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Best Practices for DFSS in Servitization

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Abstract

Purpose –This paper aims to define a set of best practices on how organizations should apply Design for Six Sigma (DFSS) to servitization for different service processes. Servitization refers to a manufacturing company offering services connected to its physical products. To survive in the global competition, it is essential to design new services that fit the products and services that are customized for the customers and assure their resilience.

Design/methodology/approach – First, the paper summarizes the key definitions and literature sources directly associated with the manufacturing. Then, the paper presents a theoretical framework that categorizes the critical characteristics of a manufacturer's operations strategy in offering services connected with its products.

Findings – This paper outlines the effectiveness of DFSS application in servitization. The model helps design the critical managerial aspects of service processes when a manufacturing organization launches new services connected to its products. From a management point of view, this paper provides manufacturing organizations with some best practices to improve their New Service Development (NSD) process.

Research limitations/implications – The basis of the work is a literature review supported by data collected from business case studies. Further research is needed to develop a DFSS approach to introduce integrated new products and related services.

Originality/value –Empirical research on the applications of DFSS to services is limited. The principal contribution of this paper is a framework that captures the key characteristics of a DFSS approach for services in a servitization framework and its application in some business cases.

Keywords: ICT, Lean, New Service Introduction, Service, Six Sigma, DFSS, Servitization, Business Model

Introduction

Innovation connected with introducing new products and services is critical in the new socio-economic environment. It is crucial to improve it as much as possible to make it more effective, efficient, and economical.

Services are now more critical due to several factors, such as globalization and customer focus. This statement also applies to manufacturing organizations that can improve profitability and customer retention by selling services connected to their products. Consequently, products today have a higher service component than in the past. The management literature refers to this as the servitization of products. Many products today have a service component with them.

A literature review concluded that servitization had evolved since its creation, increasing product potential. For this reason, it is crucial to investigate methodologies to support the development of new services and processes in servitization in a comprehensive, structured, and systematic way. It is also essential to develop the necessary capabilities to compete in current situations to reach the advanced services required (De La Torre and Sanchez, 2022).

Design For Six Sigma (DFSS) is a method that can help to meet or exceed customer satisfaction (Antony and Bañuelas, 2002; Gijo *et al.*, 2021). It uses well-established tools and techniques (Kwak and Anbari, 2006, Linderman *et al*., 2003). DFSS is an organized and systematic method for the strategic improvement and development of new products, services, and processes using statistical tools to reduce defects and variations perceived by customers. DFSS applies these tools by combining them with a team approach.

Service types are heterogeneous; because of this, it is difficult to find in the literature methodologies to support the service design process and reduce its variability. This paper applies to DFSS in servitization a method developed by Campanerut and Nicoletti (2010). This paper develops best practices for successfully implementing DFSS in servitization. We use a classification of servitization processes to demonstrate how the DFSS application needs to be adapted to be effective, efficient, and economical in different situations.

The DFSS method has not been used as widely as Six Sigma (Yang et al., 2022). The reason is that organizations, in most cases, desire to improve existing processes and products, while DFSS is suited for new processes and products. This approach benefits manufacturing organizations moving to services due to their inexperience with services and related processes. It allows the possibility to use all their experience in using DFSS in manufacturing and introduce new products and services.

Methodology

The methodology used to develop this paper relied on two activities:

1- A thorough literature analysis on NSD and servitization of studies regarding general structures and models, particularly their integration and digitization processes and their implications for effectiveness, efficiency, and sustainability.
2- An analysis of several business cases and practices regarding the practical implementation of servitization solutions, analyzing their critical success factors, the main related quantitative results, and their most challenging factors of concern. The business cases derive from the authors' managerial and consulting experiences. They are relative to the oil and gas machinery industry and metal mechanical businesses

