Sustainability in the Service Offerings of Manufacturing companies: Evidence from the industrial sector

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Abstract: Nowadays manufacturing companies are changing their businesses to satisfy the sustainable objectives driven by governments and respond to climate change. An increasing number of manufacturing companies are adopting combinations of products and services, namely Product-Service Systems (PSS), to be more sustainable, having the potential of increasing revenues and reducing the environmental footprint by extending the product's lifetime and optimizing resource consumption. Even though PSS have the potential of achieving the sustainability goals of the Triple Bottom Line (TBL) – economic, environmental and social dimensions of sustainability –, the literature shows difficulties in defining sustainable PSS because of the intangibility and multiple sources of uncertainty related to the service domain. Indeed, referring to the PSS research, the literature has identified different paradoxes (e.g., the "service paradox" and the "rebound effects") affecting the economic and environmental performances of these business models. Therefore, evaluating the economic and environmental sustainability of services is even more important. Starting from these considerations, this paper aims to understand how companies act to be more sustainable in the service delivery and to capture how they evaluate the economic and environmental sustainability performances of their services. The authors utilized semi-structured interviews to target companies selected from the "Digital Servitization" survey launched last year by an international group of researchers involved in the PSS research. These companies are characterized by diversified service offerings portfolios and declared to have metrics to evaluate the sustainability performance of their services but the results obtained show there are not supporting the design of advanced services. By offering the current status of sustainability evaluation of the service delivery through actual business cases, the article provides a contribution to the academic and industry domains. The main limitation of this study relies on the limited number of interviewed companies, although this would be increased in future developments.

Keywords: Product service systems; Sustainability; Evaluation; Business cases.

I. INTRODUCTION

Market competition and climate change are driving manufacturing companies to go beyond the traditional business models based on the sales of products and to explore marketable sets of products and services, known as Product Service Systems (PSS) business models [1]. Since the very beginning, PSSs were identified as business models able to provide new market opportunities for companies, favouring their competitiveness and generating financial benefits while potentially decreasing the products' environmental impact by introducing alternative use scenarios [2]–[4]. Therefore, in theory, PSS solutions allow manufacturing companies to meet sustainability needs. Product Service Systems were classified into three main groups, namely *product-oriented services*, *use-oriented services*, and *result-oriented services*, whose differences are based on product ownership and value generation strategies [4], [5]. Result-oriented services are considered the most

sustainable among the other PSS typologies. Here the manufacturer/provider is free to decide the necessary approach to deliver the result which typically involves the reduction of the life cycle costs and resource (such as energy) consumption in the use phase because they are responsible for them, not anymore the customer [4]. However, achieving both goals (i.e., economic and environmental savings) might not always be feasible for every PSS configuration since is a highly case-specific task [6].

Although PSS offerings show positive potential in all three dimensions of sustainability summarized in the Triple Bottom Line (TBL) [7], the literature also states the difficulty in clearly assessing the sustainability of a PSS solution, which must be designed with this purpose in mind [4], [8]–[10]. It is important to consider that designing a PSS involves different sources of uncertainties, such as:

- The return on investment that could not be the expected one. Businesses that make

significant investments in growing their service operations and expanding their service portfolios, may incur greater expenses but do not see the promised increases in returns. This is known as "*service paradox*" [11].

- Customer behaviour that is unpredictable and may give more or less attention to environmental sustainability when opting a business solution. This can cause "*consumption rebound effects*" that may be negative for the environmental perspective [4], [8], [9].

Therefore, the literature shows an increasing interest in the analysis of the economic, environmental and social impact of PSS since tools and methods capable of clearly expressing and quantifying PSS potentials are few [12]. Life Cycle Assessment method is surely the most adopted method for the environmental evaluation in the PSS context [9], [13]–[15]. The PSS economic assessment also has been addressed in the literature [16], [17]. Despite this, there is a need to clarify and systematically assess the sustainability impacts of PSS solutions in order to support practitioners in designing sustainable PSS.

