

THE IMPACT OF SCIENTIFIC RESEARCH CENTERS ON DIGITAL TRANSFORMATION AT EU LEVEL

Maxim CETULEAN*

Doctoral School of Economics I, Bucharest University of Economic Studies, Bucharest, Romania

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Abstract. The global digital transformation increases availability and integrates digital technologies into all economic activities and at all business levels. Thus, digital transformation has evolved from a competitive advantage to a current necessity. The role of scientific research centers in the field of digital transformation is to guide a society in the implementation of this transformation, to find the most reliable, flexible, efficient solutions and methods to deploy, implement, and use it. This study aims to examine the relationship between the activity related to the digital transformation of scientific research centers and The Digital Economy and Society Index (DESI) in the European Union. For this analysis, a bibliometric analysis is used, based on the Web of Science database, the number of researchers and articles on digital transformation. The results will be correlated with the level of digitalization in EU economies, considering the value of the DESI for EU countries.

Keywords: research centers, digital, DESI index, EU, impact.

JEL Classification: O32, O33, O14.

Introduction

The basis of the evolutionary course witnessed by the whole of humanity and the results we enjoy now are due to the four great industrial revolutions. Today's technological progress is the engine that makes us think faster, more agile, and more efficient to face future challenges (Schwab, 2016). Digitization, digitization, and digital transformation, which are part of the fourth industrial revolution, are characterized by the use and implementation of sophisticated technologies in the information field. The latter are often difficult to implement due to high costs and the need for trained human capital in this field (Borowiecki et al., 2021).

Digitization, digitalization and digital transformation, although they have many common elements, represent three different processes with different chronological stages, which practically formed and favored the rise of industrial revolution 4.0 (Mikalef & Parmigiani, 2022).

An important factor highlighted by every industrial evolution is the need for labour force and institutions that have the ability to implement new inventions in the real sector of the economy. The digital

transformation, seen as a revolution, aims to achieve sustainable economic growth, full employment of the workforce, and the provision of equal opportunities between generations (Iersel, 2011; Martens, 2010). However, the level of digital transformation varies from country to country, both in terms of development and the speed of incorporation of digital technologies into European economies. These differences are largely due to both the high implementation costs and the broad impact of the digital transformation on all sectors of the economy.

The digital transformation process has radically changed the course of the economy, changed the conditions of the games in the markets and the concept of competition. Due to this fact, many researchers, both theorists, and practitioners, have turned their attention to the optimization of processes within companies and private entities. This transformation process has also brought the concept and competition in the business environment to a new level, thus the subordinates within the companies had to implement information technologies within the organizational processes. As a chain effect, these changes have also left their mark on other sectors of the economy, forcing

* Corresponding author. E-mail: maximcetulean@gmail.com

them to implement information technologies in their sphere of influence as well. In this way, we can observe consistent changes, which can be studied from the perspective of four areas: human capital, connectivity, the integration of digital technologies, and digital public services.

However, we can observe significant differences in the level of digital transformation between countries. Various indicators have been developed to measure the impact of digital transformation in each country and even at the level of each field and sphere of the economy. At the level of the European Union, the Digital Economy and Society Index (DESI) was introduced, which aims to transpose the state's development stage or other specific aspects in this field as a percentage.

As highlighted previously, this evolution requires the training of specialized human capital in the field of information technology, with research and development centers specialized in this field. Thus, in this paper, we aim to identify the relationship between specialized research centers and the level of development of European economies regarding digital transformation.

The objective of this paper is to identify the impact of scientific research centers by determining the largest centers in the European Union and understanding the future directions of research in the given field.

The paper is organized as follows:

The first chapter is dedicated to a review of the literature, which aims to identify trends and the current state of knowledge. The second chapter describes the methodology that was the basis of the research. The third chapter, dedicated to analysis, provides a clear picture of the most important research centers, current research directions, and the correlation between research publications of digital transformation topic and the DESI Index. Finally, the conclusions related to the research are presented.

1. Literature review

The development of the modern economy is largely based on digital transformation processes. The creation of a global internet network, the increase in the number of scientific research and development, and the popularization of mobile communications are just some of the factors that contribute to the transition of the economy to a digital format.

In the context of the transition to a new technological order, the development of the digital economy is being updated. Digitization has affected the political, economic, cultural, and other spheres of society. The digital transformation has a colossal impact on the evolution and development of the world economy. This brings to the fore numerous benefits, such as the optimization of management processes, the reduction of time for the development of some technological processes, access to information in real-time, the increase of productivity, and

others (Lundvall, 2016; Martín-Pena et al., 2019; Nambisan et al., 2019; Salvi et al., 2021; Kolomiets & Glushach, 2017).

