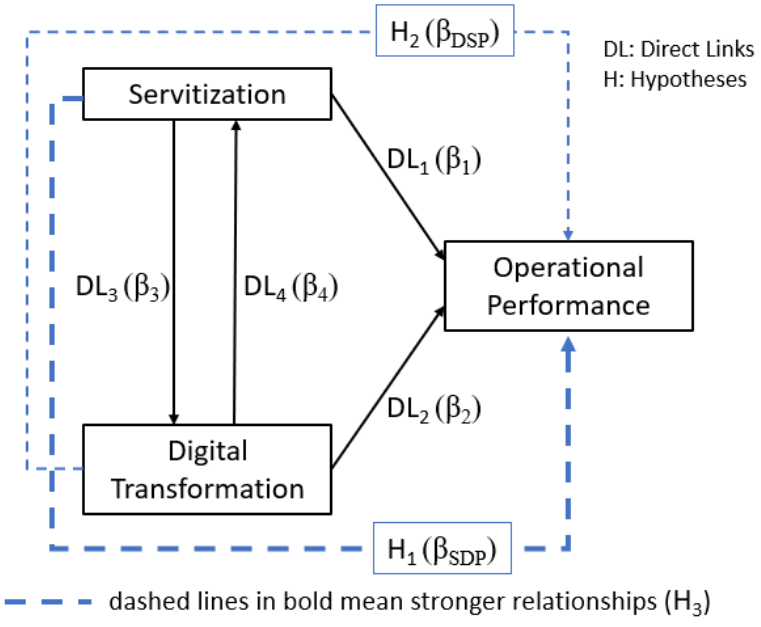


Figure 5. Results of the hypothesis model.

