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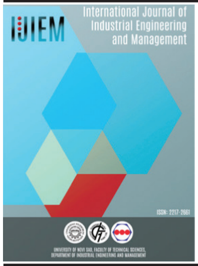

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Original research article

Improving service business of industrial companies through data: conceptualization and application

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ABSTRACT

As a consequence of the exponential growth of technologies, big data combined with increasing processing power, are leading to profound changes for industrial companies. Although the acknowledge importance of adopting a specific "big data strategy" in order to exploit the opportunity arising from servitization, how companies can do it in practice still remains poorly understood. This paper proposes a hierarchical framework to describe and operationalize the Big Data management to support servitization, in order to enable new service offerings and be able to react to fast changing customers' needs.

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1. Introduction

Integrating products and services is a growing trend among companies in today's globally competitive business environment [1]. The concept of servitization was originally introduced in 1988, as a response to the need to ensure and offer integrated products and services in order to offer added value [2]. In the manufacturing industry, this concept has gained attention recently, as a consequence to the need to reshape the strategy to compete in a global market. The growing interest in servitization strategies has reinforced the adoption of Big Data Analytics and Management for new business opportunities in the manufacturing industry. Central to this strategy is today the role played by the flows of data collected and how this data can be transformed into information, knowledge and insights to feed the decision-making process [3]. Thus, the correct management and use of data offer industrial firms the possibility to leverage technology and to innovate their strategies, towards the so called digital servitization [4].

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Despite the strategic relevance of such opportunities, research on these aspects is still in its infancy and literature calls for a more conceptual and empirical investigation in the field of data management for servitization [5].

In this line, the aim of this paper is to provide a hierarchical framework that can be used to describe and operationalize the big data management to support servitization strategy, as well as role that data have in improving all services, including existing services. In addition, the model is applied to 5 companies showing how it can be used in practice to assess how manufacturing companies are addressing the potentiality offered by the data collected from product to improve service business and identifying change actions.

The paper is organized as follows. The next section provides a literature background, the third section describes the research methodology, the fourth the new framework and the fifth the empirical application. Finally, the last section draws some concluding remarks and discusses further research directions.

2. Theoretical background

2.1 Servitization of manufacturing

Manufacturing companies are becoming more oriented to the use of the product-service offering rather than the pure product [6]. This journey towards a tightly coupled combination of products and services is known as servitization [2]. As a service-oriented business strategy, servitization has been widely used by manufacturers to undergird their competitive advantage [7] and that is now widely recognized as the process of creating value by adding services to products [8] and developing service-based business models in manufacturing industries [9]. The servitization of modern manufacturing differs greatly from traditional approaches because of rapid developments in information and data analytics technologies that support the creation and delivery of products and services. But, the extent of value that firms can capture from technological innovation depends on their business model and on their strategies [10].

Suppatvech [5] in his research identifies a series of advantages of the serviced business models enabled by IoT that allow companies to: reduce operating costs, generate additional revenue, maintain long-term business relationships with customers, increase the use of resources and assess the risks of current product or service available. But, advanced business models require data management skills and competency [5], which means firms' capability of leveraging the data created by IoT, in order to create and capture value [11]. The use of IoT technologies allows new (smart and digital) forms of services for manufacturers, boosting servitization through digitalization [12] presenting the concept of “digital servitization”. The term digital servitization is defined as the development of new services and/or the improvement of existing ones through the use of digital technologies. These can be exploited to enable new (digital) business models, to find novel ways of (co)creating value, as well as to generate knowledge from data, and gain a competitive advantage [4]. As said, central to this strategy is the role played by the flows of data collected by connected products [13] and managed through new digital technologies. This aspect is discussed in the next sub-section.

2.2 The role of IoT and data management for servitization

In recent decades, there has been a rapid development of technological solutions capable of collecting, managing data in a simple and scalable way. One of them is the IoT, which can have huge advantages. According to Zhang [14], the application of IoT technologies can improve the operational efficiency of regeneration by at least 30% in industry. IoT technologies can help all manufacturers that struggle to develop the service business due to the difficulty in monitoring product usage conditions and related data [15], as it allows the collection and transmission of data upon which firms can deploy advanced functions and services [16]. IoT technologies enable a dramatic expansion of service innovation opportunities, increasing the relevance of the transition of manufacturing firms toward service-based strategies [17]. With their capability of managing information input and output at a distance, IoT technologies are allowing new (smart and digital) forms of services for manufacturers, boosting servitization through digitalization [18].

