Digital Transformation Framework: Creating Sensing, Smart, Sustainable and Social (S^4) Organisations

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Abstract

Organisations are engaged in digitalisation or contemplating their need to start this transformation. Yet, there is not a single framework unifying the different aspects of the digital transformation based on digital value creation. This study attempts to fill this gap by reviewing existing frameworks and theoretical models on digital transformation and related concepts, such as Industry 4.0. Then, an integrated framework of the digital transformation journey emerges guiding organisations to identify capabilities allowing digital value creation. This framework suggests that the digital transformation is triggered by emerging technologies that transform the notion of value, the creation and delivery of this value, based on building blocks that allow organisations to innovate at many levels. These innovations require transformations having the potential to create organisations of the next generation, which are becoming dynamically more sensing, smart, sustainable and social-oriented.

1. Introduction

Digital transformation (DT) goes beyond technical aspects; it offers an opportunity to change business strategies and business models to make them more sustainable [1]–[4]. DT also promises organisations more integration, efficiency and agility to adapt to the globalised market and to fierce competition [5], [6]. To this end, this transformation demands deep changes in core aspects of the organisation, awareness of the external environment and deep internal knowledge to find transformational opportunities and to address new business models [7], [8]. These concepts emerge from different disciplines and there is not, to the best of our knowledge, a single integrated framework of these different facets of DT to represent organisations of the next generation.

Based on a literature review, the objective of this paper is to present an integrated framework of several aspects of the DT process in order to better organise and illustrate these related concepts with a digital value creation focus.

Despite being a subject of research since the introduction of computers in the business environment, only in its more data-oriented recent incarnation has the literature in this field grown more rapidly. There are few cases illustrating, describing or explaining a full DT process [9]. DT has so far mostly been focussed on customer-related applications, without profound changes in organisations [10]. As an emergent field, research is still fragmented with a larger focus on the technological aspects [11]. Moreover, an exploration of the literature revealed a lack of consensus on the definition of DT. Some authors decide to focus on the integration and the interconnection of cyber-physical systems [12], [13], while others focus on the technological opportunities to answer changes in the market [14], [15]. Finally, some suggest DT is the combination of several innovations profoundly changing organisations [16].

In addition to the understanding of the DT itself, the goal of this transformation is up for debate. The development of flexible, smart, and adaptable organisations in order to face the complexity and uncertainty of markets is often mentioned [11]. It also leads to a better utilisation of resources, helping organisations reach their sustainability goals [17]. Surprisingly, a recent large-scale survey of chief information officers and other information technology managers revealed that more than 80% of respondents believe their organisations are effective at understanding the concepts and the technologies of DT [10]. Nevertheless, the literature suggests that businesses are mostly managed based on traditional thinking and they still face many challenges related to strategy and governance regarding data and technology exploitation [18], which could negatively affect the perceived value of DT.

In light of this apparent contradiction, we suggest that the definition and understanding of DT might not be as clear as one would think. They could all benefit from general guidelines concerning digital value

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creation [19]. Moreover, teaching and training about DT would also benefit from a framework centralising the current state of the art in the field. This article aims to provide an answer to the question, "how can one organise the concepts surrounding DT in a single integrated framework towards a digital value creation journey ?" Our findings allowed us to answer this question by proposing an integrated framework of DT that illustrates a digital value creation based on technologies, building blocks, innovations to provide a meaningful understanding of this journey for the next generation of organisations.

In Section 2 we present the main conceptual background about DT, Section 3 presents the methodology to be able to summarise the state of the art concerning DT in Section 4. The elements of our framework are then introduced in Section 5. Finally, in Section 6 we discuss the end goal of the proposed framework, and we outline some conclusions and implications as to practice and future research avenues.

