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Analyzing the Impact Level of SMEs features over Digital Transformation: A case study

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Abstract. Digital Transformation (DT) represents a real challenge for companies worldwide, not only because of its complexity due to technology's fast evolution, but also because of the lack of appropriate guidance. Available approaches are judged generic as they do not take into account the specific context of companies. In this sense, this work explores the influence of context in DT success and introduces a performance indicator to measure the impact of the company features that represent its specific context on the dimensions involved in a DT. As the second phase in a research project aimed to build a quantitative model that explains this relationship, this paper focuses on the application of the Impact Level (IL) factor in a real case scenario. The goal is to validate a previous theoretical analysis and also to identify changes in the results with a different characterization of company features. Relevant findings confirm the critical importance of Culture (f_3) and R&D investment (f_9) for DT success, but many differences arise from the comparative analysis that reveals the DT process as highly contextual. Future work will be focused on translating the insights of both studies into a quantitative model that presents the IL as an aggregator but also with the possibility to provide enough detail for better decision-making during the DT process.

Keywords: Digital Transformation, Small and Medium Enterprises (SMEs), Manufacturing, Impact Analysis, Impact level Performance Indicator.

1 Introduction

Digital Transformation (DT) represents a real challenge for companies worldwide and the complexity of its implementation takes a different magnitude for the manufacturing sector in particular [1]. Pressure is high for manufacturers in the digital era due to the fast evolution of the technologies that digitalize the means of production [2]. But just as the technological options and possibilities grow, so does the complexity of a DT for manufacturers [3]. Substantial research work has been produced related to the concept, its strategic options, the technologies to use, as well as the models and frameworks to guide its application [4]. Government programs in many countries are also numerous in promoting the DT of manufacturers and with that, the growth of their economies [5].

Despite such enthusiasm, the efforts are not helping to increase digitalization levels or the understanding surrounding the concept and the implications for organizations [6]. As the produced works provide only partial answers to manufacturers' needs, they have still not found the necessary guidance [7]. One of the reasons is that the approaches are considered generic as they often do not take into account the company's specific context [8]. In the DT *scenario*, however, the company's context is relevant because it represents its environment and the means it has to face the challenge [9]. This relevance of the context over the DT has not yet been established, but determining it could help companies to prepare better for this type of change. In order to do so, this research has previously introduced the Impact Level (IL) factor, an indicator that measures the level of impact of the company features over the dimensions involved in a DT [10]. A particular focus on SMEs is used due to their importance for economic growth as they represent around 95% of the businesses in countries like France [11], aim of this work.

Since that first analysis was based on experts' practical experience and provided theoretical conclusions about the IL indicator, the new stage of this research is focused on a practical application. An application through a case study allows not only to validate the findings, but also to find links and proportions between, respectively, features and dimensions in order to go deeper in the definition of the IL indicator. With this goal, this study performed an Impact Analysis on seven manufacturing companies that are fairly advanced in their DT process. In order to be concise, the results of one of them, particularly illustrative, are presented in this work. The insight provided by this study is highly relevant for the future definition of a quantitative model that helps decision-makers to take the appropriate measures before starting and during a DT.

Based on this, the aim of this paper is to present the results of the qualitative application of the IL indicator in a case study. The paper is organized as follows. Section 2 reviews the basis of the definition of the IL indicator and the results of the previous Impact Analysis. Section 3 presents the case study and the methodology followed to apply the qualitative approach of the Impact Analysis, as well as the obtained results. Finally, Section 4 presents the conclusions and perspectives of this research work towards the building of a quantitative model of the IL indicator.

2 The basis of the Impact Level factor

2.1 Digital Transformation

DT is generally considered as “*the profound and accelerating transformation of business activities, processes, competencies and models to fully leverage the changes and opportunities brought by digital technologies*” [12]. Even though research literature proposes a growing number of definitions for the concept, not one has been recognized as official [13]. Thus this definition has been chosen for its relevance to this work, as it considers the transformation of the business not as a consequence of the technology introduction, but as a preparation to get the most out of technology. In this sense, the dimensions that change during a DT are central to its success, and therefore this work

explores how the features of companies, in particular those characterizing SMEs, impact the course of those changes in a positive way, facilitating them or in a negative way, making it more challenging than they already are.