Starting from these considerations, the aim of this study is to explore, from the industrial point of view, the sustainability topic in the manufacturing context to shed light on how this topic is engaged in PSS offerings. Special attention is given to the KPIs manufacturing companies are utilizing for the sustainability measurements and the methods, tools and guidelines they used in the computation. Therefore, the research questions driving the study are the following:

- How does sustainability affect the products and services offerings of manufacturing companies?

- How manufacturing companies quantify and express the sustainability impacts of their products and services?

To answer these questions, two companies have been selected and, through semi-structured interviews, data on their view have been collected for the purpose of the study.

The paper is structured as follow: Section 2 presents the methodology used in this study; Section 3 reports the interviews' results delineating the common aspects and gaps which constitute the basis for the discussion section 4. Finally, Section 5 concludes the papers, highlighting the results and future developments.

II. METHODOLOGY

The methodology adopted in this study is the semi-structured interview [18]. The authors developed the interview guide by following the 5W1H questioning technique since it is a useful framework when gathering information and investigating a problem. Following the framework, the authors defined the interview questions that can be categorized as in Table 1. Six main themes guided the interviews that respectively are listed as follow: (i) the service offerings portfolio of the manufacturing companies; (ii) the declination of the sustainability initiatives in the service offerings; (iii) the responsibility inside the organization for the sustainability initiatives; (iv) the main drivers that are guiding companies towards sustainable actions; (v) how they deal with the transparency and accessibility of their sustainability; (vi) and, lastly but of greater importance for this study, the sustainability evaluation of services which comprehends the KPIs, methods, tools, guidelines utilized to evaluate the sustainability performances, with a focus on the service. Table 10 in the Appendix A lists these main themes and the related relevant questions that were covered in the interviews.

TABLE I. MAIN THEMES GUIDING THE INTERVIEW

5H1W	Theme
What	Actual service offerings
	Sustainability initiatives that involve services
Who	Responsibility of Sustainability initiatives
Why	Drivers for Sustainability initiatives
Where *When*	Transparency and Accessibility
How	Sustainability evaluation of services

The authors selected the target companies from the sample collected through the "Digital Servitization" survey [19], an exploratory survey developed by a group of international researchers in the field of PSS research aimed at identifying the current state on service offerings and actions undertaken by companies in their Digital Servitization transformation process. The selection of the target companies for this study was driven by searching for manufacturing companies that are affirmed in their industrial sectors and that have a diversified service offerings portfolio. Moreover, they were selected since they resulted to have

metric for the sustainability assessment from the answers to the "Digital Servitization" survey. Starting from these considerations, they were identified as pertinent for a deeper investigation through the semi-structured interviews.

All interviews followed a similar structure. First, the researchers introduced the topic and the objective of the research study. The interviewees were asked to describe their role in the company. Then, the interviews were conducted following the interview guide. The duration was of 1 hour on average. The interviews were recorded and transcribed integrating the information from the interviews with additional, gathered company-contextual data. Thereafter, the interview transcripts were analysed in order to categorise the different views and address the aim of the research.

III. INTERVIEWS' RESULTS

The business cases object of this study are two firms belonging to the Capital Good sector [20], they are B2B and large realities with international markets. The authors performed three interviews target to different area of expertise and professional roles inside the companies to have a multidisciplinary result, as shown in Table 2.

TABLE 2. INTERVIEWS PER COMPANY, MAIN AREA OF EXPERTISE, PROFESSIONAL ROLE, AND ID USED TO LINK THE PERSON

Case	Area of expertise	Professional role	Int-ID
Case 1	Electrification	Product Manager for service	Int-1
	Electrification and Automation	Portfolio Sustainability Leader	Int-2
Case 2	Packaging equipment	Head of Product Line	Int-3

The interviews' answers are reported in the following sub-sections following the framework detailed in the methodology.

