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The contribution of Smart Glasses for PSS

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Abstract

Servitization is considered as a strategic option for manufacturers who need to develop higher-value offering. As a result, a manufacturer can include service to its product offer, in order to obtain different types of product service-systems (PSS). Several companies have been relying on digital technologies to enhance the PSS, especially those that allow data collection and sharing. Smart Glasses are one of the wearables digital tools that can provide more advanced service solutions. However, this technology is still emerging and, therefore, empirical research on its use for servitization is still scarce in the literature. Thus, this paper aims to provide empirical evidences of the contribution of Smart Glasses for the provision of maintenance services in manufacturing companies, as a part of the PSS offer. Using a case study approach, we analyze in a multinational manufacturer of elevators the difference in performance of maintenance technicians before and after adopting the use of Smart Glasses. The assessment is made by means of operational and managerial perceptions provided through semi-structured interviews. Our findings show that the performance of almost half of the technicians was improved with the use of Smart Glasses, however some technicians had a decreased performance. The technology was more effective for technicians with less experience in maintenance services. Other external factors, as the aptitude for the technology, were relevant for the evolution in performance of these operators. Our results provide initial evidence that Smart Glasses can support the development of PSS, supporting a more advanced service offering.

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Keywords: Servitization; Digital technologies; Smart Glasses; Maintenance services.

1. Introduction

Servitization refers to the business model transformation of the manufacturing firms, in which services are added in the product offerings, resulting in Product-Service Systems (PSSs). The main objective of servitization is to increase the offering value, bringing competitive advantage for the manufacturing firms [1, 2, 3]. Manufacturers can use their expertise in products to offer services such as repairs and maintenance, avoiding the commoditization trap [4] and creating new sources of revenues, which can also increase the relationship with the customers [5]. However, despite the potential benefits, several challenges inherent to the servitization process hamper the business model transformation of the companies [2, 6]. To support this process, many companies have been relying on digital technologies [7, 8].

Digital technologies have been revolutionizing several industrial sectors, from manufacturing processes to the development of new products [8]. The advancements in Information and Communication technologies are supporting decision-making activities and increasing operations efficiency. This can lead to the provision of more advanced services in PSS offerings, especially with the use of wearables such as Smart Glasses [10, 11]. Like smartphones and tablets, Smart Glasses can facilitate information sharing, but they have also further advantages based on hands-free interaction [12]. Through advanced communication, this technology can facilitate remote knowledge sharing from experts to operators, while they

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perform their activities, providing real-time assistance and accelerating trainings and the learning process [13, 14]. Thus, Smart Glasses hold great potential to improve the human resources skills in companies, especially in field services [11, 15, 12].

Although this technology is still growing and under development [15], some companies are investing in Smart Glasses to obtain improvements shop-floor activities and logistics processes [11]. However, since this technology is still emerging, empirical research on its use for servitization is still scarce in the literature. Therefore, this paper aims to provide empirical evidence of the contribution of Smart Glasses for the provision of maintenance services in manufacturing companies, as a part of the PSS offer. We analyze the performance of maintenance technicians before and during the utilization of Smart Glasses, and evidence the perception of the application of this technology by means of qualitative interviews.

2. Literature Review

2.1. Product-Service Systems (PSS)

In order to provide higher-value offerings, manufacturers are under a transformation of their business models called servitization, which aims to better meet the customers' needs with Product-Service Systems (PSS) [16]. Through service infusion to the product offering or even delivering the product as a service, such transformation can provide benefits in many aspects: increase of customer loyalty, new sources of revenues, improved innovation capability and more. Furthermore, the service orientation can support manufacturers to avoid the commodization of their physical products and gain competitive advantage through differentiation [1, 2, 18, 17]. According to Coreynen et al. [8], Kindström and Kowalkowski [5], and Ulaga and Renartz [19], companies with product-oriented offerings can increase their value proposition with the provision of product lifecycle services, e.g. product repairs. To a further increase in the value proposition, companies can offer a better performance of their products, with preventive maintenance services, which can lead to a result type of offering, in which the company provides the functional value of the product according to an agreed performance.

The transition towards higher value offerings means a complex addition of services. Firstly, companies seek to establish the basic services for a better product usage, to ground the development of more advanced offerings. In such context, the organization of field services is a critical resource to leverage competitive advantage in PSS [19]. The provision of services requires dedicated resources with capabilities that transcends manufacturing's expertise, requiring a proper monitoring to guarantee its performance and a capability to share knowledge among its network [20, 18]. Many firms fail to develop these resources and capabilities, impeding them from getting more benefits with PSS [19, 20]. To overcome this problem, companies have been relying on digital technologies [7, 21].