2.2 DT dimensions

The DT dimensions are the aspects of the company involved in the changes induced by digitalization. Research literature, however, has yet to propose an official set of DT dimensions [7]. For that reason, in this work, a collection of the most representative is included, based on the ones used by relevant proposals [10]. Hence, Figure 1 presents the set D of the 12 dimensions d_j , $j \in \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12\}$, with a brief description of the changes expected in each of them during a DT.

ID	Dimension	Expected Changes
d_1	Strategy	Digital Strategy definition and implementation
d_2	Business Models	Innovation of the organization's value proposition
d_3	Investment	Planning related to the realization of the Digital Strategy
d_4	Customer	Digital Experience definition
d_5	Products and Services	Creation of Smart and Connected Products and Services
d_6	Business Process	Processes creation, redesign and automation
d_7	Culture	Change towards Innovation and Collaboration
d_8	Organizational Structure	Flexibility, Agility and Cross-functional Collaboration
d_9	Leadership	Leaders aware and prepared for the Digital Era
d_{10}	(Strategic) Partnerships	Collaboration with customers and competitors
d_{11}	Employee Competences	Digital Competences
d_{12}	Technology	Digital Technologies selection and implementation

Fig. 1. DT dimensions [10].

2.3 Company features

The company features are the set of characteristics of companies that represent their context and that are relevant when facing a DT. In Figure 2, the following set F of the ten features f_i , $i \in \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$, characterize the typical manufacturing SMEs, according to a previous analysis [10].

ID	SME Features
f_1	Limited resources (financial, technical, human)
f_2	Organizational Structure less complex with informal strategy & decision making
f_3	Culture with low flexibility for change and experimentation
f_4	Personnel engaged in multiple domains of the organization
f_5	Low regard for business processes and standards
f_6	Product development with high levels of customization
f_7	Industry Knowledge focused in a specific domain
f_8	Strong Customer/Supplier Relationships
f_9	Low investment in R&D and lack of alliances with Universities
f_{10}	Low adoption of new technologies

Fig. 2. Manufacturing SMEs features [10].

2.4 Impact Factor and Impact Analysis

The Impact Level IL_{ij} is conceptualized as a performance indicator that shows the level of the positive or negative effect that a given feature f_i has over a given dimension d_j and is represented by the following function [10]:

$$\begin{aligned} ImpLev : F \times D &\rightarrow I \\ (f_i, d_j) &\rightarrow ImpLev(f_i, d_j) = IL_{ij} \end{aligned}$$

The previous work was focused on the analysis of the Impact Level IL_{ij} by using the given set of SMEs features defined by their current stereotypical characterization. This theoretical analysis performed by the knowledge and experience of the researchers and validated by industry experts resulted in the following findings [10]:

- The features that make the strongest impact over the dimensions are Limited resources f_1 , Culture with low flexibility for change and experimentation f_3 and Low investment in R&D and lack of alliances with Universities f_9 .
- The dimensions that are more impacted by the features are Strategy d_1 , Products and Services d_5 and Technology d_{12} .
- The industry experts that were consulted confirmed the general conclusions, as they recognize the importance of the limitation of resources and the critical role of the organizational culture as key components of DT success.

Industry experts also make a strong remark regarding the risks of generalizing the SMEs features. Therefore, in this new analysis, their stereotypical features will be substituted with those of a real case scenario of an SME in manufacturing. The goal is twofold, first to validate the researchers' assumptions in the first analysis and also, to identify how the differences in characteristics will affect the resulting IL.

3 Case Study

3.1 Methodology

The context of this research is defined by the French manufacturing sector, specifically companies in technologically advanced markets that are accelerating the DT of SMEs in the sector. The explorative nature of this research work allows the use of the case research method [14]. The choice of a single case study of a manufacturing SME obeys mainly the need to be concise and achieve representability at the same time [15]. In addition, the unique characteristics of the selected case, different from the SMEs stereotype, but typical of the described markets, are found relevant for the goal of this work.

