**Digital service innovation: A paradigm shift in technological innovation**

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**Abstract
Purpose** – Existing theory frameworks suggest that manufacturing firms have traditionally developed a complementary model of technological innovations comprising process and product innovations. This paper presents digital servitization as a novel form of technological innovation capable of enhancing manufacturing firms’ performance.

**Design/methodology/approach –** Drawing on technological innovation research, the present study argues that within manufacturing contexts—NAICS 31, NAICS 32, and NAICS 33—digital servitization constitutes a service innovation that complements traditional sources of technological innovation and accordingly, enhances firms' profit margins. This effect is particularly significant in manufacturing sectors with stronger industrial focus, referred to in this study as heavy manufacturing and operationalized as firms operating in metal, machinery and hardware industries (NAICS 33). We argue that those industries benefit from a broad presence of digitally-enabled services to support value capture of product and process innovations. We test our predictions on a unique sample of 423 Spanish manufacturing firms using a fuzzy-set qualitative comparative analysis (fsQCA).

**Findings –** Our analysis evidences that a necessary condition for manufacturing firms’ profit gains is to deploy simultaneous process and product innovations. Additionally, it reveals that, particularly in heavy manufacturing industries, the optimal configuration requires undertaking digital service innovation. In this way all technological sources of innovation (i.e. process, product, and service) are brought together in order to reach the highest levels of firm performance. Our evidence suggests that digital servitization should not be analysed in isolation from other forms of innovation.

**Originality** - The originality and value of this study lie in revealing the existence of firms that incorporate digital service innovation as a complement to traditional technological innovation sources, namely process and product innovation, as well as in conceptualizing and testing empirically the value-adding role of digital servitization within firms´ technological innovation portfolios.

**Keywords** - Technological innovation, Servitization, Digitalization, Fuzzy set.

**Paper type** – Research article.

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**1. Introduction**

Technological innovation studies have traditionally focused on examining the dynamics of innovation deployment in manufacturing firms, predominantly evaluating the existing interactions between process and product innovations (Martinez-Ros, 2019). They have therefore neglected, by some means, the increasingly important role of service innovation in product firms to deliver performance improvements (Benedettini and Neely, 2020; Feng *et al.*, 2020; Sjödin *et al.*, 2019).

Digital servitization, however, represents a service innovation strategy that encompasses the provision of digitally enhanced profitable and value-creating services (Vendrell-Herrero *et al.*, 2017). Derived from the mainstream servitization of manufacturing (Visnjic-Kastalli and Van Looy, 2013), it embodies a maturing technological innovation adopted by manufacturing firms looking for performance improvements in innovative contexts (Cenamor *et al.*, 2017).

While the literature on technological innovation suggests that jointly deployed innovations mutually reinforce one another, and in turn have positive effects on firm performance (Prajogo, 2016), servitization research has largely analyzed service innovation outcomes as an isolated phenomenon in manufacturing firms without considering it as part of a synergistic and complementary system of innovations (e.g. see Visnjic-Kastalli and Van Looy, 2013). The aim of this research is therefore to fill this gap in the literature by uncovering the existence of complementarity between technological innovations, namely process, product, and service innovation, and its effect on firm performance.

To this purpose, the present study draws from a sample of 423 medium-sized Spanish industrial firms operating in manufacturing contexts (NAICS 31, NAICS 32, and NAICS 33), and uses a non-parametric method as an empirical approach to study the optimal innovation portfolios, i.e., fuzzy-set qualitative comparative analysis (fsQCA).

This study makes three important contributions. First, it responds to a call for studies to assess the synchronized deployment of various innovation types (Damanpour, 2014). Second, it explains that a necessary condition for firms’ performance gains is to jointly deploy process and product innovations. Lastly, it demonstrates that in contexts with high industrial focus (NAICS 33) the optimal configuration for performance enhancement lies in the complementarity of service innovation with process and product innovation.

