

THE ROLE OF DIGITAL MATURITY IN THE KNOWLEDGE BASED ECONOMY

Nelson DUARTE¹, Carla PEREIRA², Ricardo SANTOS³, António AMARAL⁴, Davide CARNEIRO³

¹CIICESI, ESTG, Politécnico do Porto, Portugal; IRIEM, Hong-Kong, nduarte@estg.ipp.pt

² CIICESI, ESTG, Politécnico do Porto, Portugal, INESC TEC, Portugal, cpereira@estg.ipp.pt

³ CIICESI, ESTG, Politécnico do Porto, Portugal

⁴ Departamento de Engenharia Mecânica, Instituto Superior de Engenharia do Porto, Politécnico do Porto; CIICESI, Politécnico do Porto, Portugal, sal@isep.ipp.pt

Abstract. *Digital Transformation is a trend that goes beyond it and it is mandatory for organizations' competitiveness. Digital Transformation is supported by information technologies, but aims to improve and optimize business processes in order to promote business success. In the present paper we start by fitting the concepts of digital transformation and knowledge-based economies (KBE), since both are supported by decision making processes based on data, information, and knowledge. Digital transformation processes might be seen as the micro level, while KBE the macro level. In order to foster KBE, organizations must work on their digital transformation and that can be a challenge in particular to SME. The present paper identifies the most relevant dimensions that must be considered to develop and apply a model to assess digital maturity. Along with these dimensions were also identified the main constraints faced by SME in the digital transformation process.*

Keywords: SME, Digital Transformation, Digital Maturity, Knowledge-Based Economies

JEL: O33, L20, O30

1. INTRODUCTION

Nowadays terms like Industry 4.0, digital transformation, digital business models, artificial intelligence, smart factories, among many others related to these ones are very common in academic and business worlds. These concepts, can be described as a natural evolution, or just a development, of another known concept: Knowledge-Based Economies (KBE).

“The economies of all developed countries are currently based on knowledge and information, and therefore they are referred to as knowledge economies. Their functioning is conditional upon creation, distribution and use of knowledge and related information. Information and knowledge are considered to be the primary and the most productive source of wealth creation (P. F. Drucker, 1993) and have therefore replaced traditional sources used in the recent past, such as capital and energy, or earlier ones like land and labour. The transformation of economies into knowledge-based economies is connected with the emergence of the post-industrial society” (Veselá & Klimová, 2014).

“The knowledge based economy is an expression coined to describe trends in advanced economies towards greater dependence on knowledge, information and high skill levels, and the increasing need for ready access to all of these by the business and public sectors” (OECD, 2005). This definition proposed by the OECD was supported by several authors [(Godin, 2006),



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(Enache, Marin, & Vechiu, 2011), (Veselá & Klimová, 2014)]. In fact, the concept of KBE was firstly promoted by OECD (OECD, 1996), and as suggested by Chen & Dahlman (2005), KBE framework is based in 4 main pillars:

- *An economic incentive and institutional regime that provides good economic policies and institutions that permit efficient mobilization and allocation of resources and stimulate creativity and incentives for the efficient creation, dissemination, and use of existing knowledge.*
- *Educated and skilled workers who can continuously upgrade and adapt their skills to efficiently create and use knowledge.*
- *An effective innovation system of firms, research centers, universities, consultants, and other organizations that can keep up with the knowledge revolution and tap into the growing stock of global knowledge and assimilate and adapt it to local needs.*
- *A modern and adequate information infrastructure that can facilitate the effective communication, dissemination, and processing of information and knowledge.*

Later, Enache et al, (2011) suggested three concepts that are very close to KBE: data, information and knowledge. Al-Mubarak, Muhammad, & Busler (2015) argued that innovation programs strengthen tools for the modern economy based on the knowledge towards smart growth.

