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Artificial Intelligence for the Management of Servitization 5.0

Bernardo Nicoletti [1,*] and Andrea Appolloni [2]

[1] Temple University, I-00196 Rome, Italy
[2] Università di Rome Tor Vergata, I-00133 Rome, Italy
* Correspondence: bernardo.nicoletti@gmail.com

Abstract: Purpose—The sale of physical products has been manufacturing companies' main revenue source. A trend is known as servitization for earning revenue comes from services. With the convergence of servitization and digitization, many manufacturing organizations are undergoing digital servitization. In parallel, the digitization of industry is pushing new technological solutions to the top of the business agenda. Artificial intelligence can play a substantial role in this digital business transformation. This evolution is referred to in this paper as Servitization 5.0 and requires substantial changes. Aim—This paper explores the applications of artificial intelligence to Servitization 5.0 strategies and its role, particularly in changing organizations to EverythiA.I.ng as a Service. The paper underlines the contribution that A.I. can provide in moving to a human-centric, sustainable, and resilient servitization. Method used—The basis of the work is a literature review supported by information collected from business case studies by the authors. A follow-up study defined the models. The validity of the model was tested by collecting ten experts' opinions who currently work within servitization contracts sessions. Findings—For manufacturing companies, selling services requires completely different business models. In this situation, it is essential to consider advanced solutions to support these new business models. Artificial Intelligence can make it possible. On the inter-organizational side, empirical evidence also points to the support of A.I. in collaborating with ecosystems to support sustainability and resilience, as requested by Industry 5.0. Original value—Regarding theoretical implications, this paper contributes to interdisciplinary research in corporate marketing and operational servitization. It is part of the growing literature that deals with the applications of artificial intelligence-based solutions in different areas of organizational management. The approach is interesting because it highlights that digital solutions require an integrated business model approach. It is necessary to implement the technological platform with appropriate processes, people, and partners (the four Ps). The outcome of this study can be generalized for industries in high-value manufacturing. Implications—As implications for management, this paper defines how to organize the structure and support for Servitization 5.0 and how to work with the external business environment to support sustainability.

Keywords: artificial intelligence; servitization; digital servitization; Industry 5.0; human-centered; resilience; sustainability; social innovation; XaaS

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1. Introduction

Vandermerwe and Rada (1988) [1] introduced the term "servitization" to describe the extension of product-oriented business models to include services by manufacturing companies. Servitization is the "transformation process of moving from a product-oriented business model and logic to a service-oriented approach" [2]. Since then, servitization has defined a multidisciplinary research field that encompasses various industries and disciplines such as operations management and service science [3].

Servitization can include "product-oriented" and "customer-oriented" services. Product-oriented services refer to the customization, installation, monitoring, and maintenance of the product. Customer-oriented services, such as consulting and logistics, refer to the services provided during customer interaction [4–6]. Companies can offer product-oriented services based on their know-how and technologies around their products, also referred to as "basic services" Essential services provide a platform for offering more advanced services. Customer-facing services are based on the organization's customer-facing competencies [5] and are referred to as "enhanced services" [7,8]. Sousa and da Silveira (2017) [7] suggest that there should be a balance between the two types of services.

This paper analyzes the business model and support for servitization in an Industry 5.0 environment. In such an environment, servitization itself will undergo profound changes moving in the direction of Everything as a Service (XaaS). In this paper, such a new business model is called Servitization 5.0. It starts with digital servitization and adds the fundamental aspects of Industry 5.0 [8]:

- Human Automation Machine Collaboration.
- Sustainability.
- Resilience.

From a technological point of view, in a Servitization 5.0 approach, organizations can continuously improve their service offerings to sustain customer satisfaction to maintain their competitive edge within the industry. On the other hand, Industry 5.0 is characterized by bringing industries' focus towards collaboration for sustainable value co-creation rather than producing goods and services for profit. Artificial intelligence can help organizations transform their business models into an outcome-based Product as a Service (PaaS) mode. Artificial intelligence supports such transformation and creates value for customers, businesses, and society. This study aims to provide a summary overview of the evolution of servitization since its inception and to highlight the new challenges and opportunities arising from business transformation in the context of Industry 5.0.