In addition to benefits, digital transformation also brings a certain degree of uncertainty (El Hilali & El Manouar, 2019; El Hilali et al., 2020). Thanks to this industrial revolution, practically, humanity is subject to rethinking traditional processes and future sustainable development strategies.

In numerous works, we find different definitions of digital transformation, which provide us with an ambiguous framework regarding the future evolution of digital transformation (Van Veldhoven et al., 2019). The latter is due to the extent to which this phenomenon has affected the real economy. Hence, it is difficult to identify a coherent explanation and a clear direction for the development of this field (Goerzig & Bauernhansl, 2018; Haffke et al., 2016; Morakanyane et al., 2017). Thus, numerous theoretical researchers, as well as practitioners, approached the digital transformation process differently from a conceptual point of view. Thanks to this fact, we can observe different models and guidelines regarding the implementation of digital technologies, both at the level of companies and at the level of regions or countries (Vial, 2019; Henriette et al., 2015).

The most important achievements of digital transformations can be identified at the company level. The adoption of digital transformation has a positive impact on the performance of small and medium-sized enterprises (SMEs), leading to increased productivity and output of employees, and improvements in operational efficiency and cost reduction. This requires changes in the management of SMEs. Implementing digital technologies and skills leads to a significant increase in productivity at the company level. Studies indicate that there are additional productivity gains in manufacturing sectors and sectors with high routine task content, as they have high potential for automation (Gal et al., 2019; Hai, 2021; Kraft, 2022; Mosiashvili & Pareliussen, 2020). The latter outlines the urgent need for research centers, which within companies are called development centers and research centers (R&D). Research and development (R&D) centers play a crucial role in advancing scientific knowledge, developing new technologies, and improving products and services.

Overall, R&D centers are important because they drive scientific and technological progress, which can have far-reaching benefits for society. Through research and development, R&D centers can help us to solve some of the world's most pressing challenges, improve our quality of life, and create a more prosperous and sustainable future.

At the time when information technology became a strict necessity in the activities of companies, it quickly exceeded the limits of the business environment and affected other sectors of the economy. Thus, there are currently relevant studies on the impact of digital transformation on financial performance, the environment,

health, employment, and other relevant areas of the economy (Zhou, 2021).

To quantify the progress of the digital transformation, the Digital Economy and Society Index (DESI) was designed (Moroz, 2017). The DESI indicator allows us to analyze the evolution of European countries from the perspective of the development of the digital economy and society. Although the digital transformation has spread globally, significant differences exist regarding the level of integration of information technologies at the country level. Hence, the DESI indicator helps identify the level of transition of a country to the digital economy, by identifying the sectors to be prioritized and evaluating the dynamics of change in time and space. In 2015, the DESI Index was designed to generate an overview of European economies, by identifying the sectors to be prioritized to achieve a digital market and improve productivity (Stoica & Bogoslov, 2017).

This transformation highlights the urgent need to adopt cultural changes that require new educational competencies to provide people involved with new skills and knowledge (Jeladze & Pata, 2018). For these reasons, in this complex process, there is a need to develop research centers and scientific works. Scientific research is designed to develop something new. Scientific works are the theoretical basis, a kind of “training” for new technologies and inventions. With the help of the results of such projects, scientists can create goods and products of the best quality at the lowest cost, new methods of treating diseases, ways to resist natural disasters, etc. Every scientific research has its own value. This criterion is expressed in the theoretical or practical significance of the project, its novelty (Zeferino de Menezes, 2020; Ross, 1962; Mickens & Patterson, 2016).

In the era of digital transformation, scientific research is one of the industries whose operations are transforming the structure of the economy in favor of knowledge-intensive industries. Thanks to new technologies, researchers have gained access to new effective tools for analysis and study, opening up new horizons and possibilities. Additionally, in a favorable environment with effective tools, researchers can develop new strategies and models that make processes in the global economy more efficient (Sanchez, 2017; Salminen et al., 2017; Savastano et al., 2019; Schluter & Sommerhoff, 2017; Turkeli & Schophuizen, 2019).

2. Research methodology

Using bibliometric indicators, this study identified highly productive authors, source titles, documents, and organizations in the field of digital transformation between 2017 and 2022. The researchers analyzed 3826 scientific publications from the Web of Science database using VOS viewer software and Excel to establish correlations between the number of researchers by the country of origin and the DESI indicator. To accomplish their research objectives, we used content analysis, a bibliometric analysis method, employing VOS viewer software to conduct

the analysis. Bibliometric analysis involves quantitative analysis based on article similarity in a bibliographic database and has grown in popularity (Almajali et al., 2022; Al-Okaily et al., 2021).