This brief presentation of KBE and concepts related, turn easy to accept the relation among KBE, and the digital revolution that we are assisting nowadays. (Furjan, Tomičić-Pupek, & Pihir, 2020) present digital transformation (DT) “*as an inevitable path for surviving onto today’s market*”. Quoting other authors (Furjan et al., 2020) use expression such as “Digital or Death” or “Digital Darwinism”.

On what regards DT objectives, there are several and different approaches according to diverse authors. As examples we may list:

- Improve customer experience and engagement; Increase efficiency; Increase innovation; Improve business decision making; Transform business processes and/or business models - (Kane, Palmer, Phillips, Kiron, & Buckley, 2016).
- Ensure digital readiness; Digitally enhance products; Embrace product innovation; Develop new business models; Improve digital channels; Increase customer satisfaction and dialogue - (Osmundsen, Iden, & Bygstad, 2018).
- Application of information systems aimed at improving business processes to gain efficiency, cost savings, and business process optimization; Enhance operational efficiency and market orientation; Create value; Promote interaction between organizations and consumers; Enabling better understanding of requirements and facilitating customized offerings and new products tailored to specific customer need - (Matarazzo, Penco, Profumo, & Quaglia, 2021).
- Reducing costs through automation; Revenues growth through enhanced customer experience - (Verhoef et al., 2019).

In short it is possible to say that DT aims to contribute to business excellence. This excellence depends on several different aspects (internal and external), but it is clear, that real time data and information for decision making is something that DT promotes contributing to the improvement of KBE.

According to (Grebe, Rübmann, Leyh, & Franke, 2018) organizations that include digitalization in their processes present advantages such as: improved time to market, cost

efficiency, increased product quality, and better results in customer satisfaction. The authors also argue that becoming digital pays off in superior performance.

Considering that the new trend of digitalisation and DT are a key factor to the development of the KBE, and the Knowledge-based Organization, it is the aim of this paper to present a research on the critical factors that organizations (in particular SME) must take into consideration in order to adapt and transform their strategy and processes.

It will also be addressed the measurement issues of SME digital transformation, in other words: what are the factors that must be taken into account to know how mature organizations are in terms of DT.

Therefore, this paper presents a theoretical approach to DT and Industry 4.0 concepts in order to identify the main factors, and the best strategies to help SME in the process of their DT.

2. DIGITAL MATURITY IN SME

At the beginning of this section there are some aspects that must be clarified: Maturity and Digital Maturity (in SMEs). In brief, according to Colli et al. (2019) Maturity is a concept that comes from quality management and first appeared in the 1930s. Since then, several maturity models have been designed. In general, those models intend to identify the level where an organization is located in terms of different maturity stages.

Based on the work of Crosby (1979), the Software Engineering Institute developed the Capability Maturity Model for Software (CMM) that was released in 1991, later, in 2000 the Capability Maturity Model Integration (CMMI) – a framework that IT organizations could use in order to know whether they are using the best practices for software development. According to Colli et al. (2019) after CMMI, several maturity models have been designed. *“The aim of a maturity model is to describe the anticipated, desired or typical evolution path (Becker, Knackstedt, & Pöppelbuß, 2009) in a simplified way (Klimko, 2001). In 1979, Crosby and Free (Crosby & Free, 1979), with their quality management process maturity grid, provided a tool to systematically measure the current level of maturity of an entity along its evolution path”* (Colli et al., 2019).

These models are frequent in IT (CMMI) and in Management Processes, such as the Maturity Models developed in the field of project management (OPM3®, IPMA-OCB, P2MM). According to Lahrmann, Marx, Winter, & Wortmann (2011) maturity is a state of being complete, perfect or ready. While for Teichert (2019) maturing systems (e.g. organizations) improve their capabilities over time towards the achievement of some desirable future state. But in general Maturity Models aim continuous improvement (Uskarcı & Demirörs, 2017). This brief overview allow us to conclude that maturity involves an evolution path (as proposed by Crosby (1979)), and the positioning of an organization somewhere in that path. In short: the position where an organization is in the path to achieve excellence. On what regards Digital Maturity it *“describes the willingness and ability of the company to change and apply innovative technologies, depending on the trends, in order to remain competitive in the market”* (Eremina, Lace, & Bistrova, 2019). And we are back to idea of excellence and continuous improvement. But, while Maturity Models are focused in business processes, recently, several authors present Digital Maturity related to na organization’s DT [(Chaniias & Hess, 2016), (Kane, Palmer, Philips Nguyen, Kiron, & Buckley, 2015), (Fletcher & Griffiths, 2020)]. DT is defined as the implementation of innovative and new digital technologies to effect business improvements in an organization (Brown & Brown, 2019).