2. Digital Transformation

DT brings changes in the orchestrating role digital technologies play in the innovation process [20], and it opens new pairs between problems and solutions [21]. DT is also the connection of all players and objects, through innovative technologies that affect the whole value chain, aiming to create more competitive organisations [22]. For [16], DT combines several digital innovations for organisations and networks that have a strong impact on organisational structures, managerial practices and organisational culture. We define DT as the process by which innovative solutions based on digital technologies transform all areas of organisations to reach a new form in which the technological and social aspects are integrated, ultimately driving digital value creation. Besides DT, Industry 4.0 occupies a large proportion of research and professional interest in DT in the industrial domain [23]. The two concepts have similarities such as data integration and reliance on analytics and networking technologies, and their end goal is the transformation of the organisation [24].

Several frameworks describe DT, Industry 4.0 or the Industrial Internet of Things. Often, they focus on the enabling technologies, inter-connectivity and interoperability [11], [25], as is the case with cyber-physical architectures [12]. Others focus primarily on the business and operations model transformation [14], [26]. Based on an early analysis of the literature, we propose to study DT considering the following perspectives: the enabling technologies, the principles of the transformation, the business transformations and the goals of the transformation.

3. Methodology

A research gap remains in the lack of guidelines for the transformation of the organisations [17]. When a research field has not reached full maturity, literature reviews can pose the basis for theoretical foundations [27]. Thus, a literature review design was chosen for this study aiming to propose the fundamental basis of a theoretical framework for the digital journey of organisations. Articles search was performed on the main scientific databases, namely SCOPUS, Science Direct, Business Source Complete, Computers & Applied Sciences Complete, Directory of Open Access Journals, IEEE Digital Library and Academic Search Complete. We considered peer-reviewed articles and conference proceedings published before 2019, when the review was realised. The keywords, models, frameworks or theory, split with an "AND" operator with the keywords digital transformation, Industry 4.0, Industrie 4.0, digitalisation or digitalisation in the abstract were used.

The initial search yielded many articles not fitting within the inclusion criterion, which was to include articles presenting frameworks in part or in whole the concept of DT. Some papers were rejected after an initial round of article evaluation based on the abstracts and a second round based on a full reading of the article.

In the end, 23 papers describing, explaining or classifying concepts of DT of organisations were found. Papers which used DT only as a context were excluded, since the primary purpose of the paper is to suggest guidelines for an integrated framework about the DT process. The content of the article was then coded, first concerning the aspect of DT they were addressing, then by a further subdivision of the aspects. Four main aspects of DT were identified at the end of the first analysis step: the technologies involved in DT, the principles with which DT is implemented, the types of innovations resulting from DT, and the goals of DT. The complete subdivisions are presented in the following section.

4. Results

DT, Industry 4.0 and Industrial Internet of Things initiatives have in common the utilisation of new technologies to improve business performance, in innovative ways [16], [28]. To do so, several technologies may be employed according to several transformation principles [28]. Thus, the technologies of the DT, the guiding principles, the innovation and the transformation goals are the main guidelines for the following summary of literature.

4.1 Main Technologies Related to DT

For several authors, DT is strongly related to Cyber-Physical Systems (CPS) and the Internet of Things (IoT) [12], [13], [29]–[31]. Specifically, [12], [29] describe the 5C architecture corresponding to the automation pyramid. The lower level represents the connection and the transmission of data, while the highest level includes intelligent systems able to self-configure and self-optimise [29].[15] also apply self-configured systems to smart workstations, while real-time optimisation helps eliminate process wastes [15]. Cloud computing is mentioned as an enabler for connectivity [25], [32]. Big data and analytics (BD&A) help support decision-making [19], [33], [34]. Worker augmentation [9] and collaborative robots [9], [15] contribute to improving plant floor jobs. Several other technologies are mentioned in the literature as potential drivers of DT. A summary is presented in Table 1.