A. Actual service offerings and Sustainability initiatives

The selected companies have a very diversified service offerings portfolio, as reported in Table 3. They both provide their customers with technical assistance to their products (both on-site and remotely), trainings for the use and maintenance of the products (both on-site and remotely), on-site repairs and preventive maintenance also in form of contracts, consumables and spare parts, engineering and consulting, and installation services. The digital influence of the Industry 4.0 technologies ca be traced in the presence of sensors

for data collection later enabling data analytics and cloud sharing. Thus, it is possible to observe in their portfolio of services also the presence of platform that connects the machines and web portal for data visualization.

TABLE 3. ACTUAL SERVICE OFFERING

Int-ID	Int answer
Int-1, Int-2	Installation and commissioning; Technical support; Training (on-site or remote); Spares and consumables; Repairs and maintenance (corrective, preventive and predictive); Engineering and consulting; Services (extensions, upgrades, and retrofit); End-of-life services; Replacements; Service agreements.
Int-3	Installation; Remote assistance; Training (on-site and remotely); Maintenance contracts; On-site repair; Consumables and spare parts; Relocation service; Connectivity subscriptions; Web portal for data visualization; Tooling storage

The Sustainability actions collected from the interviews are summarized in Table 4. The service business units of the interviewed companies are both involved in the sustainability initiatives defined at corporate level, with specific targets and long term strategies. As it can be noticed from the answers, the focus of the Sustainability initiatives is saving energy consumptions and CO_2 emissions for a Low Carbon Society all across suppliers, operations and customers. Attention to the product design for reducing the economic and environmental impacts of maintenance activities, promotion of the machine connectivity and of those services delivered from remote (e.g., trainings, technical assistance), increase of the recyclability of the products supported by end-of-life services, and the certifications of the environmental impacts of the service products through a life cycle examination (EPDs, Environmental Product Declarations) are part of the Sustainability initiatives involving the service units.

TABLE 4. SUSTAINABILITY INITIATIVES INVOLVING THE SERVICE BUSINESS UNITS

Int-ID	Int answer
Int-1	EPDs for retrofit kits; Promote end-of-life services; Saving carbon emissions of services (on-site vs remote).
Int-2	Low Carbon Society; Preserve resources; Promote social progress.
Int-3	Develop new products with a reduced maintenance cost, energy consumption and CO2 emissions for the customer thanks to the technologies of Industry 4.0; Promote machine connectivity; Promote remote training

B. Responsibility for Sustainability initiatives

Table 5 summarizes the answers related to the responsibility for sustainability initiatives. In both cases, Sustainability Managers at corporate level have been identified. They are responsible for transferring sustainability corporate guidelines and that is involved in every business area, thus also the service business units. Int-3 reports that *"we have a team that works independently from the business units and monitors sustainability."* The interviewed companies have embraced the Sustainability in their business strategies and, consequently, they have assigned responsibility for reaching the sustainable targets. But Int-2, being a sustainability leader also highlights that *"Everybody needs to embed sustainability in his/her day-to-day actions."*

TABLE 5. RESPONSIBILITY OF SUSTAINABILITY INITIATIVES

Int-ID	Int answer
Int-1	Business Area's Division Sustainability manager; Global Sustainability Manager.
Int-2	Everybody (day-to-day actions); Support from top management is required; Responsibilities sitting in 9 different functions who designated accountable and responsible people for each.
Int-3	Independent director at corporate level who decides independently of the board responsible for transferring sustainability corporate guidelines.

C. Ecosystem for Sustainability initiatives

Also, the ecosystem topic has been explored, as shown in Table 6. Mainly, the interviewed highlighted that there is a mutual support between the company and the third parties in the sustainability initiatives, recognizing the increasing importance that this theme is gaining.

TABLE 6. RESPONSIBILITY OF SUSTAINABILITY INITIATIVES

Int-ID	Int answer
Int-1	Support by third parties.
Int-2	Supported by third parties and we also support third parties in their initiatives.
Int-3	Different partners; Members of the ECMA (European Carton Makers Association); Sponsors at global level of Associations on recycled packing and sustainable packaging.