This paper aims to provide responses to two research questions:

Q1. Which are the stages of servitization during the industrial revolutions to arrive at Servitization 5.0?

Q2. Which support can artificial intelligence provides to Servitization 5.0?

2. Literature Review

Organizations have widely viewed servitization in the business-to-business context as "a transformation process in which an organization moves from a product-centric to a service-centric business model and logic" [2]. Palo et al. (2019) [9] identified the servitization business model configuration and categories of resources and capabilities that need to support the transition to services [4,10–12]. Huntingford et al. (2019) [13] and Spring and Arauj (2017) [14] argue that servitization is increasingly a sociotechnical dimension that needs to be addressed in the current business ecosystem characterized by sustainability pressures, smart decarbonization solutions, and strong government regulations.

Macroeconomically, the industrial sector is critical to most developed countries. Servitization benefits industrial companies by generating more revenue, integrating deeper into their customers' value chains, and improving their competitiveness [15]. Digital transformation enables servitization toward more advanced services with a solid customer-centric view. Digital transformation presents a triple challenge for manufacturers. It requires the evolution of existing business models, changes in organizational structure, and solid leadership to remain successful. Companies must re-evaluate their market objectives and define their value proposition for existing and potential new customers. New data and analytics capabilities are needed, represented by the Industrial Internet of Things (IIoT) and artificial intelligence (A.I.). These capabilities are becoming increasingly critical to the way companies interact with their existing and new customers. Conversely, servitization is associated with higher risk and reward potential for industrial companies.

AI-based technologies open new opportunities for companies to maintain their technological edge and address relevant societal challenges [16]. Abou-Foul et al. found that examining the relationships between A.I. capabilities, servitization, and the potential role of absorptive capacity is essential. They found that A.I. skills positively influence servitization and that absorptive capacity positively moderates this relationship. The path to servitization is through A.I. capabilities in internal processes and the integration of resource optimization with A.I. for social innovation services.

Digital capabilities in operations and delivery through continuous data collection and forecasting support digital servitization through reduced uncertainty [17]. These authors investigated how the contractual flexibility of price variations and contract lengths affect customer-perceived value in digital offerings with artificial intelligence (A.I.). They introduce flexibility into value creation concepts such as dynamic and value-based pricing. At the same time, they analyzed the role of transparency on the perceived value of such offerings. The study is based on an experimental survey and quantitative assessment in a business-to-business setting with 137 respondents from various industrial companies in the Nordic region [16]. The authors' observations suggest that the flexibility that digital offerings bring to value creation, i.e., price variations and longer contract terms, is perceived by customers as more valuable than standard offerings with general terms and conditions. The transparency of these offerings, enabled by data-driven digital technologies, could explain the increased value perception. The authors' findings suggest that the flexibility introduced is perceived as an opportunity rather than uncertainty, leading to a higher sense of value among customers.

The concept of servitization has continued to evolve since its inception. With the advent of Industry 4.0, the complexity of the concept and its typologies of value propositions has evolved considerably, opening endless possibilities [18]. Servitization will evolve where all organizations must adapt to these new trends. To this end, these authors conducted a systematic review of the leading databases in the field of services. They found the potential of servitization and the need to examine each reality to adapt to new opportunities. This approach can help organizations become service-oriented and achieve significant benefits.

Farsi and Erkoyuncu [19] investigated the possible enablers to design and deploy service solutions that fulfill product-service contracts' desirable availability, capability, and reliability. The research outcomes are presented as a transition framework and a set of recommendations towards the desired future state, with phased timings for implementing the critical enablers with a potential 2035 vision to support the Industry 5.0 transition.

Ghobakhloo et al. (2022) [20] noted that supply partners should proactively monitor core business processes and functions to analyze their economic and socio-environmental performance and risks. The development of these functions should enable companies to integrate renewables and move toward servitization and product customization to develop new value streams and improve the customer experience. Companies should leverage Industry 5.0 technologies, principles, and capabilities to develop smart circular products that can integrate into the circular economy throughout their lifecycle.

Zeb et al. (2022) [21] analyzed the Everything as a Service (XaaS) paradigm. XaaS has led to a massive shift in the use of subscription-based business models that are closely linked to "servitization" in emerging enterprises, i.e., linking softwarized products with on-demand service models in a single package. Thus, depending on the type of XaaS servitization model and subscription, NextG–Wireless Networks (NGWNs) can provide a wide range of service benefits.

