Technology as Driver, Enabler and Barrier of Digital Transformation: A Review

Vasilis Tsiavos[1(✉)] and Fotis Kitsios[1,2]

[1] Department of Applied Informatics, University of Macedonia, Thessaloniki, Greece
vtsiavos@uom.edu.gr, kitsios@uom.gr
[2] School of Social Science, Hellenic Open University, Parodos Aristotelous 18, 26335 Patras, Greece

Abstract. In recent years, organizations and researchers have become increasingly interested in digital transformation. Technology has found its way into the lives of customers, but at the same time is disrupting industries by enabling organizations, that have embraced it, to gain more and more competitive advantages. However, technology is only one factor of a successful digital transformation strategy, where culture, management, human resources etc. also play an important role. While digital transformation has been researched over the years from multiple points of view, limited studies have focused in detail on the impact of technology on digital transformation. Questions such as how fast an organization should adapt to the evolution of technology, which technologies should be preferred and finally, in which cases technology might delay the digital transformation process, remain unanswered. The present paper aims to fill this gap by conducting a systematic literature review of 74 related articles, based on the Webster & Watson methodology, followed by a concept analysis of technology related themes in digital transformation. The results of the analysis reveal that technology does not only act as an enabler or driver of digital transformation, but can also be a barrier of it. While we contribute with our paper to the research body in digital transformation, at the same time, we identify potential research gaps that leave space for further investigation.

Keywords: Digital transformation · Technology · Industry 4.0

1 Introduction

We live in a rapidly moving world where entire industry sectors are being disrupted by digital technologies. Organizations in a multitude of industries are experiencing the impact of digital technologies that are continuously transforming their external environment regarding customer expectations and competition. This trend, called digital disruption, is altering the rulebook of business [1, 2]. Digital transformation is about how companies manage to respond to this new reality created by digital disruption [32]. It is likely that companies that will fail to adapt to the new digital reality will become

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victims of "digital Darwinism", where established firms may disappear and only those firms that are more adaptable and responsive to technological trends will survive and remain in this new competitive landscape. [3, 4].

The digital transformation of an organization is a complex process that starts with the awareness that a digital transformation is needed followed by a detailed digital strategy along with the identification of potential barriers. The formulation of a digital transformation strategy must consider, besides the technological factor, also shaping a digital culture and other factors [1, 2, 5, 9]. Although, technology is undoubtedly at the heart of digital transformation, little research attention has been paid on how in detail technology impacts digital transformation.

The goal of this paper is to reveal important aspects of the contribution of technology to digital transformation, through a systematic literature review. Seventy-four articles were reviewed based on the Webster and Watson (2002) [10] methodology. Digital transformation is a challenge for companies all over the world and technology, which is a key pillar of it, requires careful attention as it is constantly evolving. Hence, it is necessary to capture the current level of research on the technology's impact on digital transformation.

This paper is structured as follows: Sect. 2 outlines the methodology we used to conduct the literature review. The results of the analysis of the articles are discussed in Sect. 3. Finally, in the last section we state our conclusion and provide suggestions for future research.

2 Methodology and Data

We followed the systematic literature review process, as introduced by Webster and Watson [10]. It is a three-stage process: 1) The current literature reviews were examined to identify databases and keywords. 2) This was followed by an extensive backward search to examine citations and forward search to identify citations of the selected articles. 3) Finally, all articles were classified by concept based on their content and potential research opportunities were identified.

2.1 Previous Literature Reviews

To the best of our knowledge, no current literature review has exclusively addressed the technological aspects of digital transformation but has researched the phenomenon by studying a wide range of factors affecting it. There are, however, existing literature reviews that place greater emphasis on digital technology as an important factor of digital transformation (Table 1).

Pihir et al. (2019) [12] point out that the concepts of business innovation and agility in change management, are equally important as technologies. They list the technologies that are important for the digital transformation process of a business and emphasize on the fact that technologies evolve over time following a technological life cycle. Vial (2019) [11] argues that digital technologies allow for new forms of collaborative working between distributed networks of different actors and offer an enormous potential for

Table 1. Previous literature reviews

Authors	Year	Title	Methodology	Findings
Pihir et al. [9]	2020	Digital transformation playground - literature review and framework of concepts	2 Databases 528 Articles Quantitative Analysis 10 most cited Articles Qualitative Analysis	Business innovation and agility are as important as new technologies. A list of current technology trends is presented
Vial [11]	2019	Understanding digital transformation: A review and a research agenda	3 Databases 282 Articles	Technologies can be classified according to categories. Technologies are often source of disruption

innovation and organizational performance. He supports that technology can be classified under the acronym "SMACIT" (Social, Mobile, Analytics, Cloud, IoT). However, what existing literature reviews did not manage to address, is when an organization should respond to the evolution of technology, which technologies should it utilize on priority and how failing to adapt to technological advances in time, affects its digital transformation efforts.

