Identifying the scope of the implications of a Digital Transformation A formal approach to define the business dimensions involved

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Companies around the world are finding themselves in a race against the relentless evolution of digital technologies that are accelerating innovation and creating a highly competitive environment. Many works in research and practice are trying to guide companies to a Digital Transformation (DT) that allows them to take full advantage of new technologies. However, generic solutions, that are mainly focused on technological aspects, make it clear that there is a lack of understanding of the whole scope of their implications. In this sense, this work takes a step back to analyze the origin of the shortcomings of current solution approaches. The results point out a lack of theoretical foundation on identifying the business dimensions implicated in a DT that define its scope. In this sense, this study contributes with a more comprehensive view of the DT process by using a formal approach to define the business dimensions involved in such a change based on the principles of the Socio-Technical Systems (STS) theory. As a result, this proposal goes beyond the purely technological views to (1) identify five business dimensions involved in the DT process: technology, processes, structure, competencies and culture and (2) recognize the key role of strategy and performance measurement, not as dimensions but as external elements that drive and control the DT process. A multiple case study of the DT process of three French manufacturers is presented to validate the proposition. General remarks and future research concerning the implementation of these dimensions conclude this study.

CCS CONCEPTS • Applied computing~Enterprise computing~Business-IT alignment • Social and professional topics~Professional topics~Computing and business~Socio-technical systems • Applied computing~Operations research~Industry and manufacturing

Additional Keywords and Phrases: Digital Transformation (DT), Business Dimensions, Socio-Technical Systems (STS), Case Study Research

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1 INTRODUCTION

In the last years, Digital Transformation (DT) has become the necessary requirement for companies that want to take advantage of the opportunities that the new digital technologies bring [1]. Long understand by many as "the use of technology to radically improve performance" [2], DT is a complex process that goes beyond the changes on the technological aspect and forces companies to re-evaluate their business and operational models [3]. This complexity has been the subject of a growing number of research works that are conceived to provide the much needed guidance for companies contemplating a DT. These solution approaches, however, mostly in the form of Maturity Models (MMs), also present a predominantly technological vision that results in a shortened view of the effects that a DT is believed to have on all company aspects [4]. More recently evolving to comprise other aspects or business dimensions, MMs still face criticism regarding their method of development and the resulting quality of their content and scope [5]. An apparent lack of rigor in their development [6,7] and the exclusion of organizational elements that are critical in processes of change [8] show that there is still much to do to understand this phenomenon in all its magnitude.

As technological advancements are paving the way for the 4th industrial revolution [9], and DT is quickly becoming a reality for companies of all sectors [1], understanding the whole scope of its implications is a key issue to solve in order to provide better guidance. It is the hypothesis of this work that a formal approach will help define the right scope of the DT that contributes to building better solution approaches. In this sense, this research work aims to provide a holistic and comprehensive view of the concept that identifies all the business dimensions affected by a DT by using a theoretical approach. Therefore, the organization of this paper is as follows. Section 1 introduces the current context of this research work. Section 2 presents the literature review of the DT solution approaches and an analysis of their current scope. Section 3 and 4 presents the formal proposal of a new set of business dimensions based on a theoretical approach and a case study of industrial companies to validate the main propositions. Finally, Section 5 presents the conclusions and perspectives of this research work.

2 LITERATURE REVIEW

2.1 Digital Transformation and its solution approaches

DT, though it has not a formal definition, for the purposes of this work it can be defined as "the profound and accelerating transformation of business activities, processes, competencies, and models to fully leverage the changes and opportunities brought by digital technologies and their impact across society in a strategic and prioritized way" [10]. According to this definition, a DT naturally implies a radical organizational change that goes beyond the technology being introduced and whose impact requires that companies question their current business and operational models [3]. Naturally, the scope of the implications of a DT on the business dimensions can be extensive and therefore it is expected that the proposed solution approaches reflect those considerations.