All these studies have not considered a comprehensive review of servitization within the general approach of Industry 5.0 [8].

3. Artificial Intelligence

Mikalef and Gupta (2021) [22] define artificial intelligence as "the ability of a system to identify, interpret, draw inferences from, and learn from data to achieve predetermined organizational and societal goals". Despite all the attention given to this area of research, its ultimate uses and applications are still new and often over-promised [23]. Artificial intelligence is an interdisciplinary field that opens new possibilities.

Artificial intelligence is a technology based on disciplines that deal with the natural intelligence of human thinking, feeling, reasoning, problem solving, and learning. The goal of A.I. is to develop an intelligent machine. A major concern of A.I. is to increase the capabilities of computer functions commonly associated with human intelligence. A.I. techniques are very result-oriented, more innovative, functional, and cost effective than conventional intelligence techniques [24]:

Development and Classification of Artificial Intelligence Techniques

Narrow artificial Intelligence (ANI) is the most used A.I. [25]. Wirtz et al. (2017) [26] categorized A.I. functions that are widely used in business applications. They range from A.I. process automation systems, virtual agents, predictive analytics and data visualization, cognitive robotics and autonomous systems, intelligent digital assistants, cognitive security analytics and threat intelligence, identity analytics, edge analytics, and machine vision and recognition. Sjodin et al. (2020) [27] classified A.I. capabilities in a digitally servitized manufacturing context into data pipeline capabilities, algorithm development capabilities, A.I. democratization capabilities, customer co-creation capabilities, and data-driven delivery operations that improve social well-being.

A.I. has now become a powerful tool. It has begun to enable machines to take on some capabilities long reserved for humans. To accomplish its task, A.I. must have reasoning, learning, adaptation, and generation capabilities:

- Logical reasoning in A.I. helps machines apply deductive, inductive, abductive, and monotonic approaches to large data sets, facts, and/or knowledge. In this way, they can make predictions and draw valid conclusions [28].
- Learning and integrating various human functions such as perception, attention, memory, language, or planning can improve the knowledge of an A.I. application. It can be classified as supervised, semi-supervised, unsupervised, and reinforcement learning [29]. Supervised learning is a data mining task in which a function or class is inferred from labeled training data. Semi-supervised learning typically uses a small amount of labeled data with a large amount of unlabeled data. In unsupervised learning, hidden structures and patterns can be found in unlabeled data. In models of reinforced learning, machines learn through trial-and-error methods. Such technologies learn from the way humans perform certain tasks and proceed based on positive or negative rewards as outcomes [30]. Learning is a critical component of artificial intelligence. There is no guarantee that the statistical rules learned by the machine can adapt to a rapidly changing situation. An AI-based method that can modify, adapt, and change what it learns as needed is essential for data science [31].
- Adaptation in A.I. mimics biological organisms. It uses mathematical functions to mimic the natural intelligence of living organisms and animals using one or a combination of algorithms [32]. In adaptation, machines learn by moving, taking in sensory input, controlling the environment, and developing situational awareness. The literature points to significant advances in A.I. through the modification of existing methods. Traditional approaches such as artificial neural networks and decision trees are ineffective at adapting to different environments. Newer models such as reinforcement learning, complex neural networks, federated models, and tiny and deep neural networks can solve complex problems, for example, in the context of using A.I. in sustainability [30].
- Generative artificial intelligence [33] shifts A.I. solutions from classification, optimization, and prediction to the generation of high-quality artifacts (such as text, images, designs, and code) [11]. It can enable organizations to accelerate the transformation of collaboration between humans, automation, and machines, and repurpose human resources to support higher-value creative activities. Generative A.I. is not yet fully effective.

Another possible classification of A.I. models is based on their technology [34,35].