Table 1. Technologies in DT models in the literature

	Authors										
Technologies	Bageri et al. (2015) [29]	Bortolini et al. (2017) [15]	Chien et al. (2017) [13]	Fantini et al. (2018) [9]	Fatorachian & Kazemi (2018) [25]	Hermann et al. (2015) [28]	Hofmann & Rüsch (2017) [30]	Kayikci et al. (2018) [32]	Lee et al. (2015) [29]	Pinzone et al. (2018) [34]	Zaki et al. (2017) [33]
CPS	x	x	x	x	x	x	x		x	x	
IoT	x	x	x		x	x	x	x		x	
BD&A	x		x	x	x	x		x	x	x	x
Autonomous decisions/smart systems	x			x	x	x	x		x	x	
AI		x					x		x		
VR/ AR/ wearables		x									
Digital twin	x								x		
Cloud computing		x			x	x		x			
Advanced robotics/Cobots		x		x				x		x	
Additive manufacturing		x						x			
Autonomous vehicles/drones							x	x			
Worker augmentation				x							

Legend: CPS (Cyber-Physical System), IoT (Internet-of-Things), BD&A (Big Data & Analytics), AI (Artificial Intelligence), VR (Virtual Reality), AR (Augmented Reality).

While many of these technologies are not new, recent technological developments put them in the spotlight. For example, artificial intelligence benefits from new algorithms able to efficiently learn from data to undertake tasks previously required by human judgement [35]. The combination of many digital technologies creates immediate consequences that allow the emergence of principles for the DT.

4.2 DT Principles

Design principles guide managers to make the best choices concerning technology implementations [28]. Table 2 lists all the cited DT principles found in our literature review. These principles have also been cited in other works [28]. In addition to the list of Hermann [28], connectivity, integration and autonomy were added by some authors [30], [32]. Hofmann and Rüsch [30] also added information transparency as a digital principle. Finally, a framework to rate DT applications according to two axes, intelligence and autonomy has been proposed [36].

Table 2. Principles in the DT literature

	Authors				
Principles	Hermann et al. (2015) [28]	Hofmann & Rüsch (2017) [30]	Ibarra et al. (2018) [37]	Kayikci et al. (2018) [32]	Qin et al. (2016) [36]
Interoperability	x		x		
Virtualisation	x	x	x		
Decentralisation	x	x	x		
Real-Time Capability	x	x	x		
Service Orientation	x		x		
Modularity	x		x		
Integration		x		x	
Connectivity		x		x	
Traceability		x			
Transparency		x			
Autonomy		x		x	
Cognition				x	
Adaptiveness				x	
Cooperation				x	
Intelligence					x
Automation					x

DT principles facilitate ways to apply and reorganise technological capabilities and offer conditions for innovation in organisations in different forms.

4.3 Innovation in the DT process

As a business transformation, DT leads to innovation in organisations [17], [38]. There are several frameworks to categorise innovation types [38]. Notably, the definition of innovation is not limited to technological aspects [39]. Three categories of innovations have been suggested in operations management literature [40], known together as the three pillars of competitiveness shown in Table 3. The most frequently mentioned business digital innovations relate to processes, such as internal operations [9], [14], [26], [41] and customer relationship [26], [42]–[44]. Offering new services based on the established product offer is also a frequently mentioned innovation potential [37], [42], [43]. Product innovation can be derived from IoT [26] and new machine technologies [41]. However, innovations in a digital context are not limited to the 'what', the product and services, and the 'how', the processes [20]. DT also offers opportunities for managerial innovation, such as co-creation and joint decisions with customers [41] and supplier-manufacturer-customer partnerships [42].

Table 3. Innovation in the DT literature

Innovations / Authors	Product / Service	Processes	Management
Berman (2012) [14]	x	x	
Fantini et al. (2018) [9]		x	
Ibarra et al. (2018) [37]		x	
Kans & Ingwald (2016) [42]	x	x	x
Kiel et al. (2017) [26]	x	x	
Li (2018) [43]	x	x	
Man & Strandhagen (2017) [3]	x	x	
Müller et al. (2018) [41]	x	x	x
von Leipzig et al. (2017) [44]	x	x	x