2.2 Article Selection

The articles were retrieved from the Scopus and Web of Science databases using combinations of the keywords digital, transform, industry 4.0, business strategy etc. in the title, keyword and abstract fields. All articles were published in peer reviewed journals and conference proceedings. No constraints were imposed on the year of publication.

In total 2276 articles were gathered by searching for the above keywords. After applying the language, source and category restrictions in 510 articles were left. The remaining articles were examined for their contents, which resulted in the exclusion of 236 articles based on their title, 139 articles based on their abstract and 71 articles based on content. Thereafter, 3 duplicate articles were removed, leaving a total of 61. To these 11 articles were added from the backward search and 2 articles from the forward search. This yielded 74 articles for analysis (Fig. 1).

The search was completed when repeating articles for the various keyword combinations were found. Consequently, the critical number of articles had been obtained [10].

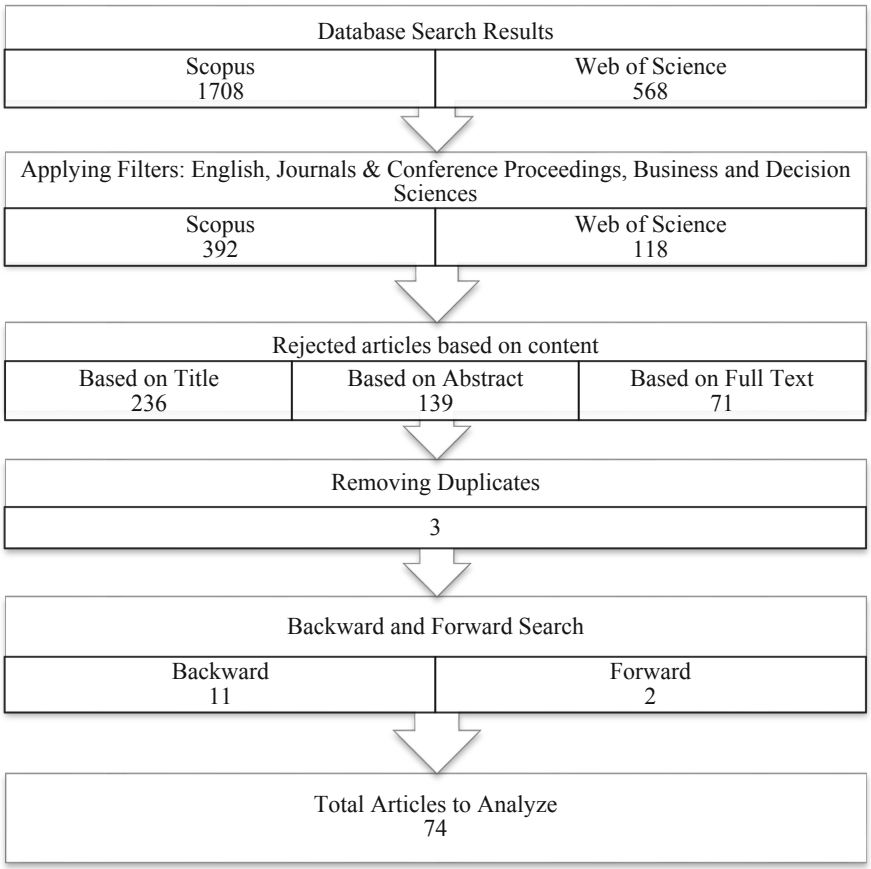

Fig. 1. Article selection process

2.3 Classification Framework

Seventy-four articles were analyzed using a classification framework. All articles were classified into 3 broad concepts (Technology as driver of digital transformation, Technology as enabler of digital transformation, Technology as barrier of digital transformation), that will provide a better understanding about the role of technology in digital transformation and aid future researchers to expand the related research body.