The paper is organized as follows: the Introduction, Section two, which presents a literature review and sets out testable propositions; Section three, which describes the empirical research; Section four, which shows the results; and Section five, which discusses the conclusions and their implications.

**2. Literature review**

*2.1. Technological innovation*

Technological innovation in industrial contexts has been widely categorized into process and product innovation, in agreement with the notion that both innovation types possess meaningful strategic values for providing firms with a competitive edge (Damanpour, 2010; Onufrey and Bergek, 2020).

Process innovation is regarded as the implementation of new or significantly enhanced production or delivery methods, through the introduction of substantial changes in techniques, equipment and/or software (OECD, 2005). This type of innovation has proven to upgrade firms´ operating processes, leading to enhanced efficiency (e.g. time savings), quality (e.g., defect reduction), and profitability in production (e.g., cost optimization) (Chai *et al.*, 2020). Through process innovation firms accumulate technology and knowledge, which boosts the development of new products and thereby affords further opportunities to expand market share (Lisboa *et al.*, 2011). Furthermore, process innovation materializes at an internal level, which makes replication difficult, erecting higher entry barriers for competitors and thus, protecting the firms' market advantage (Prajogo, 2016). One example of process innovation can be observed at the Zara Group, the star brand of the Inditex holding, which implemented an information system to provide its operations analysts with real-time access to all its retail outlets around the world to control, evaluate, and decide on the necessary production levels to supply them seamlessly, hence greatly reducing product inventory (Garcia-Alvarez, 2015).

Product innovation, on the other hand, implies the introduction of technical specifications, components and materials, software technologies, or other functional features in products or services for meeting market demands (OECD, 2005). This type of innovation has shown to enhance the value delivered by products/services for meeting customers´ needs (Sok and O'Cass, 2015), increasing customer experience (Foroudi *et al.*, 2016), and hereby achieving further product/service differentiation (Aliasghar *et al.*, 2019). Through the use of new technologies and knowledge (or a combination of the two), product innovation provides a consistent means of improving competitiveness, gaining higher profits and market shares (Martinez-Ros, 2019). Moreover, product innovation increases the potential of firms´ product/service portfolios, opening up possibilities to seize unexploited market niches (Cormican and O’Sullivan, 2004), thus contributing to the achievement of competitive advantage as well as superior growth performance (Chapman and Hyland, 2004). A noted example of product innovation is Nespresso, the Nestlé Gourmet Coffee division, which developed its own coffee machine with electronic water temperature control and an extraction and brewing system; to be operated using the brand’s own vacuum-packed capsules. With an average growth of 30 percent per year; Nespresso has become Nestlé’s product portfolio’s fastest growing business unit (Brem *et al.*, 2016).

Despite the fact that technological innovation has substantiated positive effects on business performance (Damanpour, 2010), and that both process and product innovations are considered to be equal drivers of innovation activities (Onufrey and Bergek, 2020), the deployment of these innovations separately is considered to be insufficient to sustain competitiveness in well-positioned industries (Hullova *et al.*, 2019). This is partly due to the fact that their full benefit is fully achieved only when the two innovative activities are undertaken together (Hullova *et al.*, 2016) and partly because competitors can replicate product and process innovation much faster than in the twentieth century (Graham and Nafukho, 2007). This has led firms, across industries, to pursue both innovation types simultaneously so as to reap the benefits of newness and the added value embodied in the complementarity of these innovations (Najafi-Tavani *et al.*, 2018) and to assemble more complex innovation portfolios, that is, more valued and difficult to replicate (Rivkin, 2000). Hence, process and product innovations together have long been considered the “single best complementarity strategy” (Damanpour, 2010), as well as the “forefront strategy” of the modern manufacturing archetype (Miravete and Pernias, 2006).