D. Drivers for Sustainability initiatives

The drivers for sustainability collected from the interviews are reported in Table 7. *"Sustainability is embedded in everything we do"* stated Int-2. There are external drivers, such as market regulations, policies, incentives, and, especially, the customer requests. According to the interviewees, the non-renewable energy consumption should be reduced in favour of

renewable one, and the carbon footprint should be reduced for helping to reverse the climate change our world is experiencing. These goals and the respective actions are important for the companies themselves but also for the client. Also, considering that the business cases are B2B companies of Capital goods, the sustainability of their products and services is really important to be guaranteed through the entire lifecycle. Internal drivers were as well identified. Among these, the need of create new values for differentiating on the market and being sustainability leaders. Int-3 suggested that *"Sustainability can really be a business to exploit in order to differentiate ourselves on the market."*

TABLE 7. DRIVERS FOR SUSTAINABILITY INITIATIVES

Int-ID	Int answer
Int-1, Int-2	External market drivers (incl. regulations and client request); Competitive advantage.
Int-3	Differentiation on the market (but if Sustainability is measured); Customer request for support on reducing the costs, energy consumption site and on the predictive use of the equipment.

E. Transparency and Accessibility

Table 8 summarizes the findings related to the sustainability data transparency and accessibility. The reporting of the sustainability performance of the companies are accessible on their websites, therefore everyone can find their sustainability reports (aggregate results). Moreover, the client is constantly monitored on the energy consumption if the equipment is connected and the client can visualize the collected data in the dashboards.

TABLE 8. SUSTAINABILITY DATA TRANSPARENCY AND ACCESSIBILITY

Int-ID	Int answer
Int-1, Int-2	Integrated report published once a year; Real-time data dashboarding and publication.
Int-3	Reports (aggregate results) on the webpage; Client is constantly monitored on the energy consumption.

F. Evaluation of services' sustainability

From the interviews it appears that the companies are focused on evaluating their internal sustainability performances. Table 9 summarizes all the answers. Int-2 mainly provide the sustainability KPIs that are used internally for the reporting activity, they are related to capture the internal sustainability performance of the company, such as the Total GHG emissions, SF6 emissions, but also revenues and women leader in senior management (social dimension). The sustainability KPIs which are specifically used for evaluating the sustainability of services are the

time for installation which is seen as a KPI able to track the reduction of resource utilization, the maintenance costs and energy consumption, and the CO_2-equivalent emissions of services. Some of these KPIs are shared with the customer since also the client wants to track its sustainability performance. Int-3 said that the company provide dashboard with these KPIs that are continuously monitored, thus the client can visualize the costs and energy consumption that the customer has to face for maintenance interventions on the equipment. The evaluation of the services' sustainability through the mentioned KPIs is actually performed but it is clear that other KPIs are required to have a comprehensive evaluation of the service sustainability. Currently, the sustainability evaluation seems to be exploited just for reporting activities but it has the potentials for improving the design of the product and the services.

TABLE 9. KPIs FOR SERVICES' SUSTAINABILITY EVALUATION

Int-ID	Int answer
Int-1	Developing a tool that report the CO_2-equivalent emission of the services based on the GHG reporting guidelines.
Int-2	Total GHG emissions; SF6 emissions; Revenue covered by EPDs; Women leader in senior management.
Int-3	Equipment monetary costs, energetic costs; Equipment energy, ink, and pneumatic consumption; Equipment CO_2 emissions; Maintenance cost (not only monetary but also energetic cost); Net Profit Score (overall and related to the installation service); Time for installation.

IV. DISCUSSION

This study was performed to shed light to the sustainability topic in the PSS context directly from the industrial field. Hereafter, the authors summarized these evidences in order to address the research questions of the study.