IoT, as a system capable of transmitting data over a network without human interaction, has led to an exponential increase in the number of data produced. A large number of obtained data is called Big Data: they are a complex set of extremely different information [19]. This amount of data cannot be archived using traditional database methods or techniques. In order to be used for information and decisions, a thorough analysis is required [20]. Various data analysis tools have been developed, with the aim of converting data into useful and usable information, which gives companies the ability to exploit and process that information in real time [21]. Advanced services are directly connected to the firms' capability of leveraging the data created by IoT, and in particular the ability to use customers' Big Data to design better-tailored products and services in order to create and capture value [18].

Servitization is using advanced information throughout the product value chain, data analytics technologies to help industrial-ists to effectively build upon the insights derived from big data usage [22].

As said before, proper management of (big) data collected from product is today critical for digital servitization. However, the way in which this data is used to improve service business is not sufficiently studied and further conceptual and empirical investigations are needed [5], [23]. Few authors have proposed frameworks and business models earlier. Hartmann presented a data-driven business model framework to classify business models that rely on data as a critical resource [24]. Lim, Kim, Kim, and Yeon Heo [25] identified nine key factors that characterize the value creation mechanisms into information-intensive services. Rizk, Bergvall-Kåreborn, and Elragal [26] proposed a taxonomy for data-driven digital services, defining four different key characteristics of the value chain of big data and extracted knowledge. Frank [27] proposed a conceptual framework to explain the convergence of servitization and digital transformation of product firms, resulting in nine different possibilities [28]. Rapaccini and Adrodegari [29] proposed a framework which establishes linkages between the ways data are transformed into digital services and proposes four archetypes. These previous works supported the need to synthesize and classify the knowledge on the topic.

3. Research process and Method

As presented in Figure 1 the research process consisted of two main activities: 1) the development of the framework, based on the existing literature and 2) its empirical application, which allowed to both refine it and explore its managerial usefulness.

In order to develop the framework proposed in this paper, we reviewed the literature on the relevant domain such as servitization, digital servitization and data management. To do that we borrowed an approach often used when relevant research is spread across a number of different literature streams [30], [4]. We started our analysis with recently published reviews on these topics and then, the literature analysis was carried out analyzing the most cited papers and evaluating their most relevant references. Through this literature analysis, a first version of the framework was developed. The framework is presented in detail in section 4.

Then, the framework has been applied to 5 manufacturing companies, in order to test its comprehensiveness and managerial applicability. Table 1 provides a description of the company sample under analysis and the key respondents that were interviewed for each company.