- Machine learning is a set of algorithms that can make a system artificially intelligent, recognize patterns from large data sets, and apply them to new data. Most practical applications of machine learning involve supervised learning algorithms [36]:

- Neural networks are a subset of machine learning algorithms. They use multiple layers of neural networks (algorithms that mimic the human brain) and require intensive supervised or unsupervised learning [37].
- Rule-based reasoning is a set of algorithms that store and process knowledge to make sense of information [38].
- Natural Language Processing understands human language and interaction, including natural language understanding (sentiment analysis and conversationalA.I. bots.) and natural language generation [39].
- Computer vision is concerned with automatically extracting, analyzing, and recognizing information from a single image or sequence of images. A machine can visually perceive its environment and recognize objects of interest [40].
- Cognitive search collects and analyzes different types of data and uses rule-based or machine learning algorithms to give them meaning, often like human cognition, to make decisions in complex situations [41].
- Predictive analytics combines data, statistical algorithms, and machine learning tools to determine the likelihood of possible outcomes based on historical data. This solution dramatically improves the reliability of predictions [42].
- Other promising technologies include augmented reality (A.R.)/virtual reality (V.R.) and identification technology. Mature technologies include pattern recognition, knowledge representation, optimization, and solution finding [43].

4. Industry 5.0

Industry 5.0 refers to a new level of flawless and harmonious integration between people, automation, and machines in organizations such as delivery networks [8]. Many industry leaders saw automation as a quick fix to the problem of inefficient processes [44]. Automation refers to process management, process optimization, and technology execution. Therefore, the definition, selection, and implementation of automation is essential. Several definitions of automation can be found in the literature:

- Replacement or support of human tasks by automated tasks.
- Performance is a physical or virtual (in whole or in part) of a function that was previously performed (in whole or in part) by a human.
- A system or method in which processes are executed automatically or controlled by self-acting automation or the like [45].
- "A person or animal acting in a monotonous, routine manner and without active intelligence" [46].
- Replacement of human activities with robots or intelligent machines that perform monotonous, routine, and standardized tasks or functions [47].

In enterprises, automation mainly refers to the progress of digital business transformation [48]. In this paper, it is implemented in the enterprise transformation to Servitization 5.0.

The main benefits of Industry 5.0 are higher productivity, agility, profitability, improved adaptability, readiness for change, a responsive work environment [47], and overall cost reduction [48]. In addition to the economic aspects, there are other significant benefits to consider [48]:

- Global society in evolution can play a significant role in continuous business transformation in companies, without employees fearing losing their jobs due to the introduction of new business models. This approach can produce open-minded, well-educated, and innovative workers.
- Waste reduction supports sustainability, saves costs, protects the environment, and creates better social relationships.
- Resilience and agility provide continuity in challenging and unexpected situations and markets or economic developments.

It is interesting to analyze how artificial intelligence can support Industry 5.0. This paper considers this aspect for Servitization 5.0.

5. Servitization 5.0

Servitization has evolved from Industry 1.0 to Industry 5.0 [49] (Figure 1).