Those improvements must also be at the cultural level, digital transformation is as much about people as it is about technology (Kane, Palmer, Philips Nguyen, Kiron, & Buckley, 2017). Even related to IT concepts, digital maturity must be analyzed under a broader environment. It should reflect a managerial interpretation describing what an organization has already achieved in terms of performing DT efforts including changes in products, services and processes (Chanas & Hess, 2016). Digital Maturity might be presented as a holistic concept reflecting a technological and managerial aspect aiming companies success through processes optimization [(Lahrman et al., 2011), (Teichert, 2019)]. According to Colli et al, (2019) a digital maturity model describes what a was already achieved in terms of performing transformation efforts and how na organization systematically prepares to adapt to an increasingly digital environment in order to stay competitive. Ulas (2019) “*argues that the main purpose of digital transformation is to redesign the organizational business through the introduction of digital technologies, achieving benefits such as productivity improvements, cost reductions and innovation.*” Some of those benefits, related to industry 4.0 in organizations were identified by Moeuf, Pellerin, Lamouri, Tamayo-Giraldo, & Barbaray (2018) and are the following: Flexibility, Cost Reduction, Improved Productivity, Improved Quality and Delivery Time Reduction. From the presented perspective it is possible to argue that all these concepts (Maturity, Maturity Models, Digital Transformation, Industry 4.0) are aligned to promote the business success (organization excellence).

Even with a clear relation between the digital and the business perspectives, DT and the raising of an organisation's digital maturity is not something that can easily and rapidly be implemented (Fletcher & Griffiths, 2020).—According to these authors it is clear that organisations must improve their digital maturity, that less digitally mature organisations are more fragile and finally that organisations with higher levels of digital maturity are generally more flexible. The same authors concluded that digitally mature organisations recognise that external change is an ever-present aspect of doing business and have made themselves sufficiently able to respond rapidly and strategically. The study of Zapata et al, (2020) pointed that organizations feel that they do not have the elements to define their current state of their transformation journey, it seems important to pinpoint that digital maturity models already existent, as well as the elements included in those models. The identification of the most relevant elements to measure digital maturity in SMEs is presented as a crucial goal.

3. CRITICAL FACTORS TO ANALYZE DIGITAL MATURITY IN SME

In order to identify the critical factors for Digital Maturity, we will present an overview on digital maturity models. By doing this research it was easily realized that there are at least 3 categories that can be found in the literature: 1) Digital Maturity Models; 2) Maturity Models for Industry 4.0; and, 3) other elements identified by some authors that result from a literature review. These elements were presented in researches on digital maturity but those researches did not suggest any maturity model.

Table 1. Dimensions considered by different models and authors on digital transformation and Industry 4.0

Model	Dimensions	Reference
Digitalization (Digital Transformation) Models		
The Digital Maturity Model 4.0	Culture; Organization; Technology; Insights - each dimension is evaluated by 7 items.	(VanBoskirk, 2016)
Digital Maturity	Customer (4 items); Strategy (7 items);	(Delloite, 2018)