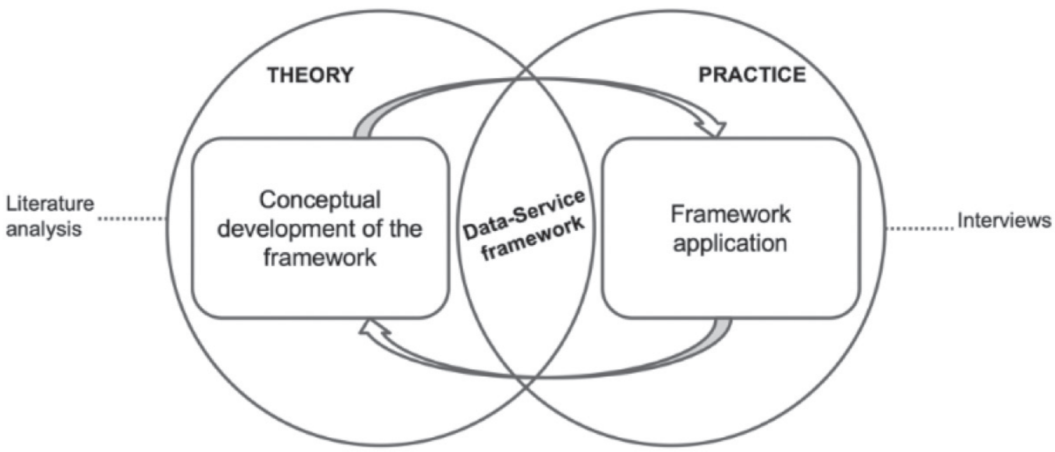

Figure 1. Research process

Table 1. Company sample

Case	Description	People interviewed
A	Company "A" is a multinational company based in Germany and was one of the first to manufacture sensors in the 1980s. The experience gained has allowed her to compare herself in different industrial sectors and to develop solutions capable of satisfying every customer need in terms of industrial automation, safety and regulatory constraints, especially with the growing diffusion of new digital technologies, that allowed to create advanced digital services.	Managing Director; Service Manager; Marketing Manager; Commercial Manager; Marketing Manager
B	The company "B" started its production by creating chillers and heat pumps, continuing with the innovation of its range of products offered on the market by introducing Roof top units, ring and water systems and systems dedicated to residential. With the sale of some shares, they completed the offer, integrating it with products such as air conditioners and large appliances for B2C channels, or small businesses, and allowed to develop new technologies in the climate sector, pushing towards an offer oriented to customer, configurable and able to meet needs.	Managing Director; Service Manager; Marketing Manager
C	Company "C" is a worldwide company, with a globally renowned brand, leader in the consumer electronics sector: smartphones, tablets, notebooks, TVs, Hi-Fi systems, and large and small appliances. The research is focused on the line of household appliances intended for the B2C market, oriented towards the customer by integrating the offer with product-service solutions capable of improving the customer's user experience.	Managing Director; Service Manager; Commercial Manager; Operation Manager
D	The "D" company is a world leader in the offer of machines, automation solutions, services for the production of molds and tools and for the production of high precision components. The company is based in Switzerland and has a network of branches in over 50 locations around the world.	Service Manager; Marketing Manager
E	The "E" company is a subsidiary of an important multinational group, and is an Italian company that is a world leader in the design, manufacture and maintenance of organic Rankine cycle turbomachines. Given the high complexity and continuity of use of the products produced, it becomes crucial for the company to have a reliable after-sales service. For this reason, the company in fact has a highly qualified staff, entirely dedicated to customer assistance, both remotely and on the plant, with the aim of optimizing its management.	Managing Director; Service Manager; Commercial Manager

In order to enhance the reliability and validity of the data collection and elaboration activities [31], we designed a specific research protocol for our multiple case study research. Following the suggestion by Yin [32], the developed protocol is composed of three main steps, namely:

1. *define and design:* in this step we analysed case study literature and gather all useful information to set-up the objectives of the empirical application. Due to the exploratory perspective of our research, we adopted a judgemental sampling approach to select case companies. Following the objectives of our research, in this step we also designed the main tools used data collection and elaboration.
2. *data collection:* different data collection methods were used, including a preliminary questionnaire, semi-structured interviews and direct (field) observation. The preliminary questionnaire was designed to gather useful information about the companies (corporate data; customer segmentation; product segmentation; services portfolio; business processes; and informative system). Following the objectives of this research, the semi-structured interviews were then used to gather information about the company data management process and the how data are used to support the service business. Each interview had a variable duration (2-4 hours) depending on the number of questions and on people availability. For each company, about three people from different business roles were interviewed, for a total of 17 interviews within the 15 case studies.
3. *data analysis and elaboration:* upon the completion of the interviews, we analysed and data coding to check evidences with each case as a standalone entity. Then, this preliminary analysis allowed to perform cross-case analyses related to the investigated issues. These key evidences are discussed in the remaining of the article.

4. Data management framework for servitization

The data-service framework is composed of two main axes. The X axis presents the typical data management process. In order to describe this process, we have considered seminal [33] and recent studies on information management, to introduce in particular the data management process. We finally used the "data value chain" proposed by [25] that consists of four phases.

- Collection: the first phase where the generated data is transmitted to the company that organizes and stores it in order to make it available to the various corporate functions.
- Visualization: refers to the initial processing of the archived data, presenting it through an interface to the various corporate users.
- Processing: this is a crucial phase where information is obtained from the available data, useful for improving the company's competitiveness.
- Usage: the last phase is about the use of information obtained from the data is used within the various corporate functions, to support decision-making processes by providing periodic reports and offering to customers timely assistance services capable of meeting their needs. In this phase, the company must finalize the work done in the previous phases by transforming the information obtained into value, to be redistributed internally to improve business efficiency, and externally to the customer with superior quality services.

The Y axis instead, provides a set of dimensions and variables that can be used to characterize, with a service perspective, how the data management process is carried out in a company. These dimensions were identified on the basis of the academic literature and are briefly summarized in Table 2. In order to analyze in detail each phase, the four dimensions have been operationalized into variables. In this way, the model analyzes all aspects of the data management process.

The new data management model for servitization is summarized in the following figure (figure 2).