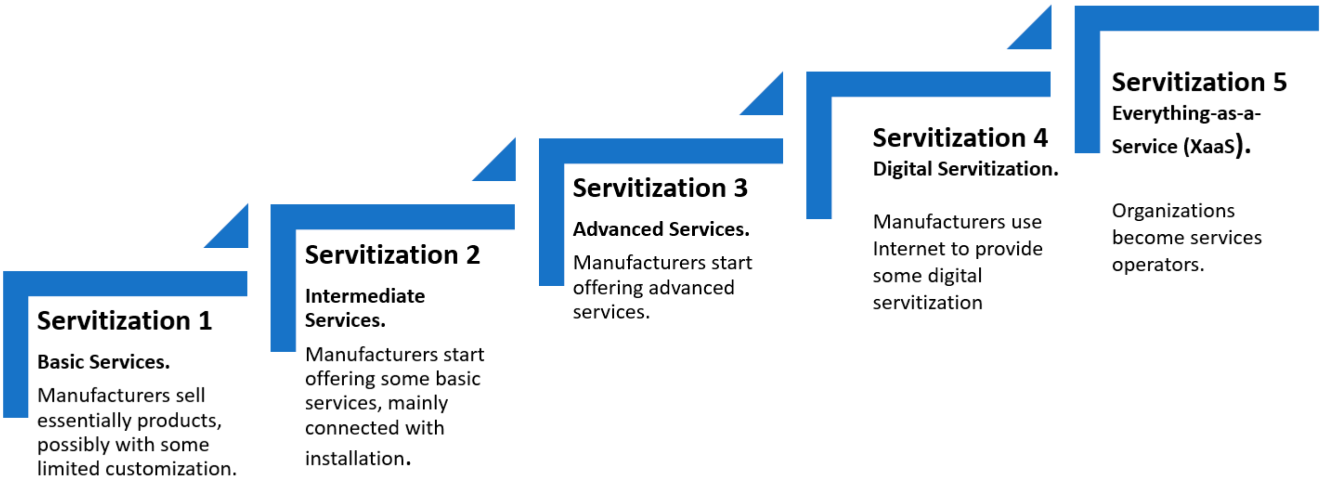

Figure 1. Stages in the development of servitization.

The introduction of the mechanical machine characterized mainly Industry 1.0. There was no real distinction between the provision of products and services. The latter was essentially left to the buyer of the product. When the product left the factory, it was no longer in the care of the manufacturer.

The same thing happened at the time of Industry 2.0, which was characterized primarily by the introduction of electricity. During this time, the sale of products was the primary source of revenue. Services were sometimes sold as an add-on to the product. They were mainly connected with the installation of the product.

The introduction of the computer marked Industry 3.0, and the service sector began to expand. Manufacturers started to offer maintenance services and help desk services.

The introduction of the internet marked Industry 4.0, and Servitization 4.0 introduced services that were primarily associated with the use of the product. Digital servitization started to be offered. The product remained the primary source of revenue. Possibly, ownership of the product remained with the company that sold the product. With the introduction of the internet and cloud computing, the customer does not buy the product, but pays per use. The fee may include additional services (such as help desk, maintenance, and insurance costs). The customer does not have to buy the product or system. He would pay a variable fee depending on the use of the product (payment per time of use, payment per unit of use).

Servitization 5.0 goes beyond digital servitization. It is the transformation process by which a product organization transforms its product-centric business model into a service-centric business model using digital technologies. These solutions enable the reconfiguration of its business processes, capabilities, products, and services to improve customer value for customers and enhance the organization's non-financial and financial performance [50]. Servitization 5.0, in conjunction with Industry 5.0, is changing dramatically. Servitization is becoming an outcome-based business. The customer does not buy the product or system but pays a fee for achieving a contractual outcome related to the performance of the product/system or the outcome of its use (e.g., final production volume) with the product use. Organizations move from products to Everything as a Service (XaaS). This term reflects how organizations adopt the as-a-Service method in everything they do, with XaaS organizations delivering anything as a service, possibly over a network, most commonly the Internet [31].

Servitization 5.0 assumes the characteristics of the highest level of maturity [51]

- Strategy and leadership: managing the service portfolio.

- Performance: assessing and managing service relationships, service-oriented measurement, or product-service innovation.
- Customers: Building and improving customer relationships.
- Organization: decentralization of decision making: Defining organizational specifics and sharing organizational resources.
- Digital solutions: Leveraging data for customer relationships or new business.

5.1. A.I. in Support of Servitization 5.0

Servitization 5.0 is an advanced or near-advanced level of digital maturity that consists of the organization intelligently increasing the collaboration of people, automation, and machines throughout the servitization process [52]. From an analytical perspective, three specific elements characterize an Industry 5.0 organization (Figure 2):

- Collaboration between people, automation, and machines within the core activities of the enterprise.
- Attention to sustainability from the perspective of the four pillars: economic, social, environmental, and governance factors.
- Implementation of a solid, resilient, and flexible servitization that can withstand catastrophic events.