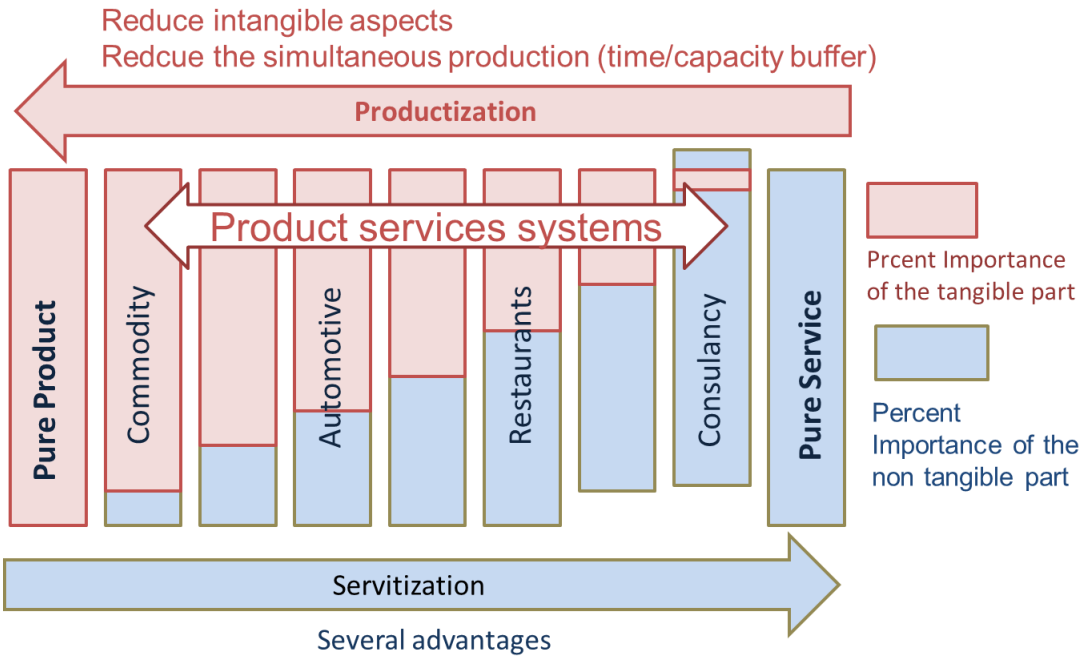
Literature Review

From a theoretical point of view, there are several contributions in the integrated product and service development and management literature. New Service Development (NSD) research is limited (Solem *et al.*, 2021). DFSS can positively impact organizational creativity and innovation (Sony and Naik, 2019). It is one of the better New Product Development (NPD) methodologies in the presence of high criticality and stringent deadlines (Awad and Shanshal, 2017). Besides, DFSS helps quantify the performance metrics at every NPD stage and ensures robust analysis throughout the NPD process leading to better decision-making (Lobo and Samaranayake, 2020). This approach is flexible and can be combined with other NPD approaches such as lean product development and innovation (Brunetti, 1995; Nicoletti, 2015), which helps better visualize components at the systems level, interactions at the parametric level and unearths the gaps that pave the way for continuous improvement (Sreeram and Thondiyath, 2015).

The literature study unearths that DFSS can accelerate achieving the Key Performance Indicators (KPI) of New Product Development (NPD), such as reliable product quality, minimized manufacturing cost, and on-time market launch (Alvarez, 2015). Over and above, the DFSS methodology applies to the online services part of the industry 4.0 initiative (Carvalho *et al.*, 2016). However, the DFSS approach demands a dedicated deployment approach with a comprehensive understanding of its interrelations with other organizational aspects to avoid backlash. Lack of effective project charter development, awareness of tools and techniques, inadequate training, internal team dynamics, lack of academic mentorship, lack of leadership, lack of management support, and poor pre-work execution hinder the DFSS project success (Awad and Shanshal, 2017).

Vandermerwe. *et al.* (1988) introduced the term servitization to describe an "increased offering of fuller market packages or bundles of customer-focused combinations of goods, services, support, self-service, and knowledge to add value to core product offerings.", It refers to the delivery of a service component as an additional benefit when providing products. It can be prior to, during, or after the sale. The main potential benefits for the manufacturers are financial, promotional, and competitive positioning. Baines *et al.* (2009) report the state-of-the-art servitization by presenting a review of literature currently available on the topic. Their paper aims to define the servitization concept, inform its origin, features, and drivers, and provide examples of its adoption and future research challenges.