*2.2. Digital servitization as a new form of technological innovation*

Digital servitization comprises the use of digital means to provide innovative, value-creating, and revenue-generating opportunities to manufacturing firms in the service ecosystem (Sklyar *et al.*, 2019; Vendrell-Herrero *et al.*, 2017). Essentially, it constitutes a technological innovation in which firms seize on the potentialities offered by the adoption of digital technologies such as the Internet of things, digital platforms, remote monitoring, big data analytics, and artificial intelligence in operations—to transition from stand-alone products to digital service solutions (Kohtamäki *et al.*, 2020; Naik *et al.*, 2020).

From a technological innovation perspective (Kowalkowski and Witell, 2020), digital servitization expands firms´ innovation possibility frontiers in industrial services by, from one side, streamlining real-time customer data collection and integration within the firm’s digital platform (Schroeder *et al.*, 2019), and from the other, by providing effective tools to monitor, optimize and automatize the functions of the product, remotely and globally (Beverungen *et al.*, 2020, Porter and Heppelmann, 2015).

As has been noted in the literature, such technological capacities may afford unprecedented possibilities for superior market differentiation (Kohtamäki *et al.*, 2018), enhanced customer engagement and collaboration (Sousa and da Silveira, 2017) —as well as for recognizing and grasping contextual opportunities to mitigate inherent risks in servitization (Dmitrijeva *et al.*, 2020).This may be achieved by expediting corrective actions or strategic adjustments (Coreynen *et al.*, 2020), and developing more effective and efficient mechanisms for value creation and customer satisfaction (Cenamor *et al.*, 2017).

Noteworthy examples include global heavy manufacturers such as Volvo and Caterpillar (heavy manufacturing & production of construction equipment), Siemens (industrial machinery & heavy equipment part manufacturing), and ABB (automation technology & heavy machinery manufacturing). They have implemented digital platforms to provide digitally-enhanced customer services (i.e., service solutions) such as remote functionalities execution and control, fleet management, and site optimization through sensor monitoring, automated traceability, and real-time product/machine performance data (Baines *et al.*, 2017; Kohtamäki *et al.*, 2019).

From a functional—back-end—perspective, digital servitization acts as a catalyst for service innovation nurture in operations, simplifying the sharing of information and knowledge across firm divisions (Vendrell-Herrero *et al.*, 2020). This broadens opportunities to enhance operational efficiency, process redesign, resource allocation, and transparency in supporting decision making (Coreynen *et al.*, 2017). Conversely, from a relational—front-end—standpoint, and deeming that servitization is essentially an ecosystemic value co-creation process; digital servitization facilitates stronger relational interactions and closer integration between actors (suppliers, intermediaries and customers) within the value-creation ecosystem (Story *et al.*, 2017). All of the above enable firms to offer highly customized value propositions based on digitally enhanced services and relationships (Kowalkowski *et al.*, 2013; Tronvoll *et al.*, 2020).

However, despite its growing prominence in manufacturing contexts, the literature suggests that transitioning to digital servitization represents a major challenge, since it demands a comprehensive consolidation of firms´ technological and strategic innovation capabilities (Bustinza *et al.*, 2018) to successfully resolve two existing paradoxes associated to its adoption (Gebauer *et al.*, 2020a). Firstly, the continued investment in services with no favorable financial results, namely service paradox, and, secondly, the under-utilization of acquired technologies that may well not earn the expected returns, the so-called technology paradox (Gebauer *et al.*, 2020b). This may lead companies to struggle in creating real customer value, while it can also prevent firms from securing revenue growth through selling digital service solutions (Coreynen *et al.*, 2020). In fact, it has been argued that digital servitization may take several years to yield results and create value for organizations (Kohtamäki *et al.*, 2020).

*2.3. An integrative view of technological innovation in modern manufacturing*

By drawing on the integrative view of innovation (Dammanpour, 2010), we intend to examine the performance effects of combining technological innovations in two distinctive manners. To begin with, we explore the joint process-product innovation strategy, and we then assess the added gains of including digital service innovation (i.e., digital servitization) to this tandem, in other words, the combination of all three innovations; product, process, and service simultaneously. Moreover, we suggest that due to the existence of sectoral heterogeneity among manufacturing firms (Pires *et al.*, 2008); there might be different optimal configurations among manufacturing industries.