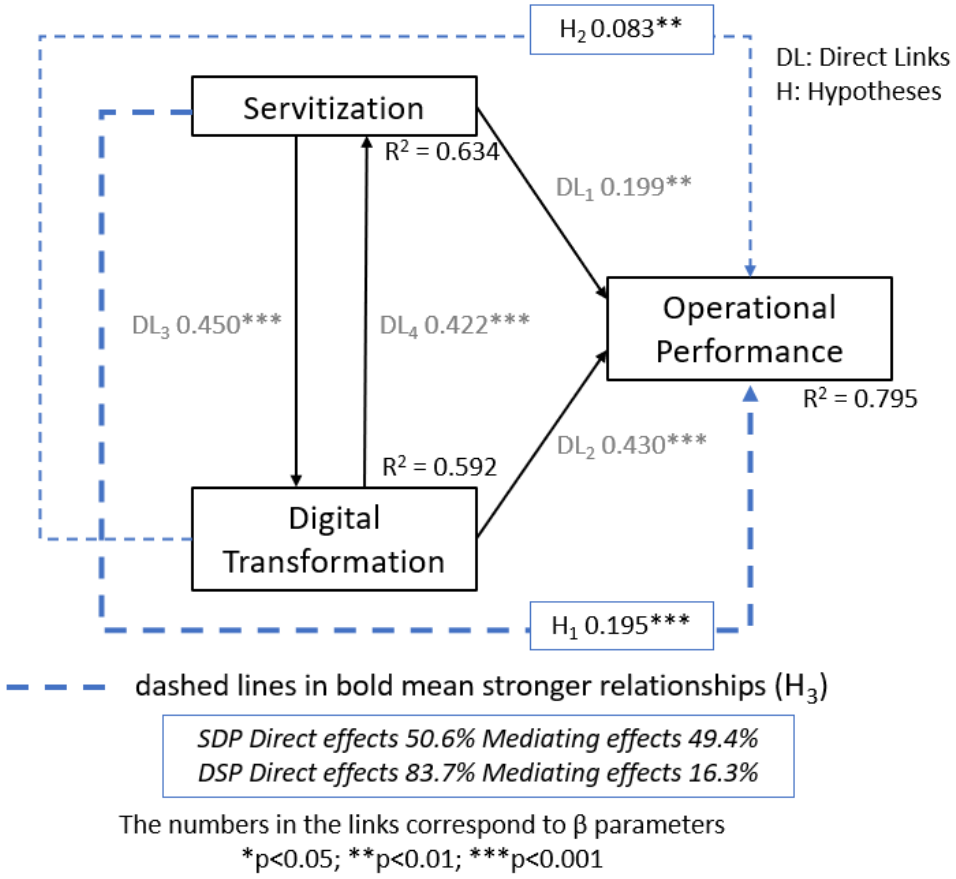


Figure 6. Multi-mediation model

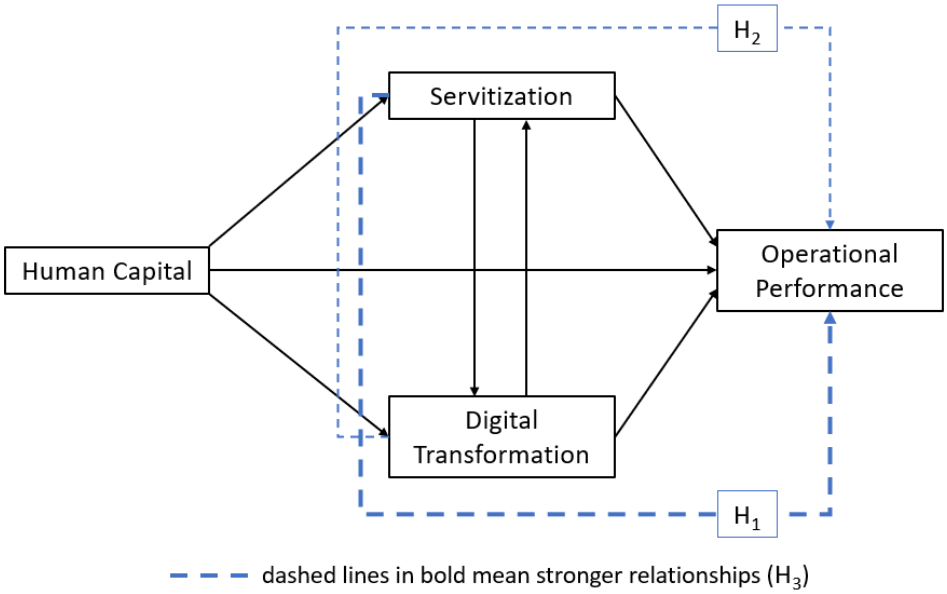
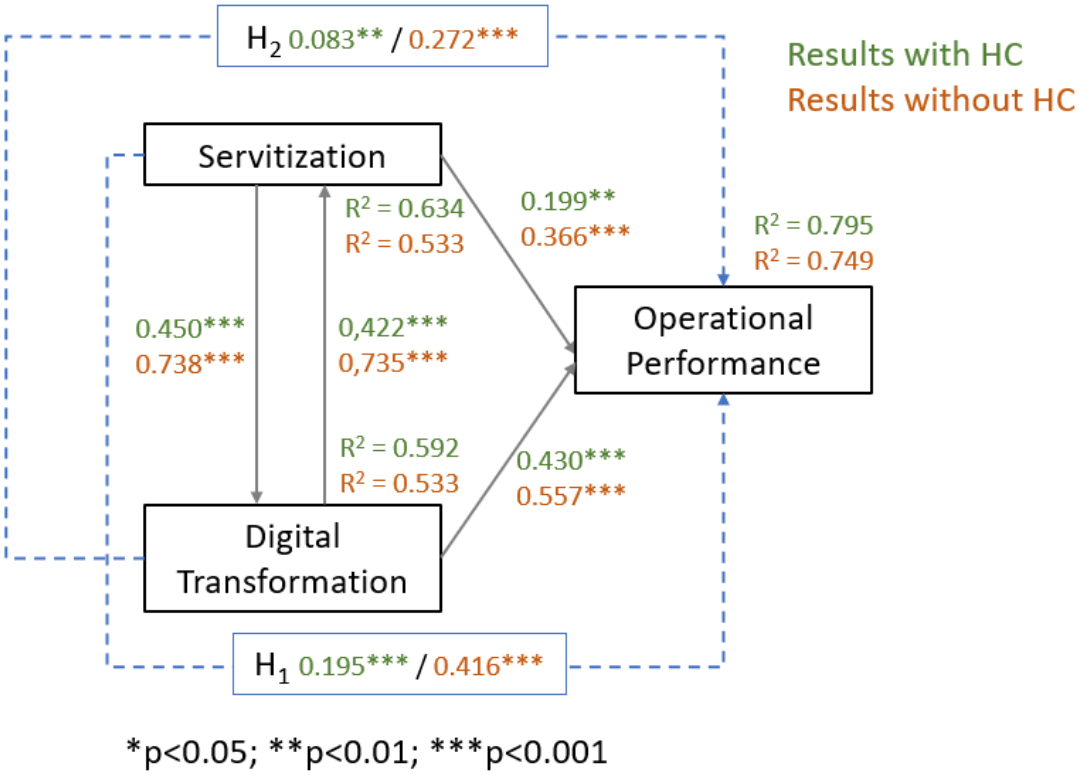