2.2. Digital technologies in PSS and Smart Glasses

The advancements in Information and Communication Technology (ICT) are transforming several industrial sectors, throughout all product lifecycle [9]. Emerging concepts such as the Internet of Things (IoT) have been grounding the service transformation in PSSs, being a solution to the development of offerings with increased operations efficiency [7, 8, 21]. The key to such transformation is the collection and analysis of data, which can be remotely managed more quickly and precisely with the assistance of wearables like Smart Glasses [22; 23, 24].

Smart Glasses are devices that can transfer information through visual interfaces [12]. Although its development was mainly to customers' use, these devices holds great potential for industrial applications [22], especially in field services [25; 14]. According to Niemöller et al. [12], Smart Glasses can share information as tablets and smartphones, but have the advantage to enable a hands-free interaction. With voice recognition, picture and video streaming features, operators can perform their tasks and be assisted by remote specialists at the same time. Therefore, the technology can improve the quality assurance of shop-floor activities [11] and simultaneously improve the operators' training with continuous feedback [13, 14].

Due to its novelty, few researches show how Smart Glasses can be applied in field services operations [15]. Considering the important role of technologies to competition [26, 27], innovative companies are already making investments in this kind of technology. With Smart Glasses, BMW aims to increase its quality management in shop floor, while Volkswagen aims its support for logistics improvement [11]. However, there is a lack of researches with empirical evidences of the impact of this technology, in which the majority of studies show an ex-ante perception of the employment of Smart Glasses [12, 11, 15].

3. Research Method

In order to identify the impact of Smart Glasses implementation in the service provision of a PSS offering, we conducted a case study in the Brazilian subsidiary of a multinational manufacturer of elevators. Through case study approach, we analyzed qualitative data of the company internal documents and conducted interviews with technicians, managers and customers.

3.1. Case study description

The company of the case study is one of the global leaders in the segment of elevators, but also offers components for various types of equipment and the automotive sector in its product portfolio. In the past years, it started to offer services with its products, aiming for customer loyalty and to increase the sales of products, e.g. components of elevators. Nowadays, the service sector of the company is responsible for almost 92% of its total profits, mostly from the maintenance of elevators. In this segment, the company offers preventive and corrective maintenance services of elevators of its own production or of others. This PSS can be offered in different types of contracts:

with customer ownership, in which he pays for the necessary replacement of components; and with company ownership, in which the customer pays a monthly fee and the company is responsible for the elevators functioning, covering the necessary replacement of components.

The maintenance services are field services performed by technicians of the company. These technicians receive trainings of standard operational procedures to conduct the inspection of elevators and corrective actions. Each technician is responsible for the elevators of certain customers, in which the elevators can be of different models, age and manufacturers. The technicians perform preventive maintenance on a monthly basis, in which they make full inspections, analyzing its functioning and identifying components that need replacement. In such case, the technicians request a new component to the company, whose payment depends on the type of maintenance contract, and execute the change of components. The main objective of the preventive maintenance is to prevent failures that impede the elevators' functioning. When failures occur, a corrective maintenance is performed by the responsible technician of such elevator. Therefore, the frequency of corrective maintenances depends on the quality of the performed preventive maintenance.

Considering the quality of the service provision a paramount, the company developed two indicators to evaluate the performance of the technicians: Corrective Maintenance Index and Sick Lifts. Corrective Maintenance Index consists in the number of corrective maintenances performed by the technician, divided by the number of elevators under his responsibility. This index provides a same unit indicator, despite the different number of elevators maintained by the technicians. The second indicator, Sick Lift, represents the percentage of elevators under each technician's responsibility that presented two or more failures in the analyzed month. These indicators have only managerial purposes, once it doesn't consider the satisfaction of the technicians or other events that affect their performance

The indicators allowed managers of the company to identify problems due to the low performance of some maintenance technicians. To overcome this, they developed a project to use Smart Glasses to remotely support them in real-time activities and improve their training. The objective of the Smart Glasses application was to provide audio and video streaming between technicians and a remote specialist, via Skype for Business app. The committee of the project analyzed two Smart Glasses options available at the market in that period, choosing the model that presented a better cost-benefit ratio. Then, a pilot project was conducted with three maintenance technicians that presented high performance in their services, in order to have a better understanding of the technology and to validate the standard operational procedures created to guide technicians under assessment of Smart Glasses. After the pilot project, the company started the Smart Glasses assessment of technicians with low performance.