4.4 Goals of DT

DT is not a goal in itself, value creation is. Rather, DT is a way to reach a new [26] and profitable [45] enterprise business model. If DT is the next industrialisation step in developed economies and gives a jump-start to new economies, it must not blindly replicate a model that has shown its limits in the past, by contributing to pollution and leading to unsustainable growth [46] or by creating waste and overproduction [17]. Enterprises strive to become more sustainable, which requires smarter decisions and sensing organisation [2]. Information systems and digital technologies offer good opportunities to reach sustainability goals, provided the organisations can make sense out of the opportunities [4]. Furthermore, organisations should also strive to emulate the social behaviours of humans, through co-opetition, transparent information sharing, co-creation, and participative management practices. Social manufacturing offers an interesting point of view on this goal, by focussing on the relationships and the decentralisation of roles in manufacturing networks [47]. We build on Weichhart et al.'s [2] position paper and on dynamic capabilities [45] to suggest that together, four characteristics (sensing, smart, sustainable and social) are the capabilities to be built along the DT journey to reach the digital value creation.

4.4.1 Sensing

The new digital technologies create and exchange a large quantity of data [12], [26]. New opportunities emerge which must be explored before they can lead to innovation [20] or disruption [48]. Making sense of technological opportunities helps clarify the goal of the digital change [49]. Sensing enterprises have the capability to capture this data and turn it into valuable information and knowledge [2]. This applies to data emerging from the Internet of Things, from the internal and external environment of the enterprise [25], [45]. Sensing organisations are more likely to capture lucrative business opportunities [45] and to favour organisational learning [2].

4.4.2 Smart

Smart enterprises leverage captured information to learn and develop highly efficient and agile processes [17]. This increased speed of decision-making enables shorter reaction times, thus increasing firm agility in a changing environment [2]. A sensing organisation might detect opportunities, but only smart organisations have the capabilities to seize the opportunities [45], adapt and act on them [2]. Smart organisations take advantage of the smart technologies, which are characterised by autonomous decision-making [29], but also support employees through advanced decision-support systems [2], [9] or other technologies, such as additive manufacturing and cobots. This attribute is essential to ensure value can be captured out of the digital opportunities [7] and the organisation can dynamically adapt to the challenges ahead [49].

4.4.3 Sustainable

DT is often presented as the solution to face increasingly demanding customers, fierce competition

and regulatory compliance [11], [14], [25], [36], [45]. This real or perceived need from growth is often positioned against the achievement of sustainable business practices [1]. This point of view places enterprises in a reactive logic, while they could envision DT as an opportunity from a sustainability perspective [4]. Indeed, DT offers new business models, operation modes, as well as products and services that are more sustainable [3], including Product-Service-Systems. Data transparency between value network actors can help energy suppliers better plan their production, thus reducing waste [46].

Circular or closed-loop economy, a key concept of sustainable manufacturing, is facilitated by big data analytics [50] and by better cooperation between value network actors [1]. Sustainability is the intersection of economic, environmental and societal viability [2]. However, according to a recent literature review, most research on sustainable DT neglects the societal aspect [17], despite the value potential of considering social sustainability aspects proactively [9], [34]. Hence, managers of the future supply chains should take care to emphasise all three core components of sustainability [2].

4.4.4 Social

Organisations are social systems where machines, technologies and humans are interconnected [51]. While it is not the only way to represent organisations, picturing them as social organisms helps emphasise the impact of a fast-changing environment on the relationships between individuals, technologies and organisations [52]. Using this metaphor for the definition of organisations also highlights the improved integration and collaboration opportunities from the use of new digital technologies [25].

This integration and increased networking are at the heart of DT, notably in the manufacturing sector with Industry 4.0 [23]. The voice of the customer becomes the focal point of the transformation [44]. Customers become partners [26], [42] and the supply chain transforms into a partner network [26]. Partners are integrated in the decision-making process as well as in some creation steps [41]. Decisions are decentralised thanks to the local generation and analysis of data [1]. This social manufacturing phenomenon enables more complex, distributed decisions with all actors of a value network, including the end-users, and leads to full customisation, or individualisation, of product and service offer [47]. Although the reviewed literature has mostly focussed on customers, the concept is also applicable to suppliers, competitors, coopetitors and other actors from the business ecosystem.