Figure 7. Results with and without Human Capital



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APPENDIX: Item description

Table A1: Items used for *Digital Transformation*

Please indicate the extent to which you disagree/agree with the following statements using a 5-point scale where 1="completely disagree" and 5="completely agree"		
ID	ITEM	QUESTION
DT1	Employee incentives	Your company has established an incentive model that effectively encourages and drives the desired employee behavior.
DT2	Value proposition	Your company recognizes and highlights the unique and compelling nature of your value proposition achieved through digitalization.
DT3	Customer understanding	Customers fully recognize and understand the value offered by your digital solutions.
DT4	Value creation	You have successfully identified the value that can be created through the process of digitization.
DT5	Hidden motivations	You have conducted thorough research to uncover the hidden needs and motivations driving customers' desire to use digital media.
DT6	Customer need	Your company has identified the customer needs that can be effectively addressed through digitalization.
DT7	Tradeoffs analysis	The balance between each risk and its corresponding reward has been carefully identified and evaluated.
DT8	Business model reconfiguration	You have the flexibility and capability to reconfigure your business model to effectively manage risks associated with digital transformation.
DT9	Risks identified	New risks arising from the digital model have been identified and assessed.
DT10	Value metrics	The appropriate financial or performance control metrics are known and utilized to accurately measure the value created by digital technology.
DT11	Congruent with traditional model	The implementation of the new digital model does not negatively impact the existing traditional model.
DT12	Financial viability	Your company has a clear understanding of the conditions under which the business model driven by digital technology makes financial sense.
DT13	Financial analysis	Critical financial parameters that have the potential to impact the profitability of the business have been thoroughly analyzed.
DT14	Risks prioritization	You have prioritized the most critical risks that could potentially hinder successful commercialization.
DT15	Data-driven understanding	Your company possesses a clear, data-driven understanding of your customers' operations.
DT16	Risk management	Your company effectively recognizes and mitigates the risks that need to be retained.

Source: Adapted from various sources. Digital Leadership (DT1-DT5) from Chen and Chang (2013), Organization agility (DT6-DT9) from Cegarra-Navarro et al. (2016), Transformational capabilities (DT10-DT13) from Nasiri et al. (2020) and Digital Strategy (DT14-DT16) from Li et al. (2021).

Table A2: Items used for *Servitization*

Please indicate the extent to which you disagree/agree with the following statements using a 5-point scale where 1=" completely disagree" and 5=" completely agree"		
ID	ITEM	QUESTION
SERV1	Engineering collaboration	The integration of products and services is jointly defined by the product development department (Engineering) and the service development team.
SERV2	Solution implementation	The implementation of solutions that integrate products and services is equally driven by the product development department (Engineering) and the service development team.
SERV3	Service role design	The role of service in the offering is specifically designed for each phase of the product life cycle to enhance customer value.
SERV4	Offering lifecycle implementation	The role of service in the offering is effectively implemented throughout each phase of the product lifecycle to enhance customer value.
SERV5	Impact evaluation	The impact of service on the company's offering is consistently evaluated at every phase of the product lifecycle to ensure its effectiveness.
SERV6	Usage data analysis	Both the product development department (Engineering) and the service development team actively capture product usage data to continuously improve the offering.
SERV7	Redesigning offering	Both the product development department (Engineering) and the service development team analyze product usage data to identify areas for continuous improvement in the offering.
SERV8	Integrated alignment	The collaborative efforts of the product development department (Engineering) and the service development team enable the company to redesign its product/service offering based on captured and analyzed information.
SERV9	Conceptualized integration	The products and services are strategically aligned to create an integrated offering that maximizes customer value.
SERV10	Technological integration	The product and service components are inherently intertwined and cannot be separated in the integrated offering.
SERV11	Coordinated lifecycles	The technological systems supporting the implementation of the product and service components are seamlessly integrated to ensure a cohesive customer experience.
SERV12	Customer involvement	The product lifecycle and the service lifecycle are effectively coordinated to deliver a unified offering that meets customer needs.
SERV13	Customer interaction	Customers are actively engaged in the innovation processes, promoting customer autonomy and collaboration through surveys, forums, direct meetings, etc.
SERV14	Opinion exchange	Customers have dedicated communities where they can interact with each other and share opinions about the products and/or services provided by your company.
SERV15	Innovative input	Customers have access to forums where they can exchange opinions with your company's employees, fostering improvements in the contracted products and/or services.
SERV16	Continuous feedback	Customers' suggestions and feedback play a crucial role in the creation and development of products, ensuring their needs are addressed.
SERV17	Concept generation	Direct feedback from customers is collected to gather their opinions on the contracted products and/or services, driving continuous improvements and innovations.

