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Service Delivery Process improvement using Decision Support Systems in two manufacturing companies

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Abstract

The Product-Service Systems (PSS) offering is spreading on the market. Companies are becoming aware that selling bundles of products and services can create additional value for them and for the customers. Despite this, the provision of additional services not natively designed to improve products usage is not trivial. In fact, not only services must be correctly customized on the customers' necessities but also the way they are provided must be redesigned. An effective service delivery process is fundamental if companies want to create additional value from their service portfolio. The way they manage the phases leading to the service provision influences the way and the time required to deliver them. This work compares the service delivery process of two manufacturing companies headquartered in different parts of the world and selling products for the B2B market. The analyses performed on the service delivery processes highlighted how, despite the technological complexity the products, the management of the service delivery process is not automated, but it is still managed by humans without any Decision Support System (DSS) by the companies' service departments. For this reason, authors proposed improvements for the two service delivery processes through the introduction of DSS able to handle part of the process and, in turn, smooth them, shortening the time required to deliver services to customers and, so, increasing their satisfaction.

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Keywords: Product Service Systems; PSS; Industry 4.0; Decision Support Systems; DSS; Manufacturing; Service Delivery Process;

1. Introduction

The introduction to the market of Product-Service Systems (PSS)-based business model is changing the way companies and customers interact. The complexity of the products offered on the market is constantly increasing due to the ongoing technological advancement also enabled by the implementation of the Industry 4.0 technologies [1] in products and production processes. In turn, this is also influencing the services offered to customers and the way they are delivered. Despite this, there is a lack in the literature regarding the way Industry 4.0 is changing how services are delivered to customers [2]. In fact, due to the nature of services, strong customization is required to efficiently and effectively deliver them to customers. Before providing services to the customers, companies must make a decision considering all the factors influencing the service delivery. For this reason, Decisions Support Systems (DSS) could be used to ease the work of decision-makers and improve service delivery. DSS could work on different levels, from service selection [3] to service scheduling [4], to other service aspects. Despite the technological progress that has characterized the products and services offerings, the service delivery process (SDP) is still managed by humans without any DSS. To cope with this, this paper proposes the analysis and comparison of the SDP of two manufacturing companies characterized by a different technological level of their PSS offering and located in different parts of the world. Then, the authors propose an improvement for the SDPs under analysis, speculating on the introduction of a DSS able to manage and automate specific parts of the SDPs. The idea behind this work

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is to investigate the effects of the introduction of a DSS, aiming to understand how it can improve the SDP and, in turn, how it affects the decision-making process and the decision-makers currently involved in the SDP, the so-called Human-in-the-Loop (HIL).

The paper is structured as follows. Section 2 deals with the state of the art on PSS and DSS. Section 3 introduces the companies and their SDPs. Section 4 makes a proposal of a DSS inside the companies' SDPs. Section 5 discusses the benefits and drawbacks of the DSS introduction. Section 6 concludes the paper summarizing the results and delineating future works.

2. State of the art

This section deals with state of the art regarding the PSS and the DSS concept.

2.1. PSS

PSS is defined by [5] as consisting of "tangible products and intangible services designed and combined so that they jointly are capable of fulfilling specific customer needs". The development of PSS offering is strongly connected to the increasing requests of more and more tailored products. To cope with this necessity, companies started offering bundles of products and services, which to be effective must be conceptualized, designed and offered jointly [6]. PSS can be classified according to the product and service mix used for the offering [5]. Many services can be offered to the market in bundles with the products. [7] uses the classification proposed by [5] as a guideline to cluster more in detail the services according to PSS orientation. In addition, not only the offering must be redesigned to highlight the benefits incoming from the joint usage of the two parts, but also the way they are delivered must be rethink to avoid reduced economic performance [8]. In fact, not only companies must analyse the way they are delivering the product to customers but, more important, they must structure the way services are delivered to create the maximum value in use. The literature analysis carried out in [2] demonstrated that the extant literature only slightly deals with the topic of SDP, which is intended by the authors as the series of actions and operations performed to deliver a service to the customers, both in front office or back office [9]. This topic should be deepened since the way services are provided to customers has a direct impact on both companies' efficiency and the customers' satisfaction. In particular, the SDP is, in many cases, slowed-down by bargain cycles or by situations where making a decision is complicated due to the situation or to the lack of information. The implementation of Industry 4.0 technologies could improve the SDP by giving a clearer picture of the situation in which the company is operating and/or of the customers' needs and requests. In turn, this would provide hints on how to improve the delivery of a particular service to them.