Process innovation has been shown to enhance a firm's ability to exploit, maximize, and reconfigure resources and capabilities used in the process of production (Chai *et al.*, 2020). Alternatively, product innovation has been found to increase the range of products to meet sales goals, market share goals, return on investment and customer satisfaction (Najafi-Tavani *et al.*, 2018). In parallel, both product and process innovations have proven to have significant implications on firms’ marketing and differentiation strategies (Lukas and Ferrell, 2000). Accordingly, their joint deployment allows the integration of diverse assets and the construction of a consistent system of interrelated innovations that mutually reinforce one another (Prajogo, 2016). All of the above enable firms to better adapt to market changes and have shorter and faster decision chains and greater flexibility (Hullova *et al.*, 2016), thus procuring a solid strategic springboard for gaining competitive advantage (Hullova *et al.*, 2019) and business performance (Damanpour, 2010). Such evidence upholds the positive effect of the interplay between process and product innovations on firm performance, and therefore enables us to state the following proposition:

**Testable proposition 1**: In manufacturing firms, joint deployment of product and process innovation is a necessary condition to achieve superior performance.

As stated earlier, we believe that this proposition may have nuances depending on the industrial sector/context (Pires *et al.*, 2008). The rationale for this assertion follows from the servitization literature which suggests that digital servitization is not a one size fits all strategy, and that in certain industries with more industrial focus there are more opportunities to benefit from such strategies (Bustinza *et al*. 2019).[[1]](#footnote-1) Firms in heavy manufacturing must strive for, among other aspects, improved supply chain interactions (Sjödin *et al.*, 2019), closer B2B relationships (Baines and Lightfoot, 2014), more consistent co-creation strategies (Bigdeli *et al.*, 2018), and increased product complexity (i.e., high levels of customization) (Raddats *et al.*, 2016)—in order to gain competitiveness and enhance performance (Kohtamäki *et al.*, 2020). Accordingly, we argue that in sectors with stronger industrial bases (i.e., NAICS 33), the additional integration of digital service innovation into process and product innovations may enhance firms’ capacity to obtain higher performance gains.

From our standpoint, process, product, and digital service innovation have important complementarities in heavy manufacturing settings. Firms with an extended technological portfolio of process, product and service innovations are more versatile and dynamic, and can develop more diverse and complex business strategies than firms with more limited innovation portfolios (Rivkin, 2000). The increased versatility and dynamism enabled by the complementarity between product, process and service innovations allow the reconfiguration of firm capabilities and resources, that is, greater flexibility (Hwang and Hsu, 2019) and provide opportunities to create new business models that generate additional above-average profits (Nason and Wiklund, 2018). Moreover, the addition of digital service innovation in manufacturing firms’ stresses the uniqueness of the firm’s offerings by integrating actors (suppliers, intermediaries and customers) within the value-creation ecosystem (Story *et al.*, 2017) enabling value capture through greater customer understanding (Jovanovic *et al.*, 2019). These notions suggest that the joint deployment of process, product, and service innovation might offer superior performance outcomes, particularly in manufacturing sectors with stronger industrial bases (i.e., heavy manufacturing), and therefore enables us to state the following proposition.

**Testable proposition 2:** In heavy manufacturing firms, joint deployment of product, process, and service innovation is a necessary and sufficient condition to achieve superior performance.

**3. Data and Method**

*3.1 Database*

This study seeks to uncover contemporary innovation trends within medium-sized Spanish manufacturers. Spain is considered to be a relevant context as it has very few large corporations and therefore private innovation takes place mostly in medium sized firms (Gonzalez-Pernia *et al*., 2012; Ortin-Angel and Vendrell-Herrero, 2014). To identify the population of firms we use the SABI database, a service of Bureau Van Dijk (BvD) (http://sabi.bvdep.com), which provides a good representation of all strata of the Spanish business population.