3.2. Data collection

Considering both indicators, the company chose 27 technicians throughout 13 subsidiaries in Brazil to be assisted by the Smart Glasses during three months. Together, the 27 technicians were responsible for the maintenance of more than 270 elevators. Based on internal documents of the company, we show the impact of the Smart Glasses in the 27 technicians' performance. For this, we made comparisons of the two corrective maintenance indicators before the employment of smart glasses and after. Furthermore, through internal documents, we compare the performance of each technician with the evaluation of their supervisors and compare the number of sales of elevator components in the periods before and after the beginning of Smart Glasses employment.

Subsequently, we conducted semi-structured interviews with five of the 27 technicians, to better identify their perception to the technology. Three of the interviewees presented increased performance, while two had no significant improvement. In addition, we also interviewed five managers and five customers to have a broader perspective of the impact of Smart Glass in the PSS offering. All interviews were transcribed for a better analysis.

3.3. Data analysis

In order to identify the change in the technicians' performance, we compared the average of the indicators of six months before the employment of Smart Glasses, to the period of its utilization and one month after. The results of performance are presented by the percentage change in the average of indicators of each technician. As shown in Table 1, we considered an increase of performance by the use of Smart Glasses when the technician shows an improvement of 10% or higher in both indicators. If one of the indicators decreased by 10% or more, we considered it as a decrease of performance. Up to 10%, we understand that the technology did not have any significant effect on the technicians' performance.

4. Results

The application of Smart Glasses for technicians' support and training had different outcomes to each technician. As shown in Figure 1 and summarized in Table 1, some technicians had significant improvements in their indicators, while others had no substantial change or even decreased their performance. However, as a general result with the Smart Glasses technology, the company benefits from a large increase of sales of components of elevators. In a comparison between the historic average of sales without and with Smart Glasses, it's noticed an increase of 334% of sales with the wearables. This increase was enabled once without the glasses, most technicians did not have enough knowledge to properly identify the exact components that needed replacement. With the remote support of specialists, the technicians could identify such components and request an order of a new component for the customer. Overall, even though some technicians did not adapt themselves to the Smart Glasses, this technology

promoted some significant performance improvements and had a great perception by most technicians, managers and customers, as shown in Table 2.

4.1. Performance change in indicators

Figure 1 shows the percentage change in both maintenance indicators of the company, to each technician, and Table 1 summarizes the findings, showing the number of technicians that resulted in improved, unchanged or decreased performance. Overall, 12 technicians had significant performance improvements. This group consists in 44% of the sample, in which 33% presented an improvement between 20% to almost 60%. In general, according to the evaluations of supervisors, this group showed aptitude for the Smart Glasses.