5. DT Framework Proposition

Considering the current state of the literature on DT, as presented in the previous section, we propose a framework that offers a structure to managers and researchers. The goal is to show emerging technology integration as triggers that require incremental and disruptive innovation in different levels (product and services, processes and managerial) to reach digital value creation. This framework is articulated around several propositions, as presented below. In the following section, we seek to organise theoretical concepts on the DT, based on the concepts previously presented. We define the DT journey in terms of technological triggers based on solid building blocks principles to achieve business transformation.

5.1 Triggers

New technologies, especially those related to the Internet, are the spark enabling DT [15]. For Industry 4.0 as a specific type of DT, the technology-push and the application-pull constitute core triggers [23]. A trigger is an element that induces change, or induces a need for change [23]. A list of technologies useful for the DT is bound to become rapidly obsolete. However, we suggest that a classification of technologies can be useful to gain a full understanding of the potential of DT.

Basically, DT results from the fusion of digital, physical and biological technologies [6], [41]. In conceptual papers dedicated to DT, the digital and physical components such as robotics, autonomous vehicles or augmented reality are mentioned systematically in 11 papers. In contrast, biological technologies such as worker augmentation or biomaterials are mentioned only in one publication. While the introduction of bio-inspired design and biotechnology in DT is still a recent concept, it has a potential transformative power [53]. Fantini [9] discuss the potential of worker augmentations to change the role of humans in the new digital workplace. In the selected papers, no mention was found about technological implants, bioprinting or neurotechnology, nor of bio-inspired design. If DT comes from digital, physical and biological, we suggest progress and incremental innovation may come from deploying one or two of these categories together, for example in cyber-physical systems. However, when technologies from all three categories are deployed altogether, we believe the revolution and rupture potential is highest. This concept is presented in Figure 1 in line with propositions 1:

Proposition 1: Emerging technologies of physical, digital or biological nature, when implemented together,

can create action and progress (or even revolution and rupture) towards digital value creation.

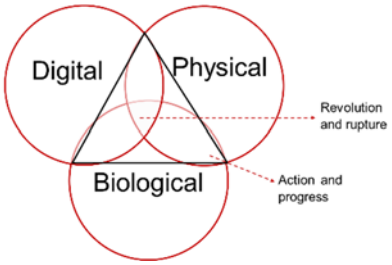

Figure 1. Triggers of DT

5.2 Building Blocks

The business environment is evolving towards greater instability for workers, with the rise of part-time employment and short-term contract on the one hand [54], and disqualification and employee stress on the other [55]. This places a great burden on organisations wishing to retain their knowledgeable employees to create a human-centric environment [34], [54]. The socio-technical system theory reminds organisations to dedicate attention to human issues in addition to the technological and organisational issues [54]. This theory illustrates socio-technical systems mutual influences between them and their context and powerfully represents the interaction of building blocks of DT. Consideration of the social-technical aspects of DT move organisations closer to sustainability targets [34].

In this context, diverse technological building blocks allow managers to identify a solid basis for their organisation's technological choices [28] and to design or redesign enterprise architecture. Similarly to how the structure of a house is built of several types of material, organisations need several types of building blocks, elements that form a stable and sustainable foundation for DT [20]. These businesses building blocks are connected to those principles summarised in Table 2. The triggers of Figure 1 may create the conditions to employ two building blocks, for example modularity and adaptiveness, to favour customisation.

As presented in Figure 2, we suggest a framework of DT made of building blocks (based on principles), which are organised according to the three components of socio-technical systems, in line with proposition 2:

Proposition 2: Emerging technologies create conditions for some building blocks (principles) to emerge from the technological, organisational and human perspectives in a way to guide action and progress (or even to promote revolution and business ruptures) towards digital value creation.