We limited our study to the population of firms with more than 50 employees that work in industries with manufacturing NAICS codes 31 to 33. These codes include industries such as food, beverage, and textile processing (NAICS 31); non-mineral manufacturing together with wood, petroleum, plastics and chemical processes, and the pharmaceutical industry (NAICS 32); and mineral manufacturing, as well as the construction of hardware, vehicles, machines, turbines, and engines (NAICS 33). We identified a population of 7,552 firms.

Firms were contacted via Computer-Aided Telephone Interviewing following procedures supported by the literature. This method is cost-effective and can measure behavior of interest (Couper, 2000). During November and December 2018, companies were contacted by phone until we obtained 438 responses, being 423 of them fully complete answers. Respondent firms were found to be representative since the sectoral and size composition were close to that of the total population. Once the survey was completed, it was merged with the SABI database to ensure that the monetary values of interest including revenues and profits for the current (2018) and subsequent (2019) periods were fully objective.

*3.2 Variables*

Firm performance is based on previous research that evaluates service innovation in product firms while focusing on profit margin (Sousa and da Silveira, 2017; Suarez *et al.*, 2013; Visnjic-Kastalli and Van Looy, 2013). We operationalize profit margin as Returns on Sales (ROS), i.e. firm’s earnings before taxes divided by the firm’s annual revenues. As profitability varies significantly over the years, we averaged ROS for two years (2018-19) to provide a better picture of the normal profits obtained by the firm. Mean ROS in the sample is 8.42%. This means that firms retain, on average, 0.0842 cents per euro in the form of profit. ROS is nearly the same in the three industrial sectors analyzed.

In line with previous innovation studies (e.g. Cirera and Muzi, 2020), we asked the firms the following question for each specific innovation: “*During the last three years, did your firm introduce any new or significantly improved product/process/digital service on the market?*” Based on this question, we can differentiate between all innovation portfolios, including “no-innovation”, isolated “product”, “process” and “service” innovation, and more importantly for our research, the joint deployment of "*process and product*" or "*process, product, and service*" innovation portfolios. As indicated in Table 1, only 6 (1.4%) of the 423 firms are non-innovators, showing that manufacturing firms are increasingly relying on some forms of technological innovation. In the 29 firms (6.8%) that have single innovation, process innovation seems to be the most popular form of innovation (22 firms, 5.2%). From the 296 firms (70%) that jointly deploy two types of innovation, 264 (62.4%) implemented “product-process” innovation. Finally, 92 firms (21.7%) jointly implement “product-process-service” innovation. This means that most firms in our sample (91.7%) simultaneously deploy two or more forms of technological innovation. When comparing manufacturing industries, we can observe that the proportion of firms in each technological innovation portfolio is fairly similar.

--- Insert Table 1 about here ---

*3.3 Method*

Testable propositions seek to uncover firms’ optimal configurations through the evaluation of necessary and sufficient conditions. For this purpose, we use a non-parametric technique, fuzzy set Qualitative Comparative Analysis (fsQCA), which is useful for analyzing equifinality, that is, different variable combinations associated with the highest level of a selected outcome (Longest and Vaisey, 2008). In this research, a certain combination of technological innovations (process, product, and service) is expected to have the greatest impact on profits. For innovation strategies, variables can only take two values, 0 if not implemented, or 1 when implemented. As profit margin is a continuous variable, fsQCA technique is preferred to crisp QCA, since the latter is only appropriate for dichotomous variables and not continuous ones. In order to introduce continuous variables in an fsQCA analysis, they first need to be calibrated through a software transformation. Logistic calibration – positive and corresponding negative end-point thresholds– is performed with the Ragin and Davey (2014)’s fsQCA software version 2.5. This software transforms these variables into intervals and makes a fuzzy set score related to the degree of membership to those intervals. Intervals are specified according to three thresholds (Ragin, 2008): full membership condition (fuzzy score value = 0.95), full non-membership condition (fuzzy score value = 0.05), and cross-over point condition (fuzzy score value = 0.50). This calibration identifies how the set of variables is related to specific outcome levels (25th, 50th and 75th percentile).