The analysis performed in this study consists of the comparison of the theoretical values of the IL_{ij} based on typical manufacturing SMEs features and those of our case study based on a real *scenario*. In order to prepare the values of the IL_{ij} for the case study, data about the company was collected from primary (semi-structured interviews) and secondary sources (websites and news articles) [16], as a way to also achieve the triangulation needed to avoid any bias in the process [14]. The interviews were held

with the relevant personnel to characterize the company features, to understand the digitalization of its production process and to identify the impact of each feature on the DT dimensions. The outcome was validated with the information available in the secondary sources. The data analysis started by defining the IL_{ij} of the value of each feature f_i on each dimension d_j , according to the information collected. This qualification was performed with a 4-level scale composed of 2 *criteria*, an intensity and a sense of this impact, to keep a practical approach. The resulting four levels are described as follows.

- **L+:** Low influence of the feature in support of the change in the dimension.
- **L-:** Low influence of the feature against the change in the dimension.
- **H+:** High influence of the feature in support of the change in the dimension.
- **H-:** High influence of the feature against the change in the dimension.

The results were entered in a matrix that displayed the individual qualification of the IL of all the possible combinations between features f_i and dimensions d_j , for the case study, along with the results of the previous theoretical analysis. This display allows comparing both sets of values to understand the links between features and dimensions.

3.2 Case Description

The company selected for this study is a French manufacturing SME that produces a small variety of patented mechanical pieces as a supplier for the automobile and aeronautics industries. Founded in the 1990s, the company of around 100 employees has found success *via* its efforts of technological innovation. Searching for new ways to achieve efficiency and growth, the company started its DT a few years back, and now it has already digitalized its line of production. For confidentiality reasons, the company name is not provided and is labelled just as “Company X”. In Figure 3, the values of its features are displayed along with those of typical SMEs (differences marked in yellow).

ID	Feature	SMEs	Company "X"
f_1	Resource availability	Low	Low
f_2	Organizational formality	Low	Low
f_3	Culture flexibility	Low	High
f_4	Personnel engagement	Multiple domains	Multiple domains
f_5	Respect of processes and standards	Low	High
f_6	Product customization	High	High
f_7	Industry Knowledge	High inside industry/ Low outside industry	High inside industry/ Low outside industry
f_8	Customer/Supplier Relationships	Strong	Strong
f_9	R&D Investment and Alliances	Low	Medium
f_{10}	Adoption of new technologies	Low	Low

Fig. 3. Comparison of company features.

3.3 Findings and Discussion

Figure 4 presents the qualification of the IL_{ij} of the company features f_i over the DT dimensions d_j . Each combination contains the value obtained by the first analysis performed by the authors and the new analysis based on the case study. Different colours identify the sense of the impact, blue for “+” and red for “-”. Additionally, the intensity

of the colour is synchronized with the intensity of the impact for better visual interpretation. Finally, the three features in Company “X” that differ from typical SMEs (see Fig. 3) are also identified with a small triangle in blue (▲).

Dimension/ Feature	Analysis	f_1	f_2	f_3 ▲	f_4	f_5 ▲	f_6	f_7	f_8	f_9 ▲	f_{10}
d_1	1st analysis	H-	H-	H-		H-	H+	H-	H+	H-	H-
	New	L-	H+	H+		H+	L+	L-	H+	L+	
d_2	1st analysis			H-	H-			H-	L+		
	New			H+			L+	L-	H+		
d_3	1st analysis	H-	H-	H-				H-		H-	H-
	New	L-	L+	H+			L+		H+	H+	
d_4	1st analysis	H-		H-		H-			H+	H-	H-
	New										
d_5	1st analysis	H-		H-	H-		H+	H-	H+	H-	H-
	New										
d_6	1st analysis	H-	H-	H-	H-	H-		H-	H+		
	New	L-	L-	H+	L-	H+		L-	H+	L+	
d_7	1st analysis	H-		H-	L+				H+	H-	H-
	New		L+	H+	L+	L-				L+	
d_8	1st analysis	H-	H-	H-	L-						
	New	L-	H+	H+	L+	L+		L-		L+	
d_9	1st analysis	H-	H-	H-							
	New		L+	H+		L+		L-	L+	L+	
d_{10}	1st analysis		H-	H-					H+	H-	
	New	L+	L+	H+				L-	H+	L+	
d_{11}	1st analysis	H-		H-	H-			H-		H-	H-
	New	L-	L+	H+	L-	H+	L+	L-		L+	
d_{12}	1st analysis	H-	H-	H-			H+	H-	H+	H-	H-
	New	L-	H+	H+		H+	L+	L-	H+	H+	

Fig. 4. Impact Level (IL_{ij}) for the first analysis (theoretical) and the new analysis (case study).