The research is focused on digital transformation due to its current and controversial nature as reflected in the articles included in the Web of Science database. The study analyzed 8357 articles on digital transformation and used analytical assessment of articles linking context after synthesis and statistical procedures to determine the papers, documents, authors relevant to digital transformation. We also used VOS viewer software to generate graphical representations of the results. VOS viewer is a software tool that creates and visualizes bibliometric networks, allowing users to analyze key terminologies in various journals and publications by researchers.

The software categorizes viewers based on co-citation, co-authoring relations, or bibliographic connection and visually distinguishes and clusters data derived from the Web of Science. Additionally, it provides map assistance to represent important information. The paper aims to investigate the correlation between published articles used in the field of digital transformation between 2017 and 2022, allowing for the observation of changes in perception over time. We also selected 2017–2022 as the time interval.

In order to describe the correlation between research centers and evolution of digital transformation phenomenon, we used data from Eurostat on the Digital Economy and Society Index (DESI). The DESI index is a combination of different measures that monitor how much progress an economy has made in terms of digital transformation.

These measures include factors such as access to the internet, education and skills of the population, the extent to which digital technologies are used, and the availability of online public services. We can analyze the impact of a country’s digital transformation by utilizing the DESI index.

For this research we have used DESI composite Index.

The database used to establish the connection between the development of scientific research centers and digital transformation phenomenon consists of two main components. Firstly, the Composite DESI index, which represents the average score of the European Union (EU) in 2017 (33.7%), 2018 (35.9%), 2019 (38.6%), 2020 (41.7%), 2021 (46.2%), and 2022 (52.3%), obtained from the EUROSTAT database. Secondly, the WebOfScience database was used to quantify the growth of scientific research centers by analyzing the number of scientific articles published by European researchers in 2017 (135), 2018 (328), 2019 (558), 2020 (1056), and 2022 (1050).

3. Analysis and findings

Digital transformation is a complex process that involves leveraging digital technologies to transform business operations and customer experiences. The aim is to

optimize processes, improve productivity, reduce costs, and enhance the overall customer experience. The process of digital transformation is not just about implementing new technologies but also involves changing organizational structures, processes, and culture to align with the digital landscape.

By utilizing the analytical features provided by the WebOfScience database, we categorized scientific publications based on their subject areas. As a result, we were able to pinpoint the primary topics and research directions that scholars pursue when investigating the digital transformation process.

The categories were weighted as a percentage according to the number of publications in the category and the total number of published works

One of the key research areas in digital transformation is the role of leadership in driving digital transformation initiatives. Therefore, researchers are focused on management, business and computer science Information Systems (see Figure 1).

This is because many organizations require large amounts of information to function effectively. Without the aid of information technology, these management processes would become sluggish, resulting in reduced competitiveness in the markets where these companies operate. Scientific research on digital transformation is essential to understand the impact of digital technologies on businesses, economies, and society as a whole. This research seeks to explore the factors that drive digital transformation, identify the challenges organizations face during the process, and develop effective strategies to manage and implement digital transformation initiatives successfully.

Then analyzing articles dealing with digital transformation, we refined materials from the WebOfScience database, and the only articles that were considered were those incorporating “digital transformation” in the TOPIC (8357 results). The second step was the selection of only EU countries as a filter (4012). The last step of our processing method on WOS database, was the selection

of temporal interval to 2017–2022. To ensure the most relevant results are identified, non-related articles were filtered out until a total of 3826 articles remained. The picture shows a growing trend in publications of articles dealing with digital transformation (see Figure 2).

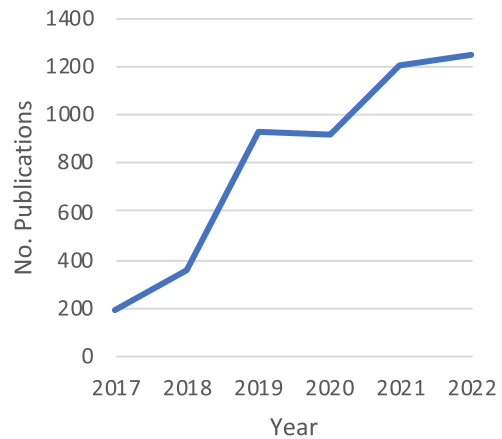


Figure 2. The number of publications on digital transformation on WebOfScience database (own computation)

To identify the most important scientific research centers in Europe, we used the VOS viewer program (see Figure 3).