To evaluate the current solution approaches that are proposed to guide the DT of companies, a literature review was executed with this purpose. The search for the available solutions approaches in literature was launched on the Science Direct database through the following combination of terms:

("smart" OR "digital" OR "Industry 4.0" OR “digitalization”) AND ("maturity model" OR "index" OR "framework" OR "roadmap" OR "assessment")

The results obtained were combined with other works referenced in the first works identified, arriving at a total of 85 solution approaches. Afterwards, 10 works were selected using the following conditions:

- The approach’s scope goes beyond the technological dimension.
- The approach includes human/social aspects of the change.
- The approach’s content and procedure of development are available with a minimum of detail.

The details of each work show that regardless of their name, they fit the description of a Maturity Model (MM), tools that were conceived to assess the degree of competence (maturity levels) in a certain domain based on a defined set of criteria [11, 12]. In the digital context, these criteria are represented by the business dimensions that are involved in a DT, the core of the content of these types of models. Table 1 presents the selected works, describing the origin of their design, the source of their content and the type of DT initiatives they pursue, along with the maturity levels considered and the number of business dimensions they cover.

Table 1: DT current solution approaches

#	Model’s name	Year	Origin	Source of content	DT initiative	Number of Dimensions	Maturity Levels
01	Industrie 4.0- Readiness [13]	2015	Practice	Industry Case studies	Smart Products & Services	6	6
02	PwC Maturity Model [14]	2016	Practice	Industry Survey	Smart Products & Services	7	4
03	Industry 4.0 Maturity Model [4]	2016	Research	Literature Review	Smart Manufacturing	9	5
04	Industrie 4.0 Maturity Index [15]	2017	Practice	Industry Case studies	Smart Manufacturing	4	6
05	Adoption Maturity Model (AMM) [16]	2018	Research	Literature Review	Smart Products & Services	3	5
06	Smart Factory Maturity Model [17]	2018	Research	Industry Case studies	Smart Manufacturing	3	4
07	Smart SMEs 4.0 maturity model [18]	2020	Research	Literature Review	Smart Manufacturing	5	5
08	CCMS 2.0 Industry 4.0 [19]	2021	Research	Literature Review	Smart Manufacturing	7	5
09	Industry 4.0-MM [5]	2021	Research	Literature Review & Experts’ Input	Smart Manufacturing	4	6
10	Extended Maturity Model for DT [20]	2021	Research	Extension of current MMs	Smart Manufacturing	6	5

After reviewing the selected works, it is evident that the creation of their content relies only on available literature and real case scenarios. It is also interesting to see that their objectives vary as they are focused on different DT initiatives, therefore the “maturity” they are referring to is not the same, probably a clue to the lack of consensus on the number of maturity levels they consider. Finally, it can be identified a high dispersion of

the number of business dimensions that they take into account on their scope. For example, as Model # 10, considers only three dimensions, Model #3 goes up to nine. In the next section, the analysis is focused on the business dimensions of the solution approaches to understanding what is their coverage of the scope of a DT.

2.2 Business Dimensions of the DT solution approaches

The business dimensions involved in a DT are the aspects of a company that have to change, redefine and/or reorganize *during* the transformation process in order to fully profit from the advantages of the technology introduction [21]. The business dimensions currently considered by the DT solution approaches are strongly linked to the criticism of their limited scope. However, it can seem incongruent to talk about their limited scope when some works present such numerous dimensions [4, 14, 20]. For this reason, an analysis is made of the dimensions represented in each work. In order to be able to compare the content of the selected works, the terminology was unified and certain concepts were grouped. Table 2 shows the detail of the business dimensions considered by each work and the number of solution approaches that consider each dimension.