**4. Findings**

*4.1 Necessary analysis*

Consistency measures whether variables are necessary for the outcome to occur, that is, if all firms with a certain casual variable –process innovation, product innovation, or service innovation– present profits. A configuration is considered to be necessary when consistency value is above a threshold value. Generally, a casual variable “necessary” or “almost necessary” consistency value must be equal or higher than 0.9 to be considered (Schneider and Wagemann, 2010). Consistency measures are reported in Table 2. In line with our theoretical predictions, only product and process have a consistency score above the 0.9 threshold for the full sample. With this result we corroborate testable proposition 1.

The analysis also shows the coverage value –the proportion of cases in which both the condition and the result of interest appear. For instance, product innovation has a coverage value of 0.707, i.e., 70.7% of the cases in which this condition –product innovation– is present, the result of interest –high profits– is also present (Schneider and Wagemann, 2012). All technological innovations (product, process, and service) are non-trivial conditions as their coverage score yields a value clearly distant from 0. Taking a value near zero would have meant that conditions occur in all cases, being theoretically and empirically considered trivial conditions (Schneider and Rohlfing, 2016).

--- Insert Table 2 about here ---

*4.2. Sufficiency analysis*

A casual condition is (almost) sufficient for the result, if, every time that it is present, the expected outcome (e.g. high profits) is also present. The usual sufficiency threshold is 0.8 for Solution Consistency value, i.e., how many of the cases in a given category have the result of interest (Ragin, 2008), and is analyzed through the “Truth Table Algorithm”, which is a method in fsQCA to unveil causal configurations that yield the highest outcome values (Ragin, 2008). Casual variable combinations exceeding a cut-off consistency score are considered sufficient (Schneider and Wagemann, 2012). fsQCA software provides three solutions: complex, intermediate, and parsimonious solutions, being intermediate solution the recommended solution –it is the most parsimonious solution allowing maximum complexity (Ragin, 2008). Table 3 shows the casual combinations of technological innovations leading to the highest profit margin, i.e., causal configurations with the highest raw coverage and unique coverage.[[2]](#footnote-2) Raw coverage indicates what proportion of the cases leading to superior profit margins is explained by the casual configurations. Conversely, unique coverage indicates that the proportion of cases leading to superior outcome levels is exclusively explained by this casual configuration, and by no other.

--- Insert Table 3 about here ---

Results show sectoral heterogeneity as firms belonging to NAICS 31 and NAICS 32 reach the highest profit margin by combining "*process and product*" innovation. However, firms operating on Heavy Manufacturing (NAICS 33) also require digital service innovation to achieve the highest level of profits ("*process, product and service*)". Overall solution coverage scores assess the explanatory power of the solution over the outcome, being similar to the *R*-squared in multivariate analysis. Therefore, consistent with testable proposition 1, results suggest that deploying process and product innovations simultaneously is a necessary and sufficient condition for firm profits in the general population of manufacturing firms, whereas having all three technological innovations is the necessary and sufficient condition for achieving the highest profit margin in heavy manufacturing. With this result we corroborate testable proposition 2.