Figure 1 Servitization



The service sector has been at the center of many types of research. Another topic has been service quality. The high interest of scholars in services and service quality reflects the change of focus of interest and the rapidly growing interest in the economy's service sector (Alayón González, 2012).

A limited number of papers and books on topics related to the customer process after delivering a product or service, such as service recovery and after-sales service. Very few papers cover strategies and management on these topics (Alayón González, 2012).

Scholars suggest that to survive in developed economies manufacturing organizations must move up the value chain, innovating and creating more sophisticated products and services, so they do not have to compete based on cost. This strategy is proving increasingly popular with policymakers and academics (Neely, 2007). There is limited empirical evidence to explore how servitization is in practice and the impact of this servitization on manufacturing. A survey has sought to fill a gap in the literature by presenting empirical evidence on the range and extent of servitization (Neely, 2008). Several studies consider servitization from an internal point of view to the organizations (Baines *et al.*, 2009). A research note sets out to fuel the debate around the practices and technologies within operations that are critical to the success of servitization. It presents a study of four companies delivering advanced services and reports on the organization and skillsets of people within these (Baines *et al.*, 2013).

Best practices make sense if they also consider the peculiarities of the sectors where they are applied. Classification of services is essential. Some scholars examined the possible classification of servitization (Niu et al., 2021; Wilkinson *et al.*, 2009) on a taxonomy based on how after-sale services use different technologies. In the first instance, people will provide services, for instance, to maintain the product sold. In the second instance, people could deliver the services with specific technologies. Scholars further stress innovation models. The ideas are promoted based on the empirical evidence of Chinese and Taiwanese organizations in the consumer electronics and automobile sectors. The book looks at organization strategies in a new business environment dominated by servitization of industrial products. It argues for organizations to integrate manufacturing and services to a great extent. To substantiate the arguments, empirical evidence comes from India, Taiwan, and Bangladesh. The study further finds evidence that innovation and knowledge acquisition strategies are influenced by the size of organizations and vary with market preferences (Hirakawa *et al.*, 2013). On the other side,

after-sale services could be, in some cases, provided remotely by persons operating a support center (Kisielnicki and Markowski, 2021). This kind of consideration is interesting in the design of services. Organizations would want to define a more financially effective strategy for selecting or moving from one service to another.

Classification of Services

One can classify services in diverse ways. It is possible to differentiate between commercial and not-for-profit services. Another classification refers to the merchandise sectors in which services operate. These classifications do not help much in the design and management of servitization, which this paper addresses. They can give rise to a sense of diversity among organizations. This approach would not help identify the most appropriate design approaches for each situation. From this latter point of view, it seems reasonable to classify organizations based on the responses to two fundamental questions (Nicoletti, 1984):

- Where is the service delivered?
- How is service delivered?

The extent of customer contact during the deployment of the services is a classification of services. The "contact" refers to the customer's physical presence in the location where services are delivered. The definition of the "extension of the contact" is the percentage of time spent by the customer in the service deployment area compared to the total service deployment time. This classification would avoid the fact that research on services is often too qualitative and does not offer good metrics to measure them (Haynes, 1990). Some of the first studies on the topic introduced this concept (Chase, 1981; Chase *et al.*, 1984). Chase (1981) presented a customer contact model asserting that the potential efficiency in services is a function of:

- Customer contact time (that is variable); and
- Service creation time (that tends to be constant).

Delivering the services remotely reduces the contacts. An example of this type would be when monitoring and, if possible, repairing a product is done remotely using sensors and remote tools. In this case, the customer does not contact the service seller. This situation can help avoid misunderstandings and perception filters that are more frequent when human relationships occur during service provision (Kotler, 2002; Chen *et al.*, 2021).

When an organization moves toward servitization, there is an increase in «customer intensity» for any client:

- Participates actively in the organization's processes since it interacts with the vendor.
- Influences the flow and the outcome of the processes.