By crossing the two dimensions we can evaluate each of four areas and related elements for the four data lifecycle phase (although the elements may not apply or be relevant for the four phases) and that's illustrated in the table 4.

Then, each variable of the framework has been analysed alongside the four phases of the data value chain. In particular, each variable scored:

- 1: they are critical, and they must be improved in order to exploit the data in terms of potential for service and servitization (low);
- 2: if it has specific aspects where it can be improved in order to increase the competitive advantage of the company (medium);
- 3: the variable is configured according to the guidelines provided by literature and best practice for manage and use data efficiently and effectively (high).

Table 2. Framework dimensions and variables

Dimension	Investigation area	Variables	Reference literature
Organization	Analyzes the internal dynamics adopted and the organizational aspects inherent to data management.	Responsibilities and control Business maturity Information sharing	Pigni, 2017; Gebauer, 2017;
Technological infrastructure	Evaluate the hardware and software technologies used in the individual phases of the process. This dimension also analyzes the IT projects that companies are completing to improve technologies in data management.	Technology implemented Project related to IoT and Big Data managment	Achary, 2017; Razzaq, 2015; Tu, 2018;
Data flow	Study the characteristics of the input data and the quality of the operations with which they are processed.	Data Usefulness Installed base dimension Data interface quality Data synchronisation Data selection criteria Data usages	Opresnik, 2015; Hair, 2007; Porter, 2014; Benjamin, 2016;
Scope	The corporate strategy is created on the basis of the information obtained from the processed data and it is analyzed.	Data impact on services porfolio Long-term strategy	Porter, 2014; Opresnick 2015; Grubic, 2018; Lerch, 2015

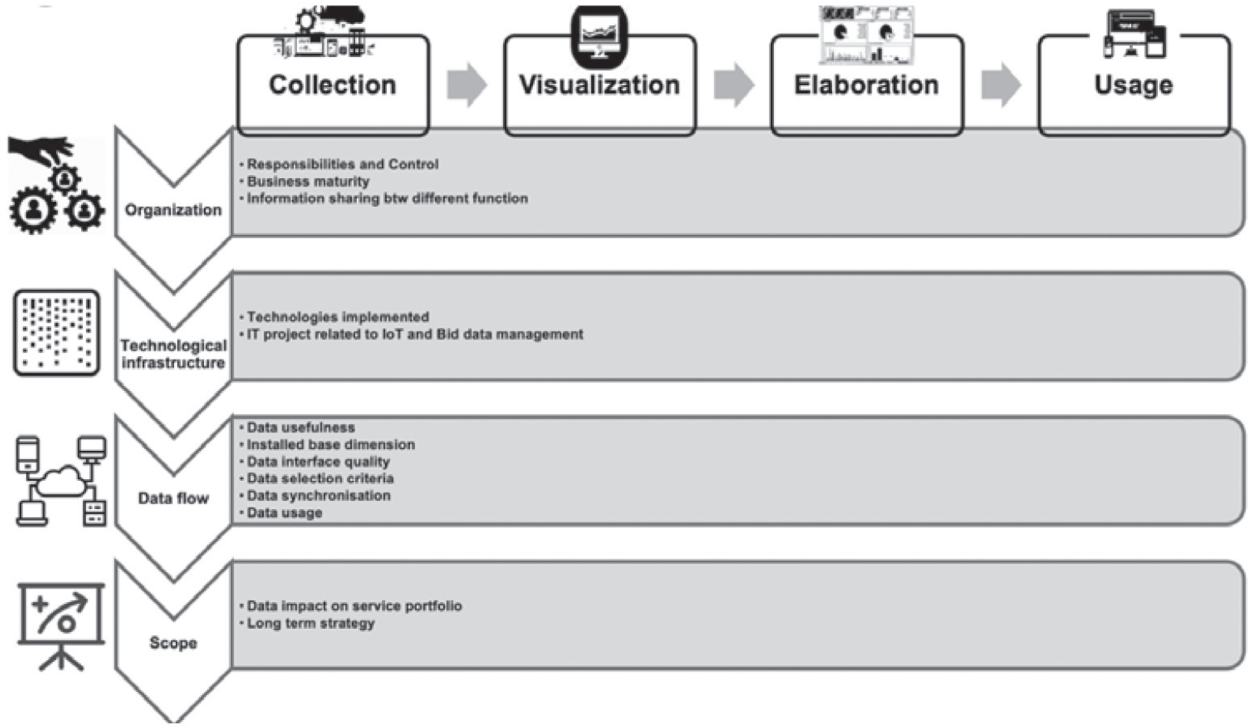

Figure 2. The new framework for data management in servitization

By aggregating the scores of the variables according to the dimension, the framework provides an assessment of each dimension in each phase of the data management process. The empirical application exemplifies the assessment mechanisms.