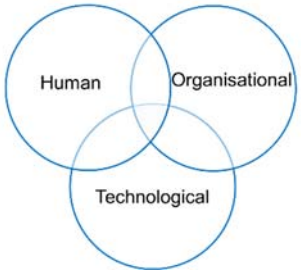

Figure 2: Building blocks of the DT

The interdependent nature between elements of the social technical systems, represented by human, technological organisational issues suggest that elements inside and outside the organisation enable the value creation and transformation. Managers should interpret this figure as guiding principles in digital value transformation, as discussed next.

5.3 Value transformations

Innovation in organisations plays a critical role. It allows companies to renew their offer of products and services while adapting this offer to the changing environment. It keeps business processes efficient and effective and it forces organisations to update their business models, knowledge management and other strategic activities [40]. In fact, DT is built through the accumulation of successive innovations [16], and DT also offers several conditions for innovation. New technologies offer products and services innovation opportunities, both at the core concepts level and between the products and services components [56].

Meanwhile, several enabling conditions for operational and management innovation emerge from DT, notably difficult problems caused by the increased expectations of customers and the competition, new management and operations paradigms and the emergence of companies with disruptive business models and practices [57]. In fact, although product innovation is still critical, the focus in digital innovation is more often on managerial innovations, notably business models and organisational culture [20].

To reach a sustainable competitive advantage, organisations can leverage the three innovative pillars of competitiveness [20]. The notion of value creation itself changes with innovative products and services, as the customer expectation. The generation of value creation through business processes innovation is also impacted, and the way organisations create and deliver value is changed. Finally, innovations occur in the way businesses manage their value chain and stakeholders take part in digital value creation [19], [40].

For example, the smartphone (with intelligent sensors and data analysis, for example) redefined telephone, i.e., the 'product value'. Additive

manufacturing may revolutionise the way companies 'generate value' to boost customisation. Delivery services based on drones change the way 'value is delivered'. Figure 3 summarises these concepts, in line with proposition 3:

Proposition 3: Emerging technologies guided by principles to promote action and progress (or sometimes revolution and business ruptures) affect the perception of value, how value is generated and how the value chain is managed, aiming to improve the potential of digital value creation.

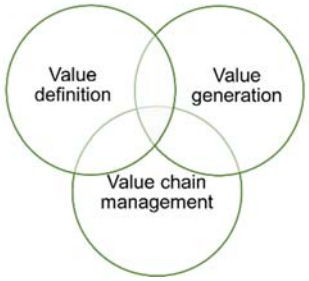

Figure 3: Value innovations in DT

At this point it is important to highlight, as shown earlier in Table 3, literature on the theory of DT does not dedicate the same attention to management innovation as products and services, and processes innovation [58]. Management innovation is characterised by a transformation of established management principles, theories and practices to change how an organisation is managed [57]. Examples applied to the domain of DT include new decision models based on customer participation [41]. We believe organisations aiming at the most sustainable benefits from DT will engage in the three aforementioned types of innovation. To leverage these three types of innovations, the ingredients presented in Table 2 can be used, such as interoperability, real-time capability, modularisation and so forth.

5.4 A framework for a meaningful transformation in the digital value chain journey

DT is at the heart of several businesses and research projects, and it is gaining attention worldwide. Yet, there is still a need for concrete guidelines to support organisations in their transformation [17]. Before such guidelines can be established, we believe a descriptive framework of the different aspects of DT can provide a common understanding for researchers and managers alike. The main aspects (or dimensions) presented also offer insights for a meaningful transformation in the digital value chain journey.