Table 2: DT dimensions

Business Dimensions	Model 01	Model 02	Model 03	Model 04	Model 05	Model 06	Model 07	Model 08	Model 09	Model 10	Total count
Strategy	x		x		x		x	x	x	x	7
Business Model		x								x	2
Investment	x		x		x					x	4
Customer		x	x				x			x	4
Partners		x	x				x			x	4
Products	x	x	x		x			x		x	6
Services	x	x			x			x		x	5
Process		x	x			x	x	x	x	x	7
Governance		x	x								2
Culture		x	x	x				x	x		5
Leadership			x							x	2
Employee Competencies	x	x	x		x	x	x	x	x	x	9
Organizational Structure		x		x					x	x	4
Technology	x	x	x	x	x	x	x	x	x	x	10
Performance Measurement					x						1

This closer view of the business dimensions confirms the predominant technological perspective of the solution approaches, considered by all the models (10 mentions). Dimensions such as organizational structure (4 mentions) and culture (5 mentions) to the contrary have a weaker presence, even when they are recognized as key factors in organizational change processes of the characteristics of a DT [8]. Concerning the number of dimensions, the first issue is the level of atomicity of the concepts. In the case of leadership, for example, it is presented as a stand-alone dimension, when in reality it should be a part of employee competencies. It is also important to acknowledge that the majority of their considered dimensions, such as strategy, investments, customer, partners, products, services, and performance measurement are concepts that do not fit in the definition of business dimension. If we take strategy, for example, it is clear that even when it has a role in defining the type of DT of a company and the initiatives that it will comprise it is not a dimension of the business.

The “maturity” of a strategy does not evolve during the DT, it sets its direction. Strategy develops a link between the ends or objectives of the business actions and the means or resources to get there [22]. Digital Strategy, in particular, a widely researched topic, is considered the driver of the DT process [3], something to be carefully designed before the DT starts. It is believed that a “coherent and clear” digital strategy that defines the new business models and the level of investment, as well as the relationship with customers and partners and the products and services to offer, will guide the DT efforts to success. Something similar happens with performance measurement, also part of the DT process, but as an external element whose role is to control the activities that will lead to a successful transformation. As the DT process takes time, is highly complex and dynamic, the performance of the organization should be constantly monitored to ensure the achievement of its objectives [23], then Performance Measurement also takes an external role in controlling the DT process.

2.3 Gap analysis

The current situation makes it understandable that several research works declare that there is not a solution approach in the digital domain that is recognized as official, either from research or practice, despite the overwhelming offer [24]. It is also not surprising that their application has been rather limited [25] as the vision of the DT they provide is still not sufficiently complete and clear [26]. Considering that current solution proposals are mostly based on literature reviews of what already exists and studies of industrial cases, company surveys or personal experience of their authors, the approach of this work will be based on theory. The need for a theory-based approach lies not only in the fact that an important gap of current solutions is the lack of a formal approach, but also that organizational change induced by technology introduction has been long studied by organizational studies [8, 27, 28, 29] and therefore the possibility of an application on the digital domain is feasible. The existing theory will provide strong elements for a new proposition that can provide a holistic view of the change with a solid foundation and clarity. With this objective in mind, a formal definition of a new set of dimensions that reflect the whole scope of the implications of a DT will be proposed by taking into consideration that at its origins, a DT is a process of (radical) organizational change in a new fast-evolving context.

3 A THEORETICAL PROPOSITION OF THE DT BUSINESS DIMENSIONS

3.1 Theoretical background: STS

The STS theory is based on the premise that organizational works systems are constituted respectively by social and technical subsystems with complex interdependencies that need to be jointly optimized to achieve the desired performance [30]. This premise has been applied and enhanced by many authors in different disciplines. The specific element that is used in this proposal is Bostrom and Heinen’s [29] definition of a set of “interactive variables classes” (technology, task, structure and people), applied in the Management of Information Systems (MIS) discipline and that represent the social and technical aspects in an STS. The authors identified that the frameworks available for MIS scenarios had a narrow focus on changes in technology and tasks, but completely ignored the effects of those changes on other organizational aspects, a situation similar to the one presented in the DT scenario. Paying attention to these four classes of variables is considered to produce the best performance outcomes for a company [31]. This definition becomes instrumental in defining a set of the business dimensions involved in a DT with a theoretical approach and a holistic vision.