3 Results

3.1 Technology as Driver of Digital Transformation

Beyond competition, an organization is subject to pressures from external touch points, such as with customers or suppliers that require it to adapt to their level of technology, but also to improve its internal processes to support this adaptation. Customers

nowadays intensively use digital technology, live and move digitally, while demanding from every company a customer value proposition and a service via new digital communication channels and at increased speed [13–19]. Therefore, firms are forced to adopt technologies that allow immediate and fast communication with the customer [6–8]. In the same sense, the concept of disintermediation has emerged in recent years, where companies that used to sell services and products through middlemen, e.g. airlines through travel agencies, have built entire technological infrastructures to process and support direct customer sales [20]. Similarly, supplier technology infrastructures are pushing businesses towards a technological revamp and digital transformation. The need for production forecasting is driving many suppliers to install supply chain software and end to end monitoring systems. Therefore, the development of a corresponding technological infrastructure and processes by their customers for proper communication with the supplier is imperative [14]. This requires alignment between the supplier and the firm in terms of the supplier's IT strategy, which needs to be factored into the firm's digital transformation efforts.

The new technologies needed for a firm to interact with its externals touch points and to face competition, also lead to the adaptation of new digitally supported internal processes that shape the firm's digital value chain [16, 21].

The above processes and interactions produce a fair amount of data, which requires new technological infrastructure, usually cloud based, for data analysis and storage [14, 22]. Beyond data storage and analysis, complex technological infrastructure and data protection legislation, also require investments in security [23–25]. However, while organizations are generally positive about the changes brought by technological developments and the competitive environment, changes imposed by regulatory frameworks are viewed negatively [26].

3.2 Technology as Enabler of Digital Transformation

In our literature review, we identified the wide variety of technologies referred to by scholars. The most frequent references are to Data, Cloud, IoT, artificial intelligence, as well as fast communications and 5G. The technologies of 3D Printing, the use of APIs, Augmented Reality, Blockchain, Analytics, Product Platforms, Robotics Automation and SOA Architecture are also referred to (Table 2). While Pihir et al. (2020) also lists a subset of our findings, he stresses the fact that technologies preferences change over time and follow a "technological life cycle" [12] In our research, however, we have not been able to identify what the speed of the adaptation to the life cycle of the evolution of technology should be and whether it varies according to the industry in which the organization operates.

Table 2. Technologies enabling digital transformation

Technologies	References	Technologies	References
3D Printing	[27–30]	Digital Analytics	[31, 33]
AI Artificial Intelligence	[16, 28, 29, 34–40]	Fast Communication & 5G	[21, 37, 40–44]
APIs	[45, 46]	IoT-Smart Connected Products	[14, 28–30, 34, 36, 38–40, 42, 43, 47, 50]
Augmented Reality	[27–29]	Product Platforms	[29, 51–53]
Data, Big Data, Effective Data Management	[14, 16, 22, 24, 28–30, 34–42, 44, 46, 48, 54–59]	Robotics Automation	[29, 37, 42]
Blockchain	[28, 51]	Services Oriented Architecture SOA	[24]
Cloud Computing	[14, 24, 28–30, 34, 38, 44, 47, 48, 50, 55]		

It is noteworthy that many scholars mention that the use of technologies also requires an IT strategy in full compliance with business objectives and the use of appropriate software that exploits these technologies [24, 60–69]. Firms which choose to develop their own software, should adopt the agile process [29, 35, 40, 70] to quickly adapt to requirement changes and, if they offer digital products and services, reduce time to market.

3.3 Technology as Barrier of Digital Transformation

While technology is best known as an enabler of digital transformation, we found that many researchers emphasize another facet of technology as barrier of digital transformation. A number of researchers stressed the issues of the incompatibility of preexisting technological infrastructure and monolithic legacy or inflexible "tailor-made" software with modern one and its lack of integration. Conventional monolithic architecture does not meet the demand for scalability and rapid development. A scalable IT architecture needs to be implemented using APIs, based on a microservices architecture and integration, both within the company and for the interaction with external partners [45, 71–73].

Moreover, a frequent issue that hinders mainly industrial sectors in the context of Industry 4.0 and the use of IoT, is the lack of high-speed communication networks and broadband infrastructure as well as missing unified communication protocols which are needed for Industry 4.0 technologies integration of systems, both inside and outside the organization [22, 49, 74].

Another significant challenge is the risk involved with IT security and data protection, where many organizations find it difficult to accept the risk of implementing new technologies and the costs involved [34, 75].

Our literature review with the concept analysis of 74 articles, has given us solid ground for a theoretical model, which is visualized below (Fig. 2).