SERV18	Early-stage involvement	Customers actively contribute specific concepts and ideas related to the development of new products.
SERV19	Initial opinion consideration	Customer opinions are sought at the beginning, middle, and throughout the innovation process to incorporate their insights into the offering.
SERV20	Collaborative interaction	Customer opinions are actively sought and considered right from the beginning of the innovation process.
SERV21	Testing participation	Customer interaction is encouraged to foster discussion, idea exchange, and co-creation opportunities.
SERV22	Outsourcing possibility	Customers participate in the final stage through testing tasks and iterative processes to evaluate and resolve any issues in the innovation process.
SERV23	Diversification motive	The possibility of outsourcing certain processes is evaluated as part of the digital transformation strategy to achieve the desired objectives.
SERV24	Purely economic	Diversification in core competencies is a key factor driving your company's consideration of outsourcing IT products or services.
SERV25	Operational efficiency	Economic factors play a significant role in your company's consideration of outsourcing IT products or services.
SERV26	Tactical support	Operational efficiency, achieved through resource and personnel sharing, drives your company's value for outsourcing IT products or services.
SERV27	Single-vendor value	Tactical support, such as outsourcing basic services for new application development, is highly valued by your company in the outsourcing of IT products or services.
SERV28	Connected suppliers	Your company highly values outsourcing services to a single, large vendor with extensive IT facilities.
SERV29	Project-based outsourcing	Your company prefers outsourcing services to multiple interconnected suppliers to leverage their combined expertise.
SERV30	Centralized IT department	Your company values outsourcing services on a project basis or through collaborative partnerships to ensure active involvement, influence, and risk reduction.
SERV31	Radical transformation	Your company emphasizes internalization of all IT capabilities, centralizing the IT department to retain full control and technical capabilities.
SERV32	Supply chain digitization	Your company has successfully undergone radical digital transformation through merger and restructuring, incorporating different technologies.
SERV33	Integration strategy	Your company has established R&D investment plans to digitally transform the supply chain and address challenges stemming from the Covid-19 crisis.
SERV34	Market pull integration	Your company follows an integration strategy to leverage partner technologies and achieve a technological boost.
SERV35	Technological similarity	Your company pursues a pull integration strategy in specific markets to gain market share and effectively meet customer needs.
SERV36	Market share consideration	When considering partnerships, your company looks for candidate companies with similar technical and technological capabilities.
SERV37	Objective criteria	Your company values candidate companies with significant market share in unexplored markets when considering partnerships.
SERV38	Resourceful partners	Your company follows a structured road mapping process and employs objective criteria evaluated by different groups to select partners.
SERV39	Market expertise	Your company actively seeks technology partners who bring valuable resources, expertise, and experience to the collaboration.

SERV40	Financial partnership	Your company seeks market partners with expertise in distribution networks, advertising, and other relevant areas to enhance its offerings.
SERV41	Strategic selection	Your company explores financial partnerships to access additional resources, assets, or investments for servitization initiatives.

Source: Adapted from various sources. Bustinza et al., (2019) for SERV1-SERV13; and Kohtamäki et al. (2019) and Kohtamäki et al. (2020) for SERV14-SERV41.