The inputs supplied by the customer can also change over time (and are only partially controllable). This solution inevitably determines inefficiencies. For this reason, DFSS is essential in designing the services and related processes.

In response to the second question above, services can be delivered by persons, technology, or a mix of two. Literature offers several examples of this categorization (Burns and Stalker, 1962; Schmenner, 1986; Haynes, 1990). For example, in the case of functional services connected to air transportation, the several types of services provided to the customers may be based either on automated equipment or supplied by specialized operators.

Crossing the two characteristics mentioned in the previous paragraphs determines four classes. They generate the matrix in Table 1, an example of the possible classification of services in servitization.

Table 1 Classification of services in the servitization

		How is the service delivered?	
		People	Technology
Extension of contact	High	*On-site in person*	*Repair*
	Low	*Help Desk*	*Remote monitoring*

In using this classification, one should consider that:

- There is a continuum rather than a pigeonhole of an organization into any of the four classes.
- The specific organizations involved in servitization can offer services classifiable in diverse types.

Application of DFSS to Different Servitization Processes

It is interesting to analyze how DFSS can be applied in servitization for the different services introduced in the previous section. Based on the analysis of many real-life situations, it is possible to define the following best practices.

The strategic project selection for DFSS (see Table 2) should support critical aspects of the servitization processes. The base of the DMAIC model is the sequence of the steps: Define, Measure, Analyze, Improve, and Control, more suitable for continuous minor improvements. The base of the DMADV model is the Define, Measure, Analyze, Design, and Verify sequence. The latter is ideal for drastic improvements.

In the case of services delivered through people and with an elevated level of contact with the customers, the front office processes should have priority due to their criticality in providing this class of services. In these cases, DMAIC is used rather than DMADV since changes must be slow rather than drastic when many persons and customers are physically present. Organizations should also use DMAIC for services delivered through people but with low contact. In this latter case, the back-office processes should be a priority in the improvements. The selection would be different when mostly technology delivers the services. In this case, when contact with the customer is high, contact technology should be a priority in the improvements. When contact is low, the remote connection technology should have priority. In the case of technology-based services, DMADV makes much more sense since there are investments connected with the technology, and there is the possibility of substantial improvements, justifying sizable efforts.

A previous study defines five aspects to evaluate DFSS in general (Campanerut and De Toni, 2010). This paper analyses the implications in the case of servitization of the classification of services discussed before from these aspects plus two additional ones, based on Kipling's approach of the 5W's+H (Kipling. 2013):

- Why? Strategic project selection.

- What? Culture and intangible assets.
- Who? Actors and organizational structure.
- When? Priority of the implementations.
- Where? Location of the interventions.
- How? Tools used in the implementation and business models adopted.

Table 2 Strategic project selection model.

		How is the service delivered?	
		People	Technology
Extension of contact	High	*On the front-office processes.* *Normally DMAIC*	*On the technology of contact.* *Normally DMADV*
	Low	*On the back-office processes.* *Normally DMAIC*	*On the technology of remote connection.* *Normally DMADV*

Culture and Intangible Assets

Culture and intangible assets have different priorities according to the class of services. From the culture and intangible assets point of view, dealing with values, knowledge, and Six Sigma training throughout the organization, the best practices suggest the classification shown in Table 3. In Table 3, when services are delivered through people and with a high contact extension, the behavioral aspects connected with the organization's culture, with a robust set of values, knowledge, and training, are critical. Standardization is vital in the case of services delivered by people but with low contact with the customer since remote customers expect a well-specified type of service. In the case of services delivered through technology, the relevant intangible asset is the brand, which is significant in low contacts.

Table 3 Culture and intangible assets model.

		How is the service delivered?	
		People	Technology
Extension of contact	High	*Behavioral aspects*	*Strong brand*
	Low	*Standardization*	*Powerful brand*

Actors and Organizational Structure

One needs to consider the meso-structure of the Six Sigma organization and the people involved in the project teams from an actor and organizational structure point of view. The best practices out of the cases studied suggest the classification shown in Table 4. In this case, the types of people or facilities more critical to the success of the servitization initiatives are different according to the class of services. For instance, the front office persons are significant in services delivered through people and with a high contact extension. They should be part of

the project team active in launching the new products and services to share the wealth of their knowledge of the customers and their business. In the case of services delivered by people but with low contact, the back-office persons are relevant due to the remoteness of the customer.