**5. Discussion and conclusion**

This study provides an important contribution to the servitization literature, shedding light on whether and in what contexts digital servitization may complement and benefit from technological innovation, that is to say, from product and process innovations in manufacturing. Regarded from the integrative view of innovations (Dammanpour, 2010), our results indicate that carrying out process and product innovation represents a necessary condition for firms’ performance gains, specifically in less industrial manufacturing contexts (NAICS 31-32). Yet, our findings provide evidence that, particularly in sectors with stronger industrial focus (NAICS 33), deploying product and process innovation is necessary, but not sufficient, for reaching the highest levels of firm performance. Within these contexts, firms also need to undertake digital servitization in conjunction with process and product innovations in order to fully benefit from the service innovation deployment. In other words, in heavy manufacturing sectors (metal, machinery and hardware industries) the optimal configuration for performance enhancement lies in the complementarity between product, process, and service innovation. Our findings have a number of important theoretical and managerial implications for researchers and practitioners.

*5.1 Theoretical implications*

Our research contributes to the servitization and innovation literature by linking two streams of research that have previously remained independent of each other; digital servitization and technological innovation. On the one hand, technological innovation literature has mainly focused on analyzing complementarity between process and product innovation (Martinez-Ros, 2019), disregarding to some degree the role of service innovation in manufacturing contexts. This issue prompted a call for studies to analyze the synchronized deployment of different innovation types (Damanpour, 2014). Accordingly, our research responds to this call and links these hitherto non-converging domains by theorizing and empirically testing performance gains from the complementarity between traditional technological innovations (process and product innovations) and digital servitization (service innovation) in manufacturing. Evidence provided in the study is important for understanding innovation in modern manufacturing. The study shows that joint deployment of technological innovations provides higher profits than single or non-innovation, which is consistent with the fact that joint innovation is considered a widely prevalent strategy (Hullova *et al.*, 2019; Najafi-Tavani *et al.*, 2018).

Servitization literature, on the other hand, has mostly analysed service innovation as an isolated phenomenon occurring in manufacturing contexts as a strategic response to commoditization. This perspective, however, considers service innovation as the fundamental (if not unique) axis of innovation developments (Visnjic-Kastalli and Van Looy, 2013). Our findings, however, indicate that service innovation should be perceived as an innovation capable of complementing other types of technological innovations, and hence be conceived of as part of a synergistic system of innovations. This is a relevant finding for the servitization community, since it opens new avenues to analyse servitization from an integrative perspective and implies that servitization research may influence and eventually reformulate more mature and wide-ranging literature streams, as it is the case of technological innovation.

*5.2 Managerial implications*

Our study suggests a number of relevant implications for managers of innovative manufacturing firms. One of the most important is that they should start considering servitization in complementarity with traditional technological innovations within the firm in order to structure more valued and complex innovation portfolios. Process and product innovation should be understood as a necessary condition to gain performance benefits in manufacturing, particularly in more conventional contexts. Service innovation yields higher performance gains when undertaken in conjunction with process and product innovation, specifically in heavy manufacturing sectors. Accordingly, managers pursuing servitization outcomes should apply an integrative view of innovations; one that considers servitization as a piece of the firm´s innovation puzzle and not an isolated innovation component, in order to fully benefit from its deployment.

*5.3 Limitations and directions for further research*

In common with other research, there are some methodological limitations to this study, which should be pointed out to provide directions for future research. Firstly, this study only investigated the complementarity effect of service innovation (i.e., digital servitization) on technological innovation (process and product innovations), without however establishing a successional pathway of implementation priorities. Accordingly, future longitudinal studies should attempt to determine the necessary pathway to adoption of technological innovations. Secondly, the article follows a non-parametric method (fsQCA) to study the optimal outcome of innovations deployment. Future research should conduct a parametric analysis in order to quantify the economic benefits included in each of the configurations. Lastly, the conclusions that emerged from this study are based on the analysis of medium-sized Spanish manufacturers. Although this setting is considered to be relevant for the purpose of the present study, it must be replicated in more settings in order to confirm the results.