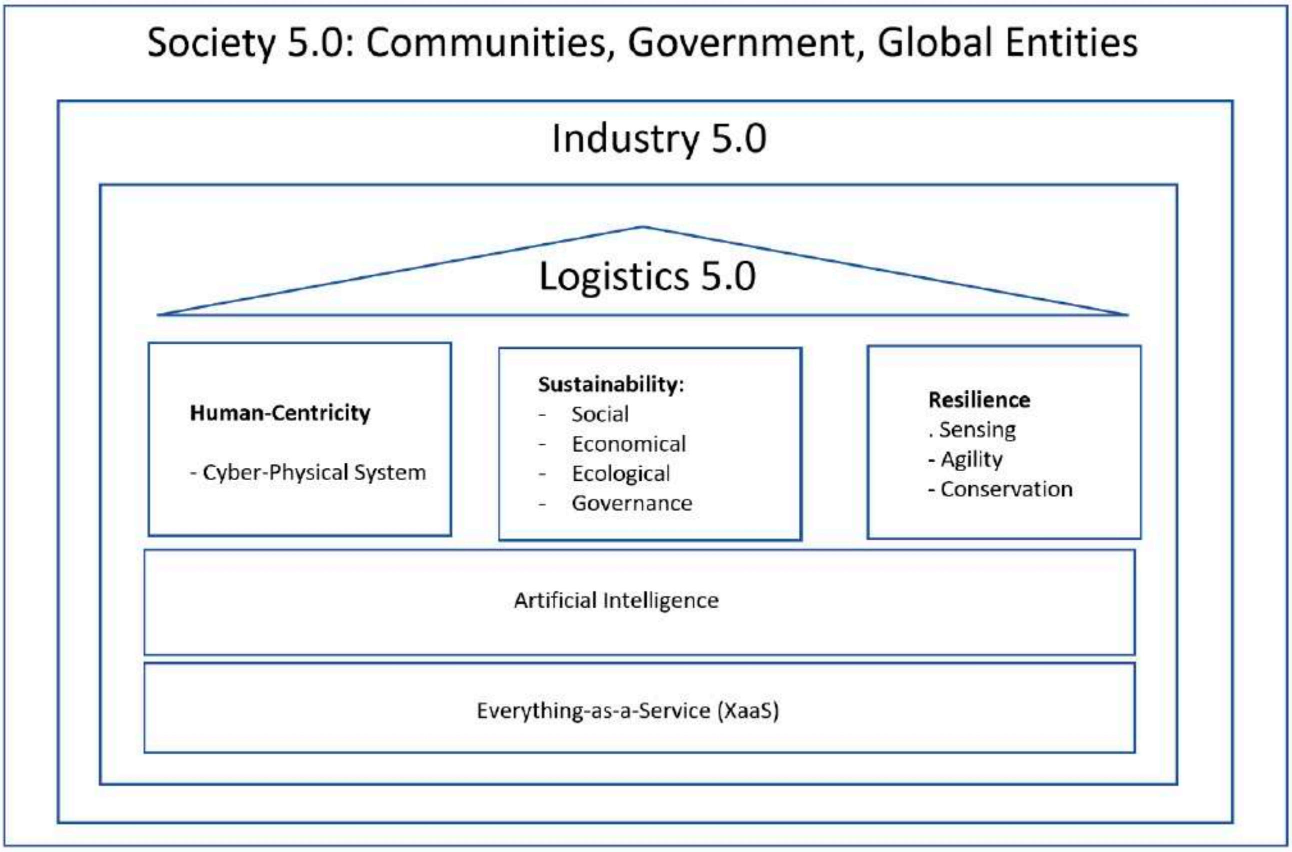

Figure 2. Servitization 5.0 in the context of Society 5.0.

5.1.1. Support for Human Centricity

Artificial intelligence excels at extracting models and information from past data and events. From a human-centeredness perspective, artificial intelligence should be called augmented intelligence. This statement is true in general, but especially in the case of servitization, where the contribution of operators can be significant. In the case of servitization, human operator contribution is responsible for several aspects: customer-centric innovation and collaboration in product and process innovation, and business model realignment to implement servitization strategies.

Servitization 5.0 is based on Cyber Physical Systems (CPS). These embedded systems enable improved processes' efficiency, accountability, sustainability, and scalability. They integrate the human/society context into the cyber-physical system [53].

A critical element that is sometimes overlooked in current CPS studies is the knowledge of human users about their tasks and the culture of the organization, which are the essence of the Toyota Production System [54]. CPS technological advances and innovations rely on people who are familiar with the manufactured product or service and have a supportive organizational culture [53]. The creativity, flexibility, and problem-solving skills of human actors and the organizational culture driven by leadership that continuously strives to improve operations are urgently needed to advance CPS [53].