Table 4 Actors and organizational structure model.

		How is the service delivered?	
		People	Technology
Extension of contact	High	*Involve the front office people*	*ICT*
	Low	*Involve the back-office peoples*	*ICT*

A systematic review of the research on digital servitization highlights two research gaps that have significant theoretical and practical implications (Tronvoll *et al*., 2015). First, "the links between digital technologies and servitization" remain under-investigated (Paschou *et al*., 2018). Servitization is a multifaceted, incremental, and emergent process (Kowalkowski *et al*., 2012), changing how organizations operate and creating value in fast-paced and potentially disruptive ways (Nagy *et al*., 2016; Simmons *et al*., 2013). The consequences are fundamentally altered business models and challenged industry boundaries and organizational identities (Ng and Wakenshaw, 2017; Svahn *et al*., 2017). Second, exploiting the growth opportunities enabled by digital technologies has proved challenging, even for service-oriented manufacturers. Many organizations find it problematic to shift "from selling equipment and aftersales service to selling digital solutions" (Parida *et al*., 2019). A survey of 215 European service executives in manufacturing organizations found that the biggest challenge posed by this transformation is the integration of new technologies and the subsequent design of new service business models (Copperberg, 2019). The critical issue of harnessing this potential to drive servitization requires research concerning changes to organizational identity and culture (Kohtamäki *et al.*, 2019; Parida *et al.*, 2019).

Information and Communication Technology (ICT) is appropriate for services delivered through technology (Kowalkowski *et al.*, 2022). The processing side is relevant in the case of high contact. The telecommunication and networking side is suitable if contact with the customer is low since the network connection is critical. Table 4 shows these aspects using a larger font for the "I" of ICT in the case of the quadrant of high contact and a larger font for the "C" of ICT in the case of the quadrant of low contact.

Implementation of the Method

Manufacturing organizations should implement servitization in diverse ways depending on the class of service. The best practices suggest the classification described in Table 5. In this Table, the phases of the DMAIC or DMADV processes that are particularly important for each class of service are marked with a capital letter. In the case of service delivered by people with high contact with the customers, the Analysis and Control phases are critical. It would not be acceptable to implement the new services with defects. They would be evident and negatively perceived by customers, significantly impacting the successful introduction of the new services. The only way to reduce such defects is to emphasize the Analyze phase. This way supports

considering all the possible events in advance. Testing the solution thoroughly in the Verify phase is also essential since the physical presence of the customers on the organization's premises could lead to unexpected problems. Besides, the Analysis phase is critical for services delivered through people with a low contact extension. In contrast, the Control phase is less important in the case of high contact due to the absence of customers on the organization's premises.

Like the previous quadrant, the Analysis phase is critical to consider all events. Design is vital for services delivered through technology with a high contact extension since it will be necessary to modify the technology. In this case, the Verify phase is also essential due to the presence of the customers in the organization's premises. The Verify phase is less important in this situation regarding the presence of high contact due to the lack of direct contact with the customers. In this situation, there is a need to reduce any defects before the launch of the new services. Finally, with services delivered through technology and low customer contact, the Design phase is essential.

Table 5 Method for the implementation of the model.

Culture and intangible assets model.

		How is the service delivered?	
		People	Technology
Extension of contact	High	*Behavioral aspects*	*Strong brand*
	Low	*Standardization*	*Powerful brand*

A paper lists the best practices of DFSS deployment from the authors' experience, consultancy, area, and successful deployment of projects across various organizations (Gijo, E.V. et al., 2021). DFSS project success largely depends on its alignment with organizational strategy, top management involvement, attention to Voice of the Customers, practical training, scientific basis for project selection and prioritization, alignment with an ISO quality management system, the scope for learning and innovation, connections with Industry 4.0 and 5.0, matured DFSS methodology, and practical human resource and management practices (Grandinetti *et al.*, 2021). The DFSS approach can be strengthened by including lean innovation, lean and digitize, and design thinking of different methodology steps (Chiarini *et al.*, 2018). Some best practices are more important than others. The correct selection of the tools may significantly contribute to the successful implementation of DFSS, as the next section will demonstrate.