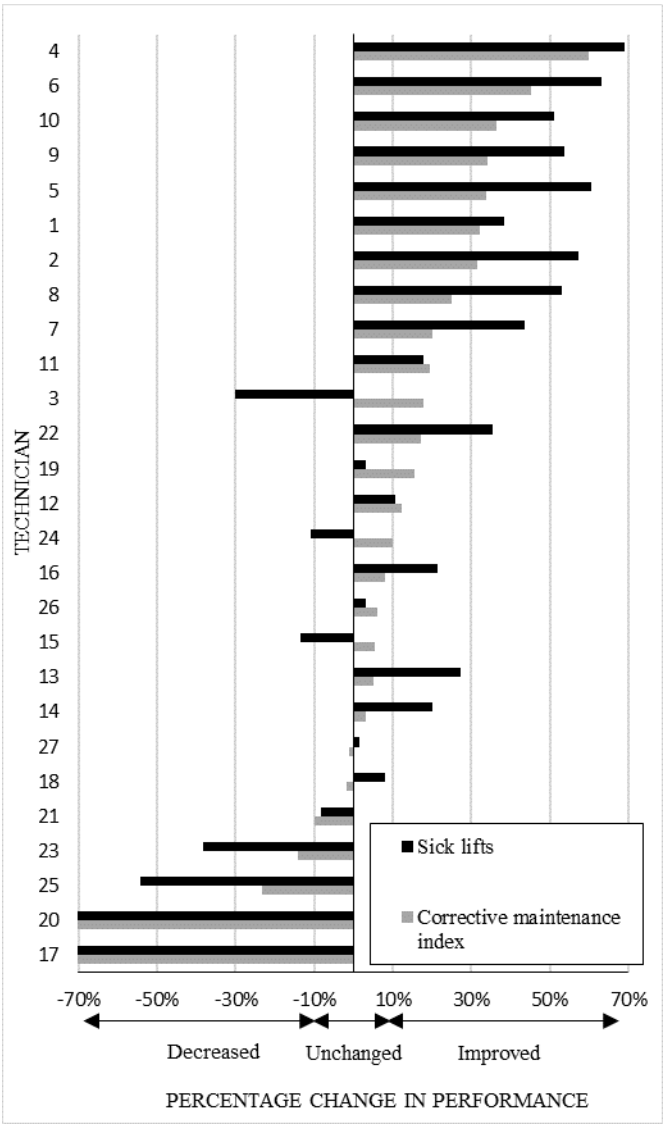

Fig. 1. Percentage change in technicians' performance

A total of eight technicians did not show significant changes in their indicators with the use of Smart Glasses, consisting in 29% of the sample. Some of these technicians showed unwillingness to their own improvements in maintenance and to the wearables (technicians 13, 14, 16, 18 and 19). Others had less experience with the standard operational procedures of the company (technicians 24, 26 and 27), and even though they showed aptitude for the Smart Glasses, they required further trainings to improve their service provision.

Lastly, seven technicians showed a decrease of performance (26% of the sample). Three of these technicians showed aptitude for the Smart Glasses, but had their performance affected due to deviations of work fronts demanded by the company (technicians 3, 23 and 25). One technician resigned from the company due to the non-adaptation to the maintenance procedures (technician 17). Two technicians (20 and 21) did not approve the use of Smart Glasses, claiming they felt under strict supervision when using the wearables. They also claimed the wearables prejudiced their vision and caused them migraines.

Table 1. Classification of technicians according to their performance with Smart Glasses

Performance	Change in indicators	Nº of techn.	Technicians
Improved	20% or higher	9	4, 6, 10, 9, 5, 1, 2, 8, 7
	10% to 20%	3	11, 33, 12
Unchanged	-10% to 10%	8	19, 24, 16, 26, 13, 14, 27, 18
Decreased	-10% to -20%	1	15
	-20% or higher	6	17, 20, 25, 23, 21, 3

4.2. Perception of technicians, managers and customers

Overall, even though two of the five interviewed technicians did not have an increased performance, all interviewees considered the Smart Glasses as an effective method of training and technical development, and perceived a quality increase in their performed maintenance. 80% of the interviewees claim they prefer to keep working with the assistance of Smart Glasses and believe in benefits from the assistance of digital technologies in maintenance processes.

According to the five managers interviewed, all managers agreed that Smart Glasses improved the identification of operational problems. 80% of the interviewees considered the wearables as a fundamental tool to improve the service operations and perceived a better identification of the behavior profile of each technician. Furthermore, 60% of the managers perceived Smart Glasses as an effective method to motivate employees.

Table 2. Perceived advantages and disadvantages with Smart Glasses.

Perspective	Advantages	Disadvantages
Technicians	Efficient training method	Affected vision, causing migraines
	Better identification of components to be replaced	Loss of autonomy
Technicians/ Managers/ Customers	Improved service quality	
Managers	Improved the identification of operational problems	
	Identification of technicians' behavior profile	
Customers	Improved the technological level of the company	

The customers of the provisioned maintenance services with Smart Glasses also had a positive perception about the technology. All interviewed customers had a better perception about the technological level of the company. 80% of the customers believe that the company is engaged to continuous improvement and believe there was an improvement in the maintenance services they received. Lastly, 60% of the customers perceived an improved communication with the technicians.

5. Discussions

The application of Smart Glasses presented a positive perception for most of the interviewees: managers, customers and technicians, according to Table 2. This is corroborated by the existing literature about this technology, which although is scarce in empirical evidences of its utilization, show a great potential of the wearables in many areas [12, 11, 15]. According to the managerial perspective, the investment was justified once the main objectives were partially achieved. The first driver of the project was the improvement in technicians' performance, aiming for the cost reduction with corrective maintenances. A second driver was the increase of revenues with the sales of components. Even though not all technicians had their performance increased, the significant increase of sales was only enabled due to the proper identification of components that needed replacement, with the assessment of Smart Glasses. In addition, managers claim the wearables provided a better identification of the behavior of technicians. Almost 60% of the technicians weren't properly following the standard maintenance procedures demanded by the company. The technology enables to identify these problems and guides the technicians in real-time, also improving their training. Therefore, Smart Glasses can support a better organization of field services, a critical resource to obtain competitive advantage in a PSS, according to Ulaga and Reinartz [19]. The interviewed customers also perceived the improvement in the services.