Model	Dimensions	Reference
Model	Technology (7 items); Operations (6 items); Organization and Culture (4 items).	
Maturity Model of Digital Transformation (Education Organizations)	Infrastructure; Strategy and Leadership; Organization; Employees; Culture; Educational Technology. These dimensions were measured by 27 items that were allocated by the authors.	(Ifenthaler & Egloffstein, 2020)
Industry 4.0 Models		
The Connected Enterprise Maturity Model	All aspects of Operations Technology and Information Technology	(Rockwell Automation, 2014)
IMPULS Industry 4.0 Readiness	Smart Products (2 items Smart Operations (4 items); Smart Factory (4 items); Strategy and Organization (3 items); Employees (2 items); Data driven services (3 items).	(IMPULS; IW CONSULT; FIR - RWTH, 2015)
Industry 4.0 Self-Assessment	Business Models, Product & Service Portfolio; Market & Customer Access; Value Chains & Processes; IT Architecture; Compliance, Legal, Risk, Security & Tax; Organization & Culture.	(PWC, 2018)
Acatech – Industrie 4.0 Maturity Index	Development; Production; Logistics; Services; Marketing & Sales. Each dimension is evaluated by 4 items.	(Schuh, Günther; Anderl & Gausemeier, Jürgen; ten Hompel, Michael; Wolfgang, 2018)
Maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises	Strategy; Leadership; Customers; Products; Operations; Culture; People; Governance; Technology. These dimensions are analysed by a total of 62 items.	(Schumacher, Erol, & Sihm, 2016)
Digital Maturity Factors (no model suggested)		
Digital Maturity (no model proposal)	Strategy; Leadership; Products; Operations; Culture; People; Governance; Technology.	(Brown & Brown, 2019)
Factors enabling Digital Maturity	Shared Digital Vision; Shared Transformation Vision; Internal Communication of Digital Vision; Perceived Impact of Digital Technologies on Business Models; Employee Training; Recruitment.	(Salviotti, Gianluca; Gaur, Aakanksha; Pennarola, 2019)
How to Measure Digitalization	All of the models studied offer a number of different dimensions to describe the target domain. Most common: customer experience, operational processes, business models and digital capabilities.	(Thordsen, Murawski, & Bick, 2020)
Requirements for	Finance, technical resource availability;	(Mittal, Khan,

Model	Dimensions	Reference
Smart Manufacturing	specialized product; standards; organizational culture; employee participation, alliances and collaboration.	Romero, & Wuest, 2018)
Pillars of Digital Transformation	Strategy and Vision; People and Culture; Process and Governance; Technologies and Capabilities.	(Kó, Andrea; Fehér & Szabó, 2019)

From an extensive literature review, Mittal et al (2018) identified 8 Maturity dimensions and 24 items firstly presented by Schumacher et al (2016), that could be listed in the previous table, however, these dimensions and items, are interesting to sum up the dimensions and items that were identified along this literature review. Moreover, the dimensions pointed by these authors are important from a SME perspective: Strategy, Leadership, Customers, Products, Operations, Culture, People, Governance and Technology. From Table 1 it is possible to conclude that there are already several attempts to measure maturity in terms of DT of their positioning in the Industry 4.0 path. It is possible to realize that there are different approaches, some science based, and some others from a consulting perspective. What is generally accepted is that most of them are suggested in a self-assessment model, and this model may also be a justification for the barriers presented by Zapata et al (2020). Anyway, this path must be done by large organizations as well as by SME (Toanca, 2016).

The main dimensions that are present in different maturity models, and are also pointed out by the literature as key factors to be considered are:

- **Technology** – Current level, and adoption necessities;
- **Organizational Culture** – In particular the vision, customer orientation, and the openness to embrace digital transformation;
- **Operations/Logistics** – The processes that are being performed, how it is done, how to optimize it;
- **Organization** – Can be related to organizations’ strategy, culture or employees’ competencies. It varies in different models;
- **Strategy** – This dimension is a global one, it is related with organizational culture, leadership, business model, among others. Organization must adopt a strategy that promotes digital transformation;
- **Employees** – Their competences and abilities, the openness to embrace change
- **Products** – The type of products offered, the level of personalization, the customer intervention in product development
- **Leadership** – The example, the commitment, and the support to employees on digital transformation;
- **Customers** – The type of relation, communication and interaction
- **Business Model** – The way the organization is organized (the internal and external strategy) for digital transformation;
- **Marketing** – Related to the Customers’ dimension;
- **Production and Processes** – Related to Operations’ dimension;
- **Governance** – Related to Employees’ dimension.