3.2 Proposal presentation

Based on the interactive variable classes, a new set of five business dimensions is defined: technology, business processes, organizational structure, competencies and culture. To arrive at this proposal a couple of adaptations were necessary, the representation of the variable “task” with the more current dimension of “business processes” and the representation of the variable “people” by the more specific dimensions of “competencies” and “culture”. In this proposal, these five dimensions are at the core of the DT and the changes inside them will depend on the type of initiatives it includes. The proposal also assigns specific roles to strategy and performance management external to the DT process. In the graphical view shown in Figure 1, the whole scope of this proposition is presented. A DT process is composed of the different DT initiatives (smart manufacturing, smart products, data-driven/smart services) and the business dimensions that will have to change during the DT. This view also positions the Digital Strategy and Performance Measurement as the elements driving and controlling the change respectively.

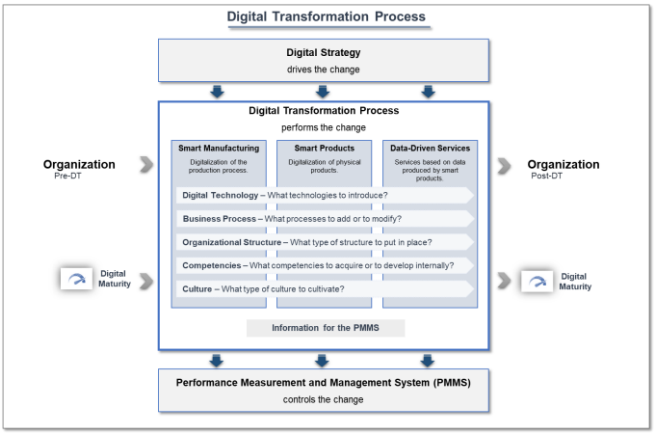

Figure 1: Proposal of the business dimensions involved in the DT process

This graphical view allows to place the different elements involved in a DT and to understand the phenomenon better by determining the full scope of its implications and acknowledging the role of elements whose proactive planning is critical for success.

4 CASE STUDY

4.1 Research design

As the objective of this work is to better understand the scope of a DT, a relatively new phenomenon, the nature of this research project is exploratory [32]. In line with its exploratory nature, a case study research method is applied for addressing the research questions of this work. The objective of this multiple case study is to validate the soundness of the proposal of this work, as case studies are an adequate method to understand complex social phenomena [33]. This research will be focused on the manufacturing industry, an industry with a key role in the new digital environment as not only the users but the producers of the new technology that is revolutionizing the way of operating and doing business [34]. For this study, three French manufacturers have

been selected by using theoretical sampling that allows the selection of the cases that are more suitable to offer theoretical insight [35].

4.2 Cases background

The companies selected for this study are mainly manufacturers of mechanical pieces that participate in Business to Business (B2B) settings in highly technological markets. It is this condition that has accelerated their DT. Table 3 shows a high-level description of the selected cases. A pseudonym has been assigned to each, as they have asked to remain anonymous.

Table 3: Cases description

Company pseudonym	Sector	Staff	Turnover	Size	Digital Initiatives
Company A	Industrial mechanics	120 employees	~25m€	Small & medium enterprise	Smart Manufacturing Smart Product Smart service
Company B	Manufacture of machinery and equipment	2,500 employees	~380m€	Mid-sized company	Smart Manufacturing Smart Product Smart service
Company C	Mechanical or industrial engineering	5,254 employees	~1,014m€	Large company	Smart Manufacturing Smart Product

4.3 Methodology

The data for this research was collected from primary and secondary sources [36]. Semi-structured interviews and observations are the main primary sources, while videos, websites, magazines and presentations represent some of the secondary sources. With the use of semi-structured interviews, the intention was to keep the consistency of the topics [37], while the use of several methods of data collection allowed triangulation to be achieved, leading thus to increase the validity of the data collected [32]. The data analysis process used in this work was performed by combining two strategies proposed by Yin [33], “relying on theoretical propositions” and “developing a case description” to validate the main propositions of this work. The technique used for the analysis was pattern matching in an effort to compare the business dimensions of the companies impacted during their DT with the ones proposed by this research work [33]. This data analysis was performed with the Computer-Assisted Qualitative Data Analysis Software (CAQDAS) NVIVO.