Tools Used in the Implementation

Empirical evidence and best practices from the cases studied suggest Table 6 for the best tools organizations should use to successfully carry out the DFSS projects. In the case of service delivered by people, even if the contact with the customers is low, the use of qualitative tools to better identify the customer needs and the Critical Quality factors (CTQ) is compelling: the higher the contact with the customers, the more important is the use of qualitative tools. At

the same time, statistical tools are more critical in the case of services delivered through technology and with high contact with customers. In this case, there is the need to process a more significant amount of data to identify constraints and critical variables to design a better service process: the lower the contact with the customers, the more meaningful would be the use of data science and advanced digital tools (Barbieri *et al.*, 2021).

Table 6 Tools models.

		How is the service delivered?	
		People	Technology
Extension of contact	High	*Rigorous use of qualitative tools*	*Use of statistical tools*
	Low	*Use of qualitative tools*	*Rigorous use of statistical tools*

Priority in the Implementation

In terms of the priority in the implementation, best practices suggest Table 7. When people deliver the service, and the contact extension is high, the recommendation is to start with improving the relationship processes due to the high contact between the customer and the persons of the organization. In the same situation, but with an extension of the contact low, the interactions of the organization's people with the customers require priority interventions. If the service is delivered using some technologies, the user interfaces are essential if the contact extension is high. If the contact extension is low, simplicity of use is of paramount importance due to the remoteness of the customer.

Table 7 Priority in the Implementation.

		How is the service delivered?	
		People	Technology
Extension of contact	High	*Relationships processes*	*User interfaces*
	Low	*Interaction with the customers*	*Simplicity in use*

Location of the Intervention

Regarding the interventions' location, if the contact extension is high and people deliver the service, the selection should be concentrated on the location where the customer is in contact with the organization. If the contact extension is low, the location of the intervention would be the contact center. When some technology provides the service, the intervention should take care of the location where the customer is present in case of a high contact extension. In this situation, if the contact extension is low, then the location of the intervention should be the location of the remote technology. Table 8 summarizes these choices.

Table 8 Location of the Intervention.

		How is the service delivered?	
		People	Technology
Extension of contact	High	*Customer location*	*Location of the Customer presence*
	Low	*Contact center*	*Location of remote technology*

Business Model

The literature identifies five business model configurations (Kohtamäki *et al*. (2019):

- Product provider refers to a typical product business model (plus add-on services), where an organization offers standardized products and only add-on essential services.
- Industrializer refers to a business model where the organization has standardized its customized offerings.
- Customized integrated solutions provider refers to a manufacturer providing large, customized solutions combined with maintenance agreement and some availability commitment (for instance, performance guarantees).
- Outcome provider sells performance instead of products, offering the performance or outcome produced by the machinery, for instance, Power-by-the-hour.
- Platform provider refers to a business model where an organization takes a platform operator role, offering a multisided exchange platform instead of only products and services.

A summary of the choices of the business models in the classification of services used in this paper is in Table 9.

When the contact is low, and people mainly provide the service, the organization should have a business model of a "Product Provider" or "Industrializer," When the contact is high, and people mainly provide the service; the business model should be the one of "Solution

Provider," With a low contact and the services mainly provided by technology, the business model should be the one of a "Platform Provider." Finally, when the contact is high and the service is provided by technology, the business model should be an "Outcome Provider."

Table 9 Business Model for the Organizations.

		How is the service delivered?	
		People	Technology
Extension of contact	High	*Solution Provider*	*Outcome Provider*
	Low	*Product Provider* *Industrializer*	*Platform Provider*

A Case Study

An example of the models' application is the case of a manufacturer of large machinery for the oil and gas industry. The company is highly active in providing global services to their customers, distributed worldwide. For oil & gas companies worldwide, even a few days of critical equipment outages could bring substantial losses (up to one million dollars per day and more). For this reason, manufacturers with a deep knowledge of their machines have moved to servitization.