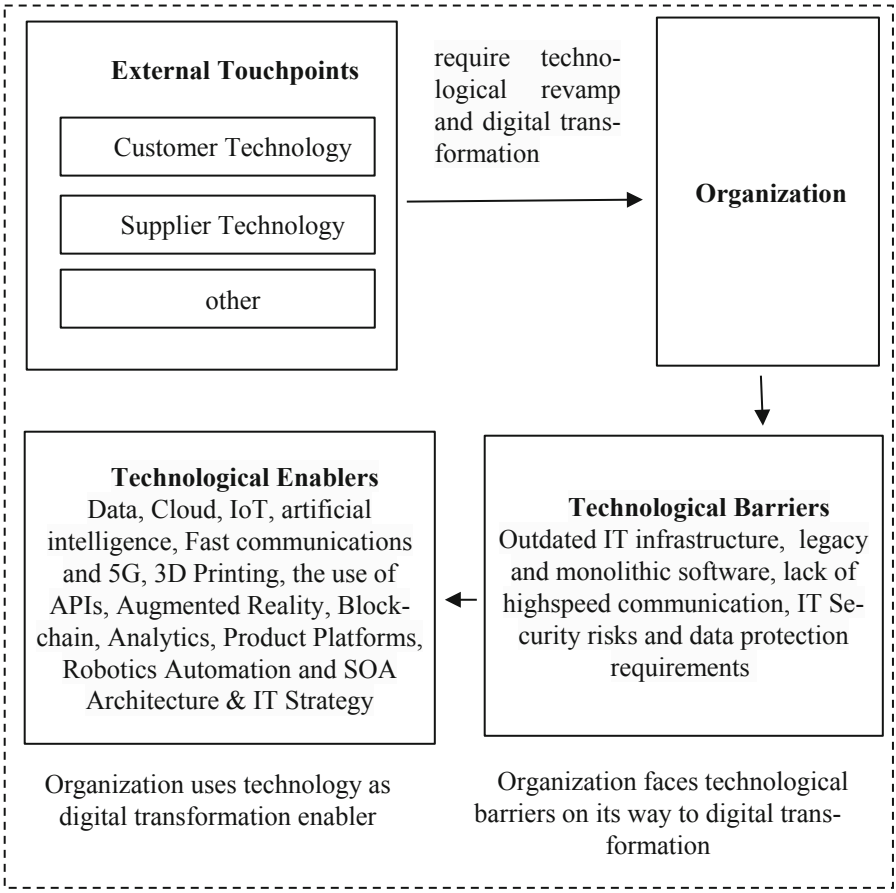

Fig. 2. Theoretical model

As illustrated in the figure above, an organization is influenced by actors at its external touch points, such as customers and suppliers and the technology they use. The organization must decide how to adapt, by upgrading its technology and adjusting its digital transformation strategy. In this endeavor it may face obstacles, such as outdated technological infrastructure, lack of broadband communication, but also issues related to IT system security and the data protection regulatory framework. The organization, after overcoming these obstacles, is leveraging modern technologies as enabler on its way to digital transformation. As evidenced in our research, it is important that this process flow is considered when designing a digital transformation strategy.

4 Conclusion

The purpose of this paper was to examine the role of technology as a driver, enabler and barrier of the digital transformation of an organization. We conducted a literature review,

based on a specific methodology, as it has been frequently used previously to explore information systems strategy and digital transformation topics [10, 76]. Although our paper discusses an essential factor of digital transformation, existing literature reviews haven't analyzed it in detail.

Our research has revealed that technological developments in a firm's environment often force it to technological upgrades and, in essence, to digital transformation. It is no longer an option, but an immediate requirement for the business to be able to interact with its environment and comply with new regulatory frameworks. At the same time technology has been repeatedly highlighted as a key enabler of a company's digital transformation. Thus, specific technologies are distinguished in terms of their frequency of use. In any case, the technologies applied must be part of an integrated information systems strategy.

The evolution of technology itself often requires frequent updates and optimization, as the use of outdated technology or missing technology makes it difficult for a company to advance and introduces security risks that act as barriers to its digital transformation. The contribution of this paper is significant for both scholars and practitioners in the field of digital transformation. Managers are given insights into the positive and negative contributions of technology in forming a digital transformation strategy, so that they will be able to better estimate risks and benefits in their endeavors. Scholars can use this work as a motivation for their own future studies and build on our findings and the research gaps we identified and propose as future research topics.

We are aware that our research has limitations. Although we searched for multiple combinations of "digital transformation" and related keywords, there still might be articles referring to digital transformation without having the term, or variations of it, in their title or abstract. Additionally, we limited our search to business related publications which excluded more technical papers. Moreover, we only examined papers written in English, which excluded articles in other languages that contribute to current research.

Our analysis focused on how external touchpoints of an organization with customers and suppliers impact its technological progress, future studies are recommended to investigate how external touchpoints with other actors, such as the government and its technology (tax collection, social security etc.) impact a firm's technological requirements. While we conducted a cross-industry analysis of the most frequent technologies used, future research might find it useful to classify existing technologies and their use, based on industry.

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