2.2. DSS

[10] defines DSS as "a class of information system that draws on transaction processing systems and interacts with the other parts of the overall information system to support the decision-making activities of managers and other knowledge workers in organizations". In other words, a DSS is an information system that could facilitate the decision-making process inside companies. In order to exploit at maximum the benefits of a DSS, companies should use the right inputs and know exactly what kinds of output the DSS is able to provide. [11] discusses the problem of the DSSs' trustworthiness and reliability starting from DSS nature. This means that by understanding the reason why a DSS is created, and its specific focus, it would be possible to understand whether it would be better or not to use it in a particular situation. Another classification of DSS is provided by [12], which distinguish DSSs on the base of the dominant technology used and the main driver that guides its usage and scope. DSS can obtain great benefits from the integration of Industry 4.0 technologies in the companies' processes [13]. Since DSS must take as input certain quality data to work properly, the introduction of Industry 4.0 technologies could be fundamental, given the possibility to connect machines and products to the internet and, in this way, collect useful data for the decision-making process. In particular, data on product usage could be collected and used as input for DSS to improve the SDP, both from the companies and the customers' point of view. In addition, as reported in the literature, DSS can be used to support the SDP decision-making process in different ways and depending on the scope of the user. An example of this can be found in [11], which proposes a case study based on the comparison of different scenarios for the maintenance provision. Similarly, [14] proposes the usage of a DSS exploiting Bayesian Networks to improve the maintenance delivery also reusing previously generated knowledge. Another example can be found in [15], which uses simulation to support the capacity planning in PSS provision. Other examples, like [16], [17], are focused on the use phase of the product and exploit the data generated during the product usage to improve service delivery.

3. Case studies

This section starts with the description of the methodology used in this work and, then, continues with the description of the two case studies. Their focus has been on the corrective maintenance SDPs of two companies with the aim to understand how each corrective maintenance is currently carried out and what are the tools used to provide it. In particular, products and SDPs have been analysed to understand the complexity and automation levels.

3.1. Methodology

The case studies have been carried through semi-structured interviews to collect information on the companies and their business models. During the interviews, the companies explained their current product portfolio and their service offering. Then, the interviews moved to the corrective maintenance delivery process. The companies described in detail their corrective maintenance SDP, listing all the activities and the actors involved in it. The authors collected the information and used the service blueprinting and BPMN2.0 to represent graphically the *as-is* SDPs. To improve the readability of the SDP and allow a better comparison among different processes, the activities have been summarized in macro-phases as proposed in [18]. Table 1 describes each phase. Following, the authors analysed the *as-is* SDPs trying to identify bargain cycles and blocks of activities that could cause problems in terms of performance, efficiency and reliability of the SDPs. This phase has been carried out with the support of the companies, whit whom the authors discussed the structure and composition of the SDPs. Finally, the authors proposed a new configuration of the SDPs (*to-be*) integrating a DSS able to support the decision-making process. Advantages and drawbacks of the new process configuration have been analysed.

Table 1. Macro-phases Description, adapted from [11].

Macro-phase	Description
Handle Customer's Requests	Receipt and logging of assistance requests from the customer. Assistance requests can be received through e-mail, phone or fax. This phase includes the validation and authorization of the assistance request with warranty/contracts verification and customers' verification.
Assess the Feasibility and Create the Offer	Submission of further request details and definition of service rate which can be negotiated with customers.
Mobilize and Plan	Agreement with customer on the intervention details and identification and reservation of resources needed for an intervention (based on service levels agreements).
Prepare the Job	Preparation of materials shipment with related documentation, expediting of materials and final on-site checking of shipment by the customer.
Perform Service Job at Customer	Preparation, product decomposition, replacement of the part and re-assembling of the product at the customer site. This phase can be performed more than one time, until the product is fully operational upon completion. In this case, the intervention should require a rescheduling.
Complete Job	Activities associated with closing the assistance request. This may include asking the customer to provide feedback on the effectiveness of the assistance offering, sending a signal to the financial processes that the internal or external billing process should begin, archiving the assistance request, and analysing the performance of the assistance processes.