Table A3: Items used for *Operational Performance*

Please indicate the extent to which you disagree/agree with the following statements using a 5-point scale where 1=" completely disagree" and 5=" completely agree"		
ID	ITEM	QUESTION
PERF1	Customer needs focus	Operational performance is focused on satisfying customer needs.
PERF2	Society's needs concern	Operational performance is focused on satisfying the needs of society.
PERF3	Active listening spaces	Active listening and responsiveness to the people within the organization are key considerations for operational performance.
PERF4	Equal recognition	Efforts of individuals and teams within the organization are equally recognized, regardless of their level.
PERF5	Effective change communication	Effective communication of changes and their reasons to employees is prioritized for operational performance.
PERF6	Stakeholder communication	Effective communication of changes and their rationale to stakeholders is a key aspect of operational performance.
PERF7	Balanced stakeholder needs	Balancing the needs and expectations of all stakeholders is an integral part of operational performance.
PERF8	Process indicators established	Operational performance includes the establishment of process indicators and performance targets.
PERF9	Policy and strategy review	Regular review of processes is conducted to ensure their effectiveness in delivering policy and strategy.
PERF10	Continuous improvement focus	Identifying and prioritizing opportunities for continuous improvement is essential for operational performance.
PERF11	Process training programs	Employees are provided with training to adapt to new or modified processes for operational performance.
PERF12	Customer needs research	Operational performance relies on using market research, customer surveys, and other information to understand current and future customer needs and expectations.
PERF13	Leveraging core competencies	Leveraging the creativity and core competencies of individuals within the organization to develop competitive products and services is a key focus of operational performance.
PERF14	Consumer awareness promotion	Promoting consumer awareness and appreciation of products and services is a priority for operational performance.
PERF15	Adequate customer service	Providing adequate customer service is a fundamental aspect of operational performance.
PERF16	Regular customer contact	Operational performance involves identifying and meeting customer requirements through regular contact.
PERF17	Complaints and claims management	Effective management of information from regular contacts, complaints, and claims is crucial for operational performance.
PERF18	High customer-perceived design quality	Operational performance aims to deliver high-quality designs that are highly perceived by customers.

PERF19	High customer-perceived product quality	Ensuring high product quality as perceived by customers is a key focus of operational performance.
PERF20	Notable market share percentage	Operational performance strives for a significant market share percentage.
PERF21	Employee participation excellence	Employee participation is encouraged to achieve operational excellence.
PERF22	Workplace health protocols	Establishing comprehensive protocols for health and safety in the workplace is a priority for operational performance.
PERF23	Structured training periods	Implementation of structured training programs to enhance employees' skills and knowledge is integral to operational performance.
PERF24	Perception assessment	Operational performance involves evaluating and considering society's perception of the organization.
PERF25	Image alignment evaluation	Assessing the company's image in alignment with prevailing societal values is a key aspect of operational performance.
PERF26	Public administration relations	Development and maintenance of effective relationships with public administration services are prioritized for operational performance.
PERF27	Recognitions and accolades	Acknowledgment and accolades received from various entities, including businesses, trade unions, and public organizations, validate operational performance.
PERF28	Sector productivity evaluation	Evaluating the company's productivity within its sector of activity is essential for operational performance.
PERF29	Product unit cost analysis	Analyzing and optimizing the unit cost of production for products is a key focus of operational performance.
PERF30	Company's financial gains	Assessing the financial gains and profitability achieved by the company is crucial for operational performance.
PERF31	Overall profitability assessment	Examining the overall profitability and financial viability of the company is a fundamental aspect of operational performance.

Source: EFQM (2021) for all items

Table A4: Items used for *Human Capital*

Please indicate the extent to which you disagree/agree with the following statements using a 5-point scale where 1=" completely disagree" and 5=" completely agree"		
ID	ITEM	QUESTION
HC1	Cost optimization with human capital	Effective cost management strategies optimize production or service expenses by recognizing the value of human capital.
HC2	Customer-aligned human capital	Human capital, aligned with customer demands, plays a vital role in efficiently meeting their needs.
HC3	Value-added initiatives	Human capital initiatives generate added value for customers, enhancing their overall experience.
HC4	Quality relies on workforce	Maintaining quality standards in products and services relies on the expertise and capabilities of the workforce.
HC5	Strengthening knowledge sharing	Facilitating knowledge sharing among employees strengthens the foundation of human capital.
HC6	Investing in employee development	Investing in the development of employees enhances their performance, driving overall organizational success.
HC7	Cultivating innovation culture	Human capital initiatives foster a culture of innovation, enabling the successful introduction and implementation of process improvements.

HC8	Unique competitive advantage	The unique skills and competencies possessed by the workforce provide a competitive advantage not easily replicated by rival companies.
HC9	Talent scarcity challenge	The scarcity of talent in the labor market poses challenges in finding suitable replacements for valuable human capital.
HC10	Industry-leading workforce	The expertise and skills of the workforce position them as industry leaders, recognized for their excellence.
HC11	Unmatched capabilities	Competing companies face difficulty in replicating or imitating the unique capabilities of the organization's human capital.
HC12	Tailored human capital strategies	Human capital strategies are tailored to respond to the specific needs and requirements of the company, leveraging the strengths of its workforce.

Source: Lepak and Snell (2002) for all items