The factors to be included in a maturity model must take into consideration the environment, and the specific characteristics where the model will be implemented. In order to define the dimensions of a digital maturity model, Thordsen et al, (2020) suggests a conceptual research method using for instance interviews. This approach will lead to a more effective model to measure the maturity levels and to identify the next steps. In other words, it seems that the

definition of a maturity model, should consider both the factors that are generally accepted as valid measurements, and then it must be validated previously to the model application.

Even being important the adoption of strategies to implement digital technologies, there are some constraints mainly to SME, that were identified: financial, knowledge and technology awareness limitation (Masood & Sonntag, 2020). Another barrier identified by Ingaldi & Ulewicz (2020) was the lack of specialized support in obtaining new technologies. Ulas (2019), in a research on Turkish SME, identified several obstacles for DT. Some were already identified such as budget deficiencies, impossibility of investment due to high investments and operational costs, inability to understand internet technologies, or insufficient information regarding digital standards. Some other barriers identified by the author are: data security, privacy concerns, technological developments, unawareness of the benefits of digitization, or lack of qualified employment. An important and not mentioned issued up to now, is related to the actual status of many organizations. According to (Ulas, 2019) *“while many SMEs have increasingly realised that the internet is a key to success, in many cases they still don’t have a website that can be viewed on a smartphone”*. This conclusion reinforces the need to promote digital knowledge, in particular among the internal resources. This training is mandatory, because as argued by Ingaldi & Ulewicz (2020) it should be remembered that Industry 4.0 (and we include here digital transformation) is not only about technology, but also about new ways of working and the role of people in industry. *“Digital transformation, or digitalization, goes beyond product and process improvement, to affect business models, organizational and management aspects and entire supply chain processes, creating significant challenges for companies”* (Bleicher & Stanley, 2016).

4. CONCLUSION

From the research developed, it is possible to present some findings that are not an end of the research, but a starting point to develop a model to analyze and promote DT in SME. Previously to the digital factors, it was verified that digital transformation is a survival strategy for organizations in order to keep competitive in the global market. The digital evolution promotes efficiency, cost reduction, customer proximity, among other competitive advantages. This transformation and processes automatization are strongly related with on-time data and information, that promotes the knowledge-based organizations and economies. One common way to assess and evaluate how organizations are dealing with DT is the use of maturity models. These models have been around for a long time to position the organization in the path to achieve excellence. It was verified that there are several models to measure the digital maturity of organizations, or their maturity in terms of industry 4.0. Considering that SMEs, due to their size, lack of resources (namely financial and knowledge), or other limitations that their larger incumbents do not face, we tried to identify the most relevant dimensions that an SME should consider in order to assess its current position and path to be done, to reach digital maturity.

From the literature review there are dimensions that are present in different maturity models, and are also pointed out by the literature as key factors such as: Technology, Organizational Culture, Operations/Logistics, Strategy, Employees/Leadership, Products, Customers, Business Model, Marketing, Production and Processes and Governance.

Besides the most important dimensions to be addressed on what regards digital maturity analysis, it were also identified the main barriers to digital transformation. Those barriers are: financial, knowledge and technology awareness limitation, lack of specialized support, security (cyber) issues, unawareness of the benefits of digitization, and lack of qualified employees. The low levels of digitalization that exist in many organizations, in particular SME, together with the

barriers previously identified are also a significant constraint to the development of digital transformation.

As final remark, it can be stated that the main areas (dimensions) to act are identified, the main constraints are also identified, the models are already available, but all of this must be adopted according to the existing environmental conditions.

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