5. Empirical application

The empirical application aims to verify the validity of the proposed models, in order to provide concrete and practical support to companies that want to establish a strategy focused on the use of data and on the creation of value through digital services. A cross-case analysis was developed between the companies in the sample, with a twofold objective:

- Verify the validity of the models used and provide a correct framework of the level of maturity reached by the analysed sample;
- Provide guidelines and suggestions for improvement to implement an efficient and effective data management process.

The following Figure shows the level of each case study, along the phases of the data management process, comparing it to the average value. This figure also presents positive and negative aspects for each dimension, based on relevant evidences, which creates the foundation for being able to provide companies some suggestions that can guide the development of a more efficient data management process for servitization.

From the graph it emerges as a sample positioned within the intermediate range (be-tween 1.7-2.3), with the exception of the two points that differ greatly from the average: the visualization phase of Case B (2.6) which is high level, unlike the use phase of Case C (1.7) which is located in the low end. However, the sample has medium level data management which in some aspects still presents some critical issues. In order to obtain more information, it is necessary to access a greater level of detail, as shown in table 4. Each cell represents the evaluation of a given variable for a specific company, according to the three levels of the framework: High (H), Medium (M), Low (L).

The first critical issue concerns the information sharing: in the companies, the data circulates only within a few or unique functions business, typically the service and the technical department and the potential of the data is not fully exploited, as many aspects are neglected. Another critical issue that emerges from the sample analysed concerns quality of the data interface, which is often not suitable for providing information immediately, that reflects on the quality of the processing and therefore on the value of the obtainable information. Often, it is not known which