3.2. Company A

Company A is a company founded in 1975 that, in 40 years, has expanded its business worldwide. Its core business areas are both the production of balancing machines for rotary components and the development of process control systems for machine tools. Company A offers services related to its current product portfolio. In particular, it is noteworthy to mention corrective maintenance, preventive maintenance, warranty, service contract, help desk, remote helpdesk (teleservice), spare part distribution, and software update. Company A is now trying to move towards the provision of data-driven PSS by installing new sensors on its machines and widening the current service offering, making it more structured. The products are equipped with sensors but, as of now, their main aim is only to collect data, without making decisions autonomously. The service department handles the SDP and all the decisions are taken by the service responsible. Few actions are automated and frequently there are cycles that slow-down the service delivery. This is due to the fact that to make certain decisions it is necessary to bargain with the customers some aspects of the SDP (such as the price for the provision of a service not included in the contract) because they are not defined in the contract or because it is necessary to match the technician's and the customer's schedule.

3.3. Company A Corrective Maintenance Service Delivery Process

As depicted in 错误!未找到引用源。, the SDP of Company A for the delivery of corrective maintenance on the balancing machines has been clustered in macro phases (as proposed by [17]) to facilitate the readability of the process map and ease the comparison with other SDPs. The SDP begins with the "Handle Customers' Request (1)" phase, where the customer calls Company A's Customer Service to signal a problem with the machine. At this point, the Customer Service passes the call to a technician that tries to solve the customer problem via telephone. In the "Complete Job (1)" phase, if the problem is solved, the data regarding the intervention are saved in a database, if not, a second try via telephone is performed ("Handle Customer Request (2)" and "Complete Job (2)" phases). If also in this case the problem is not solved, the technician remotely connects to the machine and analyse its functioning parameters. Maintenance actions are suggested and, if the problem is not fixed, a technician intervention is proposed and discussed ("Assess the feasibility and create the offer" phase). Then, the technician travel is scheduled along with all the connected details like the necessary spare parts ("Mobilize and Plan" phase). Following, the maintenance intervention is performed ("Perform Service Job at Customer" phase). Eventually, in the "Complete Job (3)" phase, the maintenance report is filled by the technician and sent back to the Customer Service who send the final expenditure to the customers. In this phase usually, the customer asks for a discount and a bargain cycle take place. After having agreed on the final expenditure, the Customer Service creates the invoice and send it to the customer who pays for the service.

3.4. Company B

Company B is a company founded in 2014 headquartered in Beijing. It covers a worldwide market. The company sells robots for logistic services and warehousing activities. Company B serves different industries – e.g. e-commerce, logistics, apparel, retail, pharmaceutical, etc. The product portfolio is composed of robots that can be used in moving systems, picking systems and sorting systems. Moreover, Company B uses Artificial Intelligence (AI) for different purposes like real-time inventory layout optimization (goods' dynamic inventory), dynamic adjusting of shelves according to heat and data analysis. AI enhances the efficiency of the robot. As of now, Company B's service portfolio is composed by solution design, customization, corrective maintenance, remote/onsite support, remote monitoring/diagnostic of the status of the robot, data analysis, training to customers, installation and shipment arrangement. Customers pay a one-off fee to buy the robot and then an annual fee for the maintenance service. Company B offers a cloud-based platform that, leveraging on AI, allow the provision of several services, such as robot management and warehouse activities management. For this reason, the technological level reached by Company level is quite high and robot are equipped with sensors to acquire data. Despite this, the SDP is still managed manually. For example, regarding corrective maintenance, the decisions are made by the Project Manager (PM), who has to understand the problem and take care of contacting the technician to schedule the intervention.