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*TABLES*

*Table 1: Technological Innovation Portfolios, number of firms.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | ***All firms*** | **NAICS-31** | **NAICS-32** | **NAICS-33** |
|  |  | Food, beverage, and textile  | Printing,chemical, and pharmaceutical  | Metal, machinery,and hardware  |
| *No innovation* | 6 | 2 | 2 | 2 |
|  | *1.42%* | *1.63%* | *1.65%* | *1.12%* |
| *Product innovation only* | 1 | 3 | 1 | 0 |
|  | *0.95%* | *2.44%* | *0.83%* | *0.00%* |
| *Process innovation only* | 22 | 8 | 6 | 8 |
|  | *5.20%* | *6.50%* | *4.96%* | *4.47%* |
| *Service innovation only* | 3 | 1 | 0 | 2 |
|  | *0.71%* | *0.81%* | *0.00%* | *1.12%* |
| *Product and Process innovation* | 264 | 76 | 79 | 109 |
|  | *62.41%* | *61.79%* | *65.29%* | *60.89%* |
| *Product and Service innovation* | 15 | 3 | 7 | 5 |
|  | *3.55%* | *2.44%* | *5.79%* | *2.79%* |
| *Process and Service innovation* | 17 | 6 | 1 | 10 |
|  | *4.02%* | *4.88%* | *0.83%* | *5.59%* |
| *All innovations* | 92 | 24 | 25 | 43 |
|  | *21.75%* | *19.51%* | *20.66%* | *24.02%* |
| ***Total firms*** | **423** | **123** | **121** | **179** |

*Table 2. Analysis of necessary conditions*

|  |  |
| --- | --- |
|  | *Profit margin* |
| *Condition* | *Consistency* | *Coverage* |
| *Full sample*  |
| Product innovation | 0.932 | 0.707 |
| Process innovation | 0.916 | 0.632 |
| Service innovation | 0.774 | 0.641 |
| NAICS-31 |
| Product innovation | 0.944 | 0.719 |
| Process innovation | 0.906 | 0.642 |
| Service innovation | 0.606 | 0.638 |
| NAICS-32 |
| Product innovation | 0.936 | 0.693 |
| Process innovation | 0.920 | 0.633 |
| Service innovation | 0.784 | 0.602 |
| NAICS-33 |
| Product innovation | 0.926 | 0.728 |
| Process innovation | 0.922 | 0.674 |
| Service innovation | 0.904 | 0.712 |

*Table 3. Technological innovation configuration and performance*

|  |  |
| --- | --- |
|  | **Outcome variable** |
| **Performance (profit margin)** |
| Product Innovation | Process Innovation | Service Innovation |
| Full sample |  |  | — |
| R = 0.725 / UC = 0.338 / C = 0.705 OSCe = 0.826 / OSCs = 0.733 |
| NAICS-31 |  |  | — |
| R = 0.731 / UC = 0.345 / C = 0.713 OSCe = 0.833 / OSCs = 0.741 |
| NAICS-32 |  |  | — |
| R = 0.728 / UC = 0.349 / C = 0.706 OSCe = 0.831 / OSCs = 0.739 |
| NAICS-33 |  |    |  |
| R = 0.705 / UC = 0.289 / C = 0.698 OSCe = 0.806 / OSCs = 0.710 |

Black circles “” indicate that companies implement these innovations; unfilled circles “” indicate that they do not implement these innovations, and a hyphen “–” indicates indifference. “C” means Consistency; “R” Raw coverage; “UC” Unique Coverage; “OSCy”: Overall Solution Consistency; “OSCe”: Overall Solution Coverage

1. Part of our argument is also based on the fact that most case-study servitization research has largely analyzed firms in metal, machinery and hardware industries (NAICS 33). However, there are practically no cases in textile, food processing, chemical or pharmaceutical firms (NAICS 31 and 32). There seems to be less implementation of service innovations in those industries, which we interpret as firms in those industries finding service innovation less financially attractive. [↑](#footnote-ref-1)
2. Table 3 shows only the configurations with consistency values above the threshold value of 0.8. [↑](#footnote-ref-2)