There are several surveys/reviews of human cyber interactions in sensing, control, and servitization applications [53]. These analyses conclude that human-centric tools are helpful and essential in the era of Industry 5.0 and smart manufacturing. Rather than placing humans outside the service, integrating humans and cyber contexts in smart services is critical. For example, in human–robot collaboration in service, humans and robots (physical or virtual) can work professionally in a shared workspace, with robots dynamically changing pre-planned tasks to ensure both human operator safety and production requirements [53]. Servitization 5.0 involves humans working with machines and with automation.

The integration of humans and cyber contexts in smart services is critical, rather than placing humans outside the service. Several surveys/reviews of human cyber interactions exist in sensing, control, and servitization applications [53]. These analyses conclude that human-centered tools are helpful and essential in the era of Industry 5.0 and smart manufacturing.

Humans in Servitization 5.0 are at all levels, including the customer. The customer is in the center point. XaaS aims to increase the value the customer can receive by trying to make them subscribers of the service rather than buying the product just once [55].

It is interesting to apply the framework introduced by Kowalkowski et al. [56] for innovation in sustainability to evaluate the possible support of generative AI in the collaboration human-automation-machines. Generative AI can help:

- Teck/Data innovation, by exploiting all the data in the ecosystem for data analysis to support decision and operation in servitization.
- Business model innovation, by supporting self-service by the users powered by the manufacturing data, to implement an outcome-based servitization.
- Financial innovation, by helping to search for the best financial dean and generate smart contracts.
- Regulatory innovation, by helping in verifying the compliance with all applicable regulations and legal practices, in the specific implementation of servitization.

5.1.2. Support for Sustainability

Organizations with high environmental performance can improve their financial performance much more with digital servitization than other organizations [57].

Some papers highlight sectors such as transportation, energy, ICT, education, food sector, services, construction, and logistics where artificial intelligence can be highly leveraged for sustainable development [32,58,59].

Use cases for Servitization 5.0 can be found in some publications [32]. Some of the most common use cases are classification and regression. They are used to predict outcomes based on available data. Researchers are also beginning to incorporate reinforcement learning into these use cases. Other use cases are emerging, such as association rule mining, ensemble, natural language processing, deep neural network, sequence mining, generative A.I. and anomaly detection.

An exciting example of promoting sustainability is additive manufacturing (AM). AM is mainly realized through 3D printing, the use of which is increasing in the manufacturing industry [60]. Companies can improve their service levels through customizable products by using AM technologies. These products provide a more sustainable value proposition. They can empower their customers by selling digital files. These products/services can be considered levers to strengthen customer relationships. Artificial is currently widely applied in 3D printing for a smart, efficient, high-quality, mass-customized, and service-oriented production process [60]. Before a printing task begins, the printability of given 3D objects can be determined by an A.I. application for printability using machine learning. Parallel slicing algorithms, accelerate prefabrication of slices and path planning is intelligently optimized. Various machine learning algorithms can detect product defects, such as cyberattacks. Such applications are good opportunities for innovative solutions based on printability with multi-indicators, lowering the complexity threshold, speeding up prefabrication, real-time inspection, improving security, and defect detection for custom designs.

There are many examples of the use of A.I. to support the sustainability of servitization [61,62]

An A.I. model introduced by Google can reduce energy consumption in its data centers and cut cooling energy costs by 40%. This deployment is critical when new energy-hungry applications are introduced, such as generative A.I. [63].

IBM uses A.I. to improve weather forecasting, increasing forecast accuracy by 30%. This helps renewable energy organizations better manage their assets, maximize production, and reduce carbon emissions.

Carbon Clean Solutions, a U.K. organization, uses A.I. to capture carbon emissions from industrial processes.

Microsoft uses A.I. to help farmers increase crop yields while reducing water use.

The Ocean Cleanup, a Dutch nonprofit organization, uses A.I. to detect and remove plastic waste in the oceans.

Plan A, a German organization has developed an A.I.- and digitally driven software-as-a-service platform for automated carbon accounting, decarbonization, environmental, social and governance management, and reporting that serves clients worldwide.