4.4 Results and Discussion

The findings of the analysis of the three case studies are organized by presenting the main changes on each dimension during the DT of each of the three companies (See Table 4).

Table 4: Key changes implemented by dimension induced by the DT

Business Dimension	Company A	Company B	Company C
Technology	Introduction of new digital technologies: Artificial Intelligence, robotics Experimentation with new technologies	Introduction of new digital technologies: cloud computing, Internet of Things, big data Experimentation with new technologies	Introduction of new digital technologies: Intelligent control, edge computing Experimentation with new technologies

Business Dimension	Company A	Company B	Company C
Business Processes	Formalization of existing processes Reengineering of processes being digitalized Creation of processes for new functions: innovation	Reengineering of processes being digitalized Creation of processes for (smart) services	Reengineering of processes being digitalized Update of existing processes for services
Organizational Structure	Creation of new roles for new digitalized processes Evolution of the Sales structure Formalization of new functions: Innovation, technology scan	Creation of new roles for new digitalized processes Evolution of the Sales structure Creation of new structures for managing the DT initiatives	Creation of new roles for new digitalized processes Evolution of the Sales structure Assignment of dedicated resources to DT initiatives
Competencies	Introduction of core digital competencies Introduction of competencies linked to sales of smart products and services Reinforcement of competencies linked to project management	Introduction of core digital competencies Introduction of competencies linked to sales of smart products and services	Introduction of core digital competencies Introduction of competencies linked to sales of smart products and services
Culture	Introduction to new cultural traits: risk-taking and learning from errors	Reinforcement of current traits: Openness to change, learning from errors	No proactive change, currently an issue for DT implementation

After the analysis of the DT process of the three companies, the main findings revealed that each of the business dimensions proposed was involved in the companies' DTs regardless of the type of initiatives implemented, validating the propositions of this work. Even when in some cases no action was identified, like in the case of Company C's cultural dimension, the consequences of the lack of change are proof of the dimension's contribution to DT success. Through this analysis, it was also identified that the DT process is highly contextual as the differences in the way each company handled the changes in each dimension originated not only from the type of initiatives implemented but also from the specific context and characteristics of each company.

5 CONCLUSIONS AND PERSPECTIVES

In the search for a holistic view of the DT phenomenon, this work first analyzed current solution approaches and the business dimensions that they considered to be implicated during a DT. The findings point out a lack of theoretical background of current propositions. Considering that disciplines such as organizational behavior have long studied technology-induced change, this work proposes a new set of business dimensions based on the Socio-technical Systems (STS) theory. The proposal identifies technology, process, organizational structure, competencies and culture as the new set of business dimensions, but also argues about giving a new role to elements such as Strategy and Performance Measurement, not as part of the DT but as the ones driving and controlling it respectively. A multiple case study of three French manufacturing companies completes this study, as a way to verify if the proposed business dimensions are involved in real case DT scenarios. Main

findings show that the business dimensions are present in every case, independently of the type of initiatives included by the companies, however, the type of changes inside each dimension are clearly linked not only to the type of initiative but also to the particular elements of their context of each company such as their size. Going further, this research work will focus on three projects: the identification of relevant variables inside each business dimension, the acknowledgement of contextual factors, inside and outside the company and the identification of key performance indicators that allow to control the DT process and lead the initiatives to success. There seems to be much to understand the DT phenomenon, but a full understanding is a necessary step that must be accomplished in order to create solution approaches that reflect the realities faced by companies in the digital context.

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