Considering that the company has not yet redefined the Customer Experience (d_4) or implemented new Smart Products (d_5), these two dimensions were excluded from the analysis. For the rest, two types of findings are identified.

1. The differences in the values of IL_{ij} in the theoretical analysis and the real case scenario, for example, between Resource availability (f_1) and Strategy (d_1).
2. The differences in the values of IL_{ij} that resulted as a consequence of the company features that does not follow the typical characterization of an SME, for example, between Culture (f_3) and Strategy (d_1).

The main findings are organized and presented by the features perspective as follows. **Culture and R&D are key.** Previously, the impact of the features Resources (f_1), Culture (f_3) and R&D investment (f_9) on DT success was clearly identified in the theoretical analysis using the typical characterization of SMEs. For the real case scenario, all three are confirmed as influential on DT success with certain differences. In the case of resources availability (f_1), the case study confirmed its importance as it impacted many DT dimensions; however, the impact was not high as previously considered. Though the need for resources is real, the company covered it either by using financing or government aid designed to impulse the digitalization of the manufacturing sector.

On the other hand, as the value of the Culture (f_3) feature changes for this company to “High”, the intensity of the impact is confirmed, but in the opposite sense, as having a flexible culture strongly supports the DT. The company also deviates from the SME stereotype regarding R&D investment (f_9), as it makes efforts to search for innovation

through these activities. The result is a positive impact as it was anticipated in the first analysis, but in more dimensions than it was previously considered. On the contrary, the initial company's low adoption of new technologies (f_{10}) did not have the expected effect on its DT. Once they were convinced of the change, they went forward with the introduction of the required technologies.

Flexibility in Structure and Processes. Company X's high regard for processes (f_5), another atypical feature for an SME derived from the highly regulated markets it serves, confirmed the expected effects on DT dimensions. However, this feature also showed other unexpected impacts, such as the fact that processes were seen as a barrier to becoming an agile company. Other interesting facts were identified in relation to the low complexity of the organizational structure and the informality of strategy and decision-making (f_2). Considered a disadvantage in theory, in reality, they provided agility, well suited with a DT process that needs speed to advance further.

Knowledge is an asset. Regarding the features of high ability to customize products (f_6) and strong customer/supplier relationships (f_8), in the case study, they both translate into knowledge. In both cases, this knowledge helped identify what they need when defining technology investments. In consequence, the positive impact on the DT was higher than anticipated. On the contrary, their Industry Knowledge (f_7), constrained to the industry they participate in, had a subtle negative influence as it limits the visibility of what is needed when expanding to other industries. Finally, the engagement of company personnel in multiple domains (f_4) initially was considered to have minimal impact, mainly negative. In reality, this feature showed a lower effect, and in some cases, it switched into a positive one because the personnel welcomed some of the changes thanks to the positive organizational culture.

In summary, these results confirm the critical importance of Culture (f_3) and R&D Investment (f_9) for DT success. In addition, the Organizational Structure (f_2) and the Industry Knowledge (f_7) become more relevant, not in the same measure that the first two, but still with a significant effect. On the other hand, even when its importance is still high, the Resources availability (f_1) become less determinant in the case study when there is access to resources other than their own and the will and creativity to get them. For companies considering a DT, a culture open to innovation, along with an investment in R&D activities, are requirements to support the change.

4 Conclusions and Perspectives

This paper focuses on the application of the Impact Level (IL) factor indicator in a real case to validate a previous theoretical analysis and also to identify changes in the results with a different characterization of company features. The main findings confirm the critical importance of Culture (f_3) and R&D investment (f_9) for DT success, but many differences arise from the comparative analysis that revealed the DT process as highly contextual. The perspectives of this research work are focused on three main objectives. First, the validation of the IL indicator through the analysis of the remaining six case studies in order to refine the understanding of its behavior. Secondly, the definition of more sophisticated numerical or symbolic scales by transforming the insight obtained

from the real case scenarios. Finally, the building of an IL aggregate expression that could be defined either numerically or symbolically to determine the DT readiness of SMEs. Some frameworks such as the Visual Management principles and Fuzzy subsets theory could be used to achieve these objectives.

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