Thus, in this paper we introduced three propositions for guiding the DT journey towards sensing, smart, sustainable and social value chains. These propositions are summarised in the framework presented in Figure 4. To keep a fire burning, we must provide it with heat, fuel and oxygen. Likewise, we suggest that building blocks, triggers and value transformations allows companies to keep reaching for the DT goals to reach digital value creation, as suggested by the fourth proposition:

Proposition 4: Different emerging digital, physical and biological technologies create conditions to explore and exploit technological, human and organisational transformation building blocks. The combination of building blocks leads to transformations (gradual or revolutionary) of businesses value definition, value generation process and value chain management. These transformations have the potential to create organisations of the next generation, which are becoming dynamically more sensing, smart, sustainable and social. These four objectives are referred to as **"S^4"**

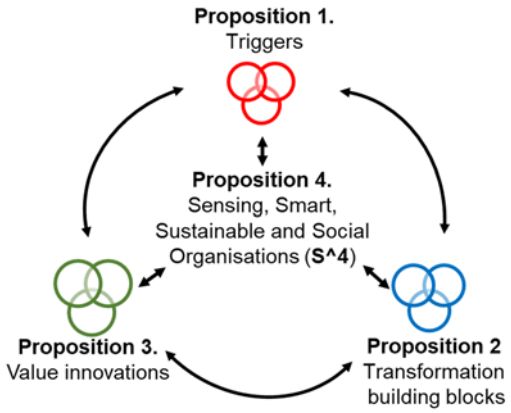

Figure 4: "S^4" Framework for the DT journey

6. Conclusion: implications for practice and research

Several years have passed since the concept of DT was first introduced, yet managers and researchers are still struggling to conceptualise both the DT process and its end goal as a value creator.

Research and practitioners on DT rely on concepts related to multidisciplinary views as mentioned before on Industry 4.0, on digitalisation, in digital innovation, on digital born business, digital technologies. Each discipline has their ontology and taxonomy to describe how technology are adopted and used in their domain or business sector. In addition, many technology hype and

"buzzwords" sometimes creates a misunderstanding of concepts and their real impact for the organisations.

In addition, research on digital value creation encompasses as well many disciplines and methodologies, from the development of new applications to the exploration of new managerial practices. It requires many capacities to explore and exploit the digital assets to create value for the organisation [19], [40]. We believe grouping the concepts related to it into a single framework allows to show that this transformation is a holistic process. It is based on an interdependent vision of different concatenated elements that are relevant to better understand the potential of the digital value creation journey. More, the **"S^4"** integrated framework of DT illustrates a digital value creation based on technologies, building blocks, innovations to provide a meaningful understanding of this journey for the next generation of organisations.

The **"S^4"** unified framework can be useful for different communities and stakeholders around DT. Lecturers and students will find a grouped explanation of the concepts of DT giving layer by layer the fundamental elements of DT (technologies, principles, innovations and value creation). It can be an approach to complement to existing pedagogical material. Researchers can use the propositions as a starting point for the design of their future work and contribute to advancing knowledge in IS and business management.

The **"S^4"** framework may help scholars and practitioners visualise a structure for DT that they may find useful in understanding the makeup of the domain, and, in turn, it may increase the likelihood of their making meaningful contributions to it. The literature review of this study revealed several research opportunities, notably on bio-inspired design applied to DT as well as managerial innovation. The **"S^4"** framework can also serve as the basis or the inspiration for a DT ontology by regrouping in each layer the ontology and taxonomy developed by many rich research in IS. Indeed, empirical studies bringing evidence is yet to be done.

Finally, managers and practitioners can also benefit by using **"S^4"** framework to show the digital value creation process from a unified framework, by making accessible at a glance concepts that are otherwise dispersed in the professional and academic literature. This unification emphasises elements that could be overlooked, such as the potential of biologicalisation [17], human-centred principles and managerial innovation.

Although the efforts to create a unified framework have done, the **"S^4"** framework has limits as all conceptual research. The concepts were organised according to a literature review in a field that has not yet reached maturity and that is evolving very fast. This is why we have focussed on the categories rather than on the content of each category. Still, it is possible that some studies were not included based on the keywords used in this search. In this context, other characteristics or dimensions not mentioned (such as financial) may emerge in future studies. Furthermore, future research need to explore empirically practical applications of **"S^4"** framework to help managers understand and guide DT strategies. Finally, we encourage future studies to shed light on a better use of building blocks, capabilities and innovation of DT **"S^4"** framework to support organisation to become a purpose-driven and conscious business.

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