This case manufacturer has been active in using Six Sigma since the '90s. It moved to Lean Six Sigma at the beginning of the 2000s (Nicoletti, 2006). The manufacturer is active in all four classes of services. It has applied the strategies for reducing customer intimacy, as shown in Figure 2, also due to the distance between its customers and the fact that they are often located in places difficult to reach in a brief time.

As an example of the models presented in this paper, in the headquarters center for remote monitoring and diagnostics, the choice has been, according to Table 6, solid use of statistical tools in the remote technology location using DMADV (Lupi, 2007):

- Web portal for customer collaboration
- Prognostic Engine: Rules processor for automatic anomaly detection and Diagnostic Automation (Roemer *et al.*, 2006).
- Knowledge management and re-utilization by using case-based reasoning.
- Asset management through integrations with specific commercial software.
- Prognostic Engine: Rules processor for automatic anomaly detection

Further Research

Despite the past research efforts in Design Theory and Methodology, no uniform theory explains process design synthesis, particularly its core process of candidate solution generation (Tomiyama, 2007). A variety of simple theories and models can explain only a minimal type of design synthesis; as a whole, there is not such a theory yet. Instead of a universal theory of design synthesis, this paper suggests how to approach DFSS in the case of different classes of services for manufacturers offering servitization. Additional case studies would certainly be helpful to support the approach. From a theoretical point of view, this paper's main limitation

is that it considers DFSS with different classes of services. It would be interesting to define a DFSS that simultaneously allows the introduction of new products and the services connected, considering the classification of the products and not only of the services.

Conclusions

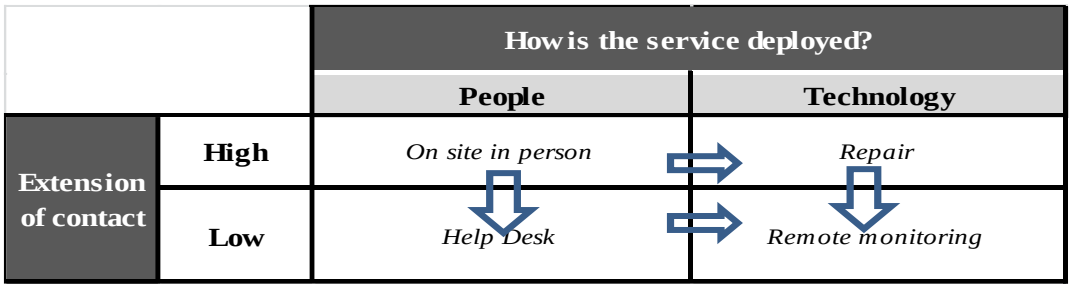
This paper presents some best models to apply DFSS for successfully introducing new services and processes in servitization. These best practices are classified for service processes. The paper summarizes the most relevant best practices for each managerial aspect, considering the different classes of services.

This research contributes to filling a gap in the Lean Six Sigma literature (Campanerut and De Toni, 2010), outlining the effectiveness of DFSS application in empirically designing the service connected with products. It is based on case studies. The method offers organizations with different services some best practices for DFSS applications. Eight models have been derived from these best practices to successfully adapt the solutions to other service classes and help define the best approach to the optimal delivery of the new services or processes in connection with a product.

From an implementation point of view, it seems interesting to follow a Lean and Digitize method (Nicoletti, 2012) (Figure 2):

- Identify the processes with high customer intimacy in terms of person-to-person relationships, such as increased contact and low use of technology.
- Verify if the inefficiency created by the interaction with the customer requires customization, which the customer is willing to pay.
  - If this is the case, it is essential to define specific pricing structures.
  - If this is impossible, it is essential to reduce customer contact by moving to a different class in the classification presented (for instance, moving from service processes to manufacturing or providing remote product support).

Figure 2 Strategies for reducing customer intimacy.



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