3.5 Company B Service Delivery Process

As in the case of Company A, also for Company B, the authors cluster the activities of the SDP in macro phases, as suggested by [18] and depicted in 错误!未找到引用源。. The SDP begins when the product gives an alarm to the customer ("Handle Customer's Requests"). When this happens, the customer contacts the PM of Company B to have support. Once remotely connected to the product and identified the problem the PM contacts the Head Quarters (HQ) Manager to have indications on the technician that should perform the maintenance activity. After having checked the details regarding the customer and the problem, the HQ Manager sends the information to the PM ("Assess the Feasibility and create the offer" phase). Following, in the "Mobilize and Plan" phase, the PM sends the information to the technician who checks his schedule and decides whether to perform by himself the intervention or not. If the technician is not able to perform the intervention by himself in the expected time, he passes the activity to a colleague. Then, the maintenance intervention is performed ("Perform Service Job at Customer" phase,). Finally, in the "Complete Job" phase, the technician fills a report and send it to the PM to collect information on the problem and to perform some data analysis. In the case of Company B, the customer is not required to pay for the single maintenance intervention because an annual fee is due. Moreover, every 6 months an intervention by an engineer is scheduled to check on the equipment status.

4. DSS proposal

This section deals with the proposal of a DSS in the SDP of each company, as a result of the discussion and analysis of the current process carried out with each company.

4.1. Company A

The SDP of Company A is characterized by multiple bargain cycles, mainly because not all the possible problematics are included in the contract with customers. Other factors that slow down the process are the following: the service department has to check manually the availability of a technician and of his schedule each time an intervention is required, the problem has to be identified along with the correct solution, and the service department has to discuss the intervention bill with the customers if something unforeseen happens. The resolution of these problems can be approached introducing DSSs in place of the current bargain cycles. In particular, the authors are proposing the introduction of two DSSs depicted in Fig.3. DSS(1) is proposed to improve the "Assess the Feasibility and Create the Offer" phase. The proposed DSS, taking in input information like the machine's problem, the type and number of machines with the problem, the customer location, the Service Level Agreement (SLA), the skills required for the maintenance activity and the technician schedule from a central database, proposes in output the name of the technician that can perform the maintenance and a quotation for the activity. DSS(2), instead, has the aim to improve the "Complete Job (3)" phase, when the maintenance activity is completed and the final quotation is sent to the customer. In this case, the inputs

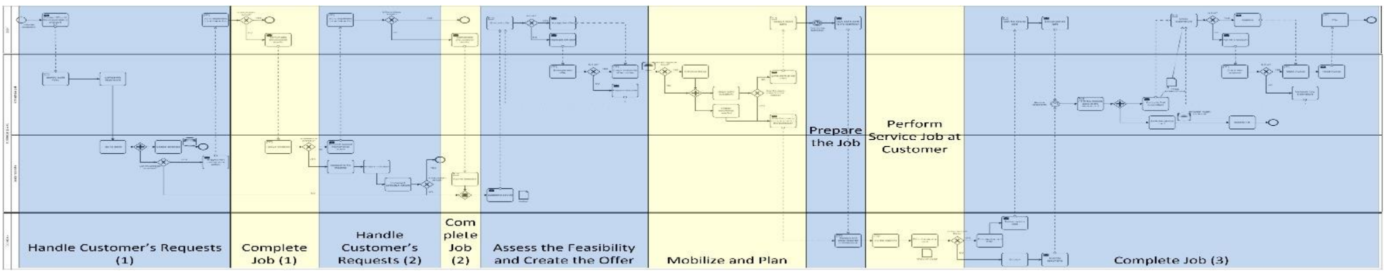

Fig. 1. Company A *As-Is* Service Delivery Process.