5.1.3. Support for Resilience

Organizational resilience refers to "the ability of an organization to respond to and recover from adverse events that disrupt its operations and stability" [64]. Servitization can improve organizational resilience. It is interesting to analyze the impact of the two types of servitization—product-focused and customer-focused—on organizational resilience. Based on a survey of nearly 2000 U.S. organizations, servitization was inversely related to organizational resilience during the pandemic: manufacturing organizations that were very active in servitization suffered significant share price losses and took longer to recover from the losses caused by the pandemic. Organizations with product-oriented services, rather than customer-oriented services, were hit harder. This study contributes to understanding the drawbacks of servitization in terms of business resilience during a significant disruption.

Organizations with diversified revenue sources tend to be more resilient to adverse circumstances because they can count on an additional source of revenue when one source is struggling [65,66].

The disruption in developing and delivering advanced services can be mitigated by advanced technologies such as cloud computing, information technologies, artificial Intelligence, and data analytics [66–68].

A.I. in networked devices such as the Internet of Things (IoT) [69] can support diverse and innovative methods for cyber analytics and mitigate the risks of intentionally influencing or disrupting the performance of sociotechnical systems. It is essential to model the connections and dependencies between the edge components of a system and external and internal services and systems. The focus is on models, infrastructures, and frameworks for IoT systems interacting with A.I. automation. A qualitative empirical study relates academic literature to critical technological advances in networked devices. The focus areas derived from the analysis are [69].

- Electronic and physical security for artificial intelligence requires real-time data collection and storage solutions for asset fleets. In this way, it can provide adaptive analytics and peer-to-peer monitoring.
- Software security and data security for A.I. must work with autonomous cognitive decision making, machine learning algorithms, high-performance computing or data analytics, and rapid sharing of cyberattack information and reporting on shared database resources.
- Asset management and access control for cyber risk analysis must evolve to CPS.
- Lifecycle and forgery protection for A.I. for cyber risk analytics need task-specific human–machine automation interfaces for self -learning machines, component prognostics, and health management.
- Software assurance and application security for artificial cognition in servitization applications require a big data platform for sensor state-based monitoring. These platforms can support complex models, such as developing cyber systems with structured communication for mobile CPS, cross-domain end-to-end communication between objects, and cloud computing tools.
- Key performance indicators must be used for forensics, predictions, and recovery plans for artificial cognition.
- Monitoring actions, preventing, or granting required access, or developing resilient control systems require tracking and tracing cyber risk analysis, feedback, and control processes.
- Timed architectures and dynamic structural control facilitate protection against malicious actions and tampering.

6. Conclusions

This paper has analyzed and confirmed the transformative role A.I. can play in organizations. The support of A.I. in servitization can greatly help manufacturing organizations in this transition.

Relative to research question Q1, the paper has presented an original classification of several generations of servitization. They are connected with the industrial revolutions that have characterized the world in the last couple of centuries. The different generations are summarized in Figure 1 A.I. can play a critical role in servitization. A.I. can help enterprises transform their business models into an outcome based Everything as a Service (XaaS) model by providing advanced health monitoring and predictive maintenance services [70]. A.I. platforms can also help organizations generate recurring revenue streams by offering advanced services that add value to their products. With this approach, thanks to A.I., it is possible to perform a fundamental digital business transformation, not just a digital transformation [71].

Relative to research question Q2, the paper analyzes the A.I. solutions that could play in the next stage of servitization development: Servitization 5.0. It is essential to use A.I. to transform servitization considering the three pillars of Industry 5.0: human-centricity, sustainability, and resilience. This approach can support Everything as a Service (XaaS) as mandatory to reposition servitization as service providers. Organizations need to rethink their business and operating models, realigning their strategy and operations. In this way, they should transform their operating model and reconfigure the business architecture to embed XaaS across the enterprise. XaaS adoption can lead to 15–20 percent annual growth in service revenue [72]. On the other side, XaaS can assure survival and growth for enterprises in the trend of deindustrialization in certain regions.

7. Limitations and Future Studies

The authors have validated a certain number of organizations the models presented. Additional analysis could consider a different sample of business cases and confirm the assumptions made. Additional research could also help identify disruptions in developing and delivering advanced services and ways to mitigate these disruptions through advanced technologies such as cloud computing, information and operational technologies, artificial intelligence, and data analytics [66–68]. The results of this paper can be generalized to other industries using business cases. The authors are researching and extending the analysis to innovative generative A.I. (GAI). GAI could support the problem determination, possibly delegating this initial phase to the users.

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