Regarding the technicians' perspective, the majority considered the Smart Glasses as a useful tool for their activities, with only two technicians (20 and 21) that assigned their decreased in performance to the technology. These technicians claimed the glasses prejudiced their vision and did not enjoy being monitored during the execution of their tasks, indicating a loss of autonomy with the technology. Although literature mentions these potential problems [12], we highlight that less than 10% of our sample have indicated this downside. Furthermore, Smart Glasses are a technology with a high degree of innovation. Even though they represent a small share of our sample, we relate this fact to the geographical context of the case study. Prior studies concluded that the technology should be improved for a better application in work environment [11]. Considering that emergent countries can have a different perception than developed countries about innovative technologies [9, 28], this outcome could be different in case studies conducted in developed countries.

Overall, the use of Smart Glasses presented a positive impact in almost half of the technicians under assessment. Although a significant share of our sample had none or negative impacts, it's important to consider all factors that affected their performance. During the assessment of Smart Glasses, the technicians 3, 23 and 25 changed their customers, due to a demand of the subsidiaries. Once this change can also mean different types of elevators, it may has affected the improvements in their performance. Other important factors that must be considered are the willingness of the technicians for improvements and their aptitude to new technologies. All technicians that did not demonstrate engagement to their own improvements and the technology had no increase of performance. In addition, the technicians under analysis had different experience levels with maintenance procedures. Some technicians (14 and 18) had considerable experience in maintenance, but did not adapt themselves to the standard procedures demanded by the company. At the other hand, other technicians (24 and 26), even with an aptitude to engage with Smart Glasses, were inexperienced with maintenance procedures and required more time of training to increase their performance. Overall, except for technicians 24 and 26, the majority of the technicians that presented improvements were inexperienced, while the ones who decreased or had an unchanged performance had more experience with the maintenance procedures. Therefore, we conclude that Smart Glasses are more prone to be effective for new employees, with little tacit knowledge. This technology can support firms to leverage on cost-leadership, by reducing costs in trainings for the qualification of human resources and increasing the efficiency of their operations. Furthermore, with the ease of knowledge sharing, the employment of Smart Glasses can assist companies to keep their competitive knowledge internally, while externalize its service provision, which can lead to more advanced PSS offerings.

6. Conclusions

Our findings showed that the application of Smart Glass technology in the service provision of PSS brought benefits in different perspectives. First, as the main objective with its employment, a significant number of maintenance technicians improved their performance in maintenance procedures. Such improvement was also noticed by the increase of the sales of elevator components, due to the analysis performed by technicians when assisted by the wearables. However, some technicians of our sample did not show improvement in their performance, which some of them demonstrated a reluctance to the technology. We conclude that not all employees are ready to work with technology of high degree of innovation, but this can be related to the context of the case study, once emerging countries have a different perception of technologies than developed countries. Furthermore, our work provides theoretical and practical insights.

6.1. Implications for theory and practice

Our work contributed to the emerging topic of PSS enabled by digital technologies, which still have a considerable gap in the literature. The majority of researches in this topic shows the advancement in the automation of manufacturing processes or

the use of data to develop smart products. We provided evidences about how digital technologies assist the human workforce and improve the service provision of a PSS, a critical capability that manufacturers must develop to the successful process of servitization.

This work provides practical insights about the use of digital wearables in PSS. Companies facing a transition of only product offering to product and services offering can benefit from our results, as we show how Smart Glasses can ease the share of knowledge for a better service provision, which is usually of one of the main barriers for the servitization process. We provided empirical evidence about the impacts of a novelty technology with little research in literature, showing how it can assist operational procedures, with managerial insights and considering the customers' perspective.

6.2. Limitations and further researches

This article contributes to the research of an unexplored technology in PSS literature. Our main limitation is that our sample did not enable further quantitative analysis to statistically evidence the impact of Smart Glasses. Therefore, suggest further researches of the same type, increasing the sample. It is important to highlight the many factors that can affect the performance of maintenance technicians. These factors, such as experience, age and aptitude to new technologies must be taken under account for a quantitative analysis. Lastly, our work focused in the managerial insights about technicians' performance. Subsequent researches should also focused in the technicians' satisfaction with the employment of the technology.

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