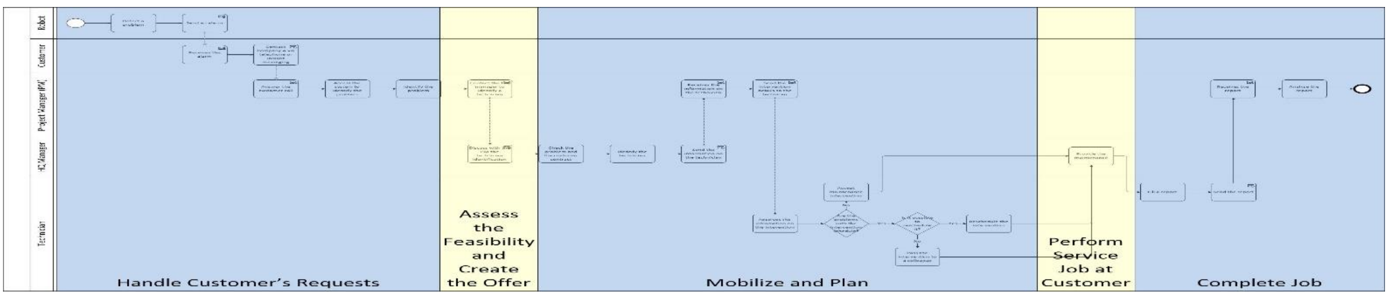

Fig. 2. Company B *As-Is* Service Delivery Process.

required by the DSS are constituted by the actions performed by the technician to perform the maintenance as well as the exact time required to perform it, the spare parts used and all the contractual information of the customer. In this case, the aim of the DSS is to provide the final quotation for the customer based on the real data of the maintenance activity, avoiding in this way the necessity to bargain with the customer for the discount requests.

4.2. Company B

In the case of Company B, the improvements proposed by the authors are focused on the selection of the technician for the maintenance intervention – “Assess the Feasibility and Create the Offer” and “Mobilize and Plan” phases (Fig. 4). As of now, once identified the problem the Project Manager (PM) and the engineers try to solve it remotely connecting to the products via Internet. In case this is not enough to solve the problem, the PM has to contact the HQ manager to have a suggestion on the technician that has to provide the intervention. In addition, the technician is chosen based on his skills, without considering his schedule. If the technician is completely booked for that period, he has to pass the maintenance request to another technician. This last part of the process is not managed by the Project Manager or by the HQ manager. The introduction of a DSS taking in input the kind of problem, the characteristics of the customers (position, machines, type of contract, service level agreement, etc.), the skills required to perform the maintenance and the schedule of the technicians could be fundamental to avoid mistakes in the definition of the maintenance interventions along with all the other details connected to it. This could lead to a fast definition of the interventions and to higher customer satisfaction.

5. Discussion

DSS implementation could be fundamental in terms of saving time and improving SDP in companies offering PSSs. As discussed in Section 2.2, DSSs reliability and flexibility are linked to the level of specialization with which DSSs are created. To implement an effective DSS, the companies have to define the output that the DSS should provide and the type of information necessary to make it work properly. To do this, companies have to list all the parts of the process involved in the phase under study and understand the information necessaries to enable the DSS and maximize its reliability. In addition, companies should also reorganize the information collection process in order to make it more efficient and able to collect all the information in the right way. Connected to this, the technologies of Industry 4.0 could result fundamental to handle data collection from machines, to ease problem identification and to improve data analysis. Regarding the improvement of data collection, companies have to figure out what kind of data it is useful to collect and in which form. Moreover, the way data are saved must be appropriately structured, so that the DSSs can handle the data easily without the necessity to pre-process them before a new analysis. Data in output from one phase should be structured in such a way that they can be used immediately in the following phase, without the need for pre-processing. A topic that should be addressed by the companies implementing the DSS inside their SDP is the evolution of the Human-in-the-Loop (HIL) role in the decision-making process. In fact, the introduction of autonomous DSSs, able to make reliable decisions on the base of data coming from products and processes can reduce the role of the HIL in the decision-making process, forcing him to find a new added-value role in the process. Moreover, the DSS introduction allows improving performance suggesting the best solution for the proposed problem. The idea behind the introduction of DSS in a process is to smooth it, organizing the information flow to collect useful information and automating the decision-making process using reliable tools. By this mean, the idea is to make reliable decisions using objective instruments aimed at improving the general performance of the company and not on the improvement of the performance of a single department. The decisions can be made on different levels [3], [4], depending on the nature of the DSS [11], [12].