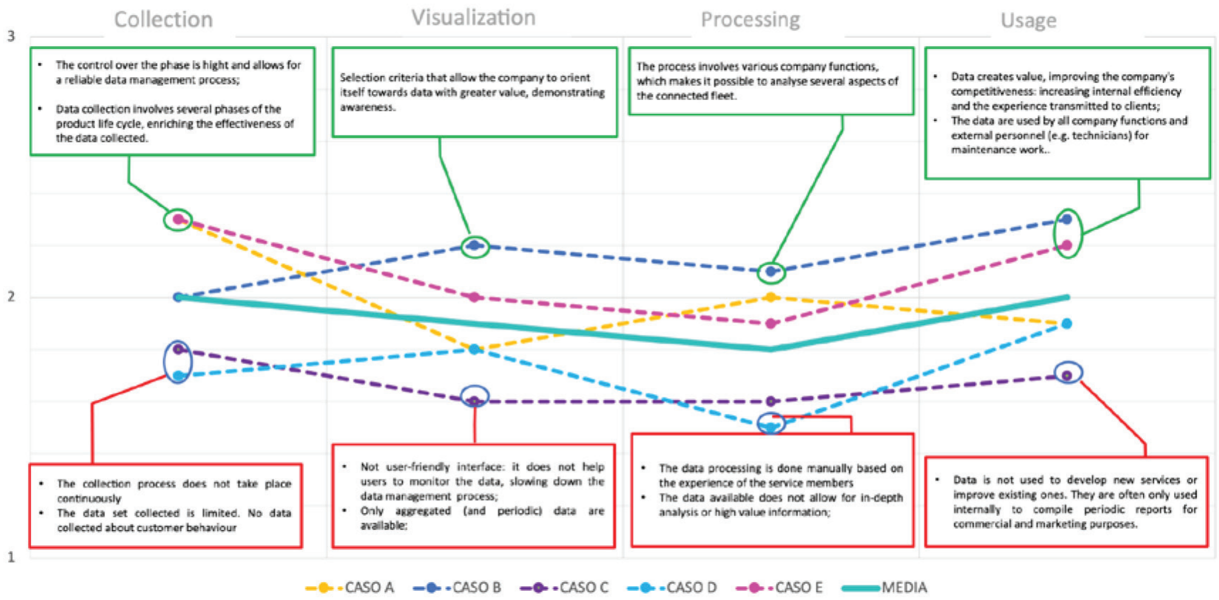

Figure 3. Sample maturity along the data management process

Table 3. Variable valuation for each case

CASES VARIABLES	A	B	C	D	E	MEDIUM
Phase control	H	M	M	H	M	H
Business-maturity	H	M	M	L	H	M
Information sharing	L	M	L	M	L	L
Used tecnologies	M	H	L	M	M	M
IT Project	M	M	H	H	M	M
Usefulness of the data	M	H	M	M	H	M
Dimension of connected park	H	L	H	L	H	M
Product life cycle phases involved	M	H	M	M	H	H
Continuity and synchronism of the process	L	H	L	L	M	L
Data interface quality	M	H	L	M	M	M
Data selection criteria	L	H	L	M	M	L
How use the data	M	H	L	H	H	M
Impact of the data on services	L	H	L	L	H	L
Long-term strategy on the use of data	M	H	H	M	H	H

data to collect in order to perform the related analyses and obtain valuable information. Sometimes, the selection of data not regulated by any criteria. Finally, a further criticality that emerged from the model is the low impact of the data on services, which are still strongly linked to traditional schemes, especially for as regards assistance in the event of breakdowns or anomalies, where the approach remains reactive. The restricted data flow, and the underperforming processing tools do not allow analysis to be carried out detailed.

In addition to testing the validity of the models, the second objective of the analysis was to provide guidelines and suggestions for improvement to develop and implement a data management process, capable of producing value, transferable to customers through digital services. However, the critical issues that emerged in the previous paragraph, were useful for determining ideas of improvement to increase maturity related to Big Data, IoT and digital issues services. These guidelines represent the most significant empirical output of this work, as they give companies a practical contribution. The guidelines can be summarized as follows:

Table 4. Managerial suggestions

Dimension	Guidelines
Organization	• Identify people from different functions to ensure that the data cycle involves the whole organization • Assimilate development guidelines, so as to optimize business operations and integrate them with the data flow from the connected fleet • The data management process must be designed by cross-functional teams, so that the aspects of interest to each function are identified
Infrastrucutre	• Identify the architecture of the technological infrastructure that best suits the size of the company, and the characteristics of the connected fleet. This can be done by a collaborative IT consultancy specializing in the digital issues of Big Data-IoT • Continuously review the data management process and identify any critical issues that can be resolved by upgrading the IT infrastructure
Data flow	• The company needs to establish a clear and defined strategy on how to use and gain value from data. In order to do so, it needs to establish precisely what data it needs, supplemented if necessary, with information from external sources. • The company needs to expand the connected fleet, making customers feel the benefits of data, and if possible, retrofitting to connect even older installations. • In order to gain a better understanding of the installed base and its behavioral trends, the company needs to collect data throughout the product life cycle. • Data must be collected continuously (real time or streaming) depending on the need to monitor the installed base • The company needs to establish a clear and defined strategy on how to use and gain value from data. In order to do so, it needs to establish precisely what data it needs, supplemented if necessary, with information from external sources. • Data must be displayed in a simple and immediate way. Each function must display the most relevant data in order to increase business efficiency.
Scope	• The company has to define a service offering, able to exploit the data collected by connected products, efficiently, transferring value to customers • Business strategy is at the heart of everything. In order to implement virtuous data management, you need to have clear and rational objectives within the reach of the company. Only with a quality data management cycle, you get quality information and quality services.

6. Conclusion

This paper contributes to body of knowledge on data management for servitization, providing a hierarchical framework organized in four dimensions. Each dimension has also been operationalized though a set of variables: this operationalization constitutes another research contribution of this paper. In fact, these variables have been derived from literature and investigate different aspects of the organization that are critical to assess how manufacturing companies are addressing the potentiality offered by the data collected from product to improve service business.

A further contribution of this work is represented by the guidelines that can be derived by apply this framework in manufacturing companies. In fact, the framework can be also used as a management tool that can support companies in identifying actions that can be implemented to better manage data for service.

The results of the empirical application show that there are still few examples of companies that have understood how to manage data collected to improve the service business. It is clear, however, that this issue is gaining more and more strategic importance because the benefits are addressed to all actors in the supply chain and have a vision both of short term, with the addition of new services and immediate benefits, but also of long term with the adoption of a truly competitive strategy compared to that of competitors.

Nevertheless, this study comes with limitations, some of which offer fruitful avenues for research. In the first place, the extension of the empirical research to different sectors would allow to generalize what has been discovered in this work. In the second place, after verifying the adoption of the guidelines by the companies, is possible to validate the suggestions and integrate them with other best practices.

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