It is possible to summarize that sustainability initiatives are mainly oriented to the environmental dimension of the TBL, the business cases presented in this study are embracing sustainability in everything they do thus also the service provision. Sustainability goals are part of the business strategies and a sustainability strategy in each of case is defined and responsibility for transferring the guidelines is assigned. This because sustainability, nowadays, is a substantial driver of differentiation and the client gives more and more attention to the sustainability issues. Therefore, services are now oriented to foster the recycle, such as end-of-life services by means of

partnerships, and save avoidable transports by means of digital connectivity, e.g., remote assistance, remote trainings, maintenance and spare parts contracts, technical advisory are now beneficing of the potential of the Industry 4.0 technologies that are becoming enablers for the service delivery. This is the case of the digital platforms where to visualize the equipment health conditions. Sustainability and digitalization of services appear to be connected but the sustainability seems a consequence of the digitalization of the services since companies are not designing their service offerings on the basis of the sustainability performances. This is strongly connected with the following evidence.

Sustainability is a driver if it is measured. Therefore, companies are measuring their sustainability impacts to align to their sustainability strategies. They are reporting them to make them accessible to their customer. But being sustainable means also supporting the customer to be sustainable and they are adding sensors to their products to collect data and provide KPIs to the customer about the energy consumed in real time, the associated monetary costs. They are also certified their products through Environmental Products Declarations and are trying to estimate the CO_2 emissions saved though their "sustainable" services. Special attention is given to the maintenance service which is significant when considering equipment with a long operational lifespan and it requires efforts in the planification of the resources. Despite this, as previously mentioned, the overview on service portfolios reveal that manufacturing companies are now providing services that are not designed for sustainability purposes but they have it as consequence.

Indeed, it is interesting to capture that the services are still mainly product-oriented. Maintenance, spare parts, assistance, and advisory, are still predominant as services added to the sales of products, and they can provide them as transactional-base or in form of contracts. More advanced Product Service Systems such as the result-oriented services are not exploited as business models even though manufacturing companies are measuring or at least they have recognized the sustainable KPIs to be measured of their services. For example, pay-per outcome business models where the focus is on achieving a specified outcomes or added value such as energy savings are not actually present in both the manufacturing companies object of the study.

Therefore, actually the sustainable KPIs are not fully used to support the design of the service business models. This recall to the paradoxes highlighted at the beginning of the study and to the necessity of methods and tools for evaluating the sustainability of PSS [12].

V. CONCLUSIONS

The authors proposed two business cases in the manufacturing context to explore how actually the Sustainability topic is affecting the product and service offerings. The results collected from the qualitative data collection through semi-structured interviews reveal that, at the moment, the sustainable KPIs are not fully used to support the design of more advanced services. Rather they are mostly used for the reporting activity which is useful to be transparent with the customer about the company sustainability level and to be aligned with the sustainability strategies. Digitalization helps manufacturing companies in reporting and monitoring the sustainability of the product and services and also to avoid unnecessary travels helping from remotely, thus sustainability and digitalization appear to be connected. However, since businesses are not basing their service offers on the sustainability performances, sustainability looks to be a result of the digitization of the services.

The main limitation of this study relies on the limited number of interviewed companies, although this will be increased in future developments.

VI. ACKNOWLEDGMENT

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Appendix A. FIRST APPENDIX

TABLE 10. EXAMPLE QUESTIONS

5W1H	Theme	Example questions
What	Actual service offerings	• What are the services your company provide?
	Sustainability initiatives that involve services	• Are you aware of your organization's sustainability initiatives? • Which of them involves the service department?
Who	Responsibility of Sustainability initiatives	• Who is responsible for sustainability initiatives in the organization?
	Ecosystem for Sustainability initiatives	• Are you supported by third parties for sustainability initiatives?
Why	Drivers for Sustainability initiatives	• What are the motivations that drive your organization towards sustainability objectives (e.g., regulations, client requests, differentiation from competitors, product and service improvement, etc.)?
Where	Transparency and accessibility	• Where can I find the results of your sustainability measurements?
When		• How many times in a year (or other time units) do you update your measurements?
How	Sustainability evaluation (KPIs, methods, tools, guidelines)	• How do you measure the sustainability in your organization? Have you got some spec=ific KPIs for sustainability performance? • Are these KPIs used to evaluate/measure the service delivery? • Do you have specific tools or methods to evaluate the sustainability inside your organization? • Are these KPIs aligned with the strategic objectives of your organization?