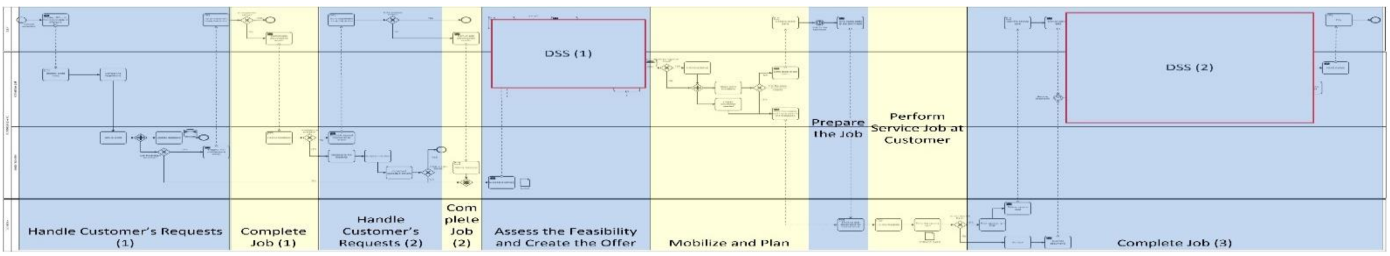

Fig. 3. Company A *To-Be* Service Delivery Process.

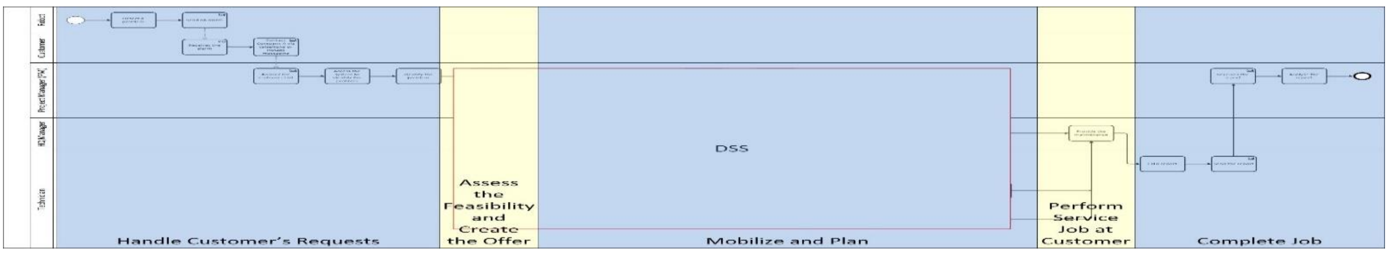

Fig. 4. Company B *To-Be* Service Delivery Process.

6. Conclusions

This work presented the current SDP of two different manufacturing companies, headquartered in different parts of the world and producing different products. The technological complexity of products offered by Company A and B is different. In fact, while products offered by Company A are only able to collect data, products offered by Company B use AI to perform analysis and make decisions on their activities. Despite the technological complexity of the products, the SDP of both companies is managed manually, nothing is automated and all the decisions are made by the HIL. The paper contributions are nested inside the research stream of SDP improvement in the PSS context. In particular, this work contributes to the introduction of DSSs inside the companies' SDPs. The idea behind this action is to automate specific activities to smooth the SDP and make the decision-making process quicker, more efficient and more reliable. The foreseen benefits are mainly related to easier management of the SDP and to a more structured decision-making approach. To do so, companies must rethink the way they collect data and the way they are making decisions. In particular, the introduction of functional and efficient DSSs could result in a reduction of the involvement of HILs inside the decision-making process. The main limitation of this work is that the proposal of the introduction of DSSs inside companies' SPD is discussed at theoretical level. Thus, the next steps in the research include a deeper analysis of the companies' SDP followed by the definition of the requirements needed for DSS implementation to improve the SDPs.

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