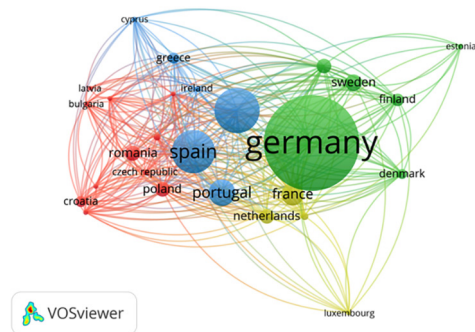


Figure 3. The scientific researcher centers across EU Countries (source: VOS viewer)

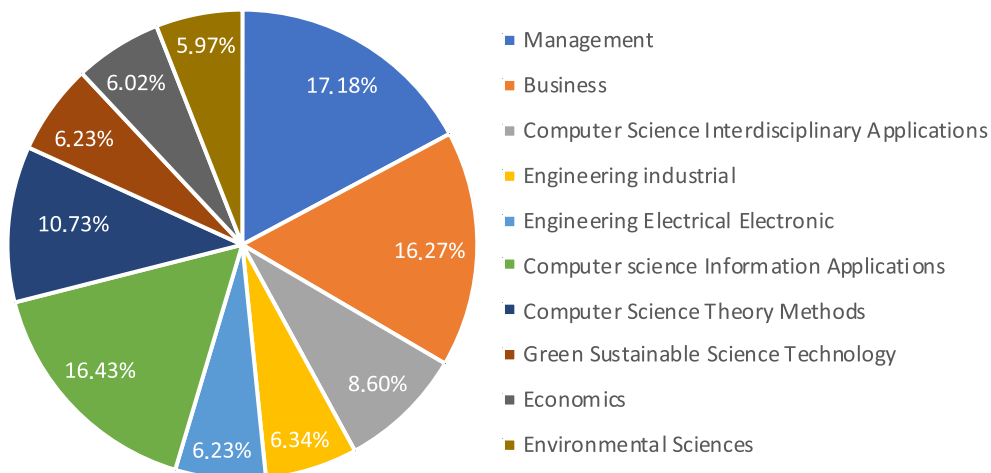


Figure 1. The sectors of interest on which the researchers focused (own computation)

Using VOSviewer, we pinpointed the primary research hubs in Europe, with Germany, Spain, Romania, and Portugal being among the most prominent. This is likely due to their robust technological infrastructures and strong governmental support. For example, Spain has implemented the Digital Transformation Hub program, which seeks to bolster digital technology development and foster collaboration between academia, industry, and government.

Using keyword filtering with the aid of VOSviewer, we identified 11 primary avenues of digital transformation (see Figure 4).

Therefore, researchers has also focused on the role of data and analytics in digital transformation. Data and analytics are critical for unlocking the full potential of digital technologies. With the rise of big data and analytics, businesses can gain valuable insights into customer behavior, market trends, and operational inefficiencies. This data can be used to optimize processes, enhance customer experiences, and develop new products and services. However, many businesses struggle with data management and analytics, which makes it challenging to realize the full benefits of digital transformation.

Another research area in digital transformation is the challenges faced by small and medium-sized enterprises (SMEs). SMEs play a critical role in the global economy, but they face unique challenges when embarking on digital transformation initiatives. SMEs often have limited resources, limited access to talent, and limited knowledge of digital technologies. This makes it challenging for them to compete with larger organizations that have more resources and expertise in digital technologies.

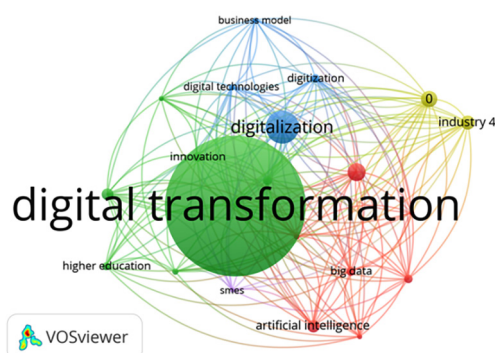


Figure 4. Bibliographic analysis of Key words (source: VOS viewer)

Overall, scientific research on digital transformation provides valuable insights into the challenges and opportunities of digital transformation initiatives. By leveraging these insights, businesses can develop effective strategies for implementing digital transformation initiatives and stay competitive in a rapidly evolving digital landscape.

- Develop a culture of innovation: A culture of innovation, experimentation, and collaboration is essential to drive digital transformation initiatives. Businesses must create an environment where em-

ployees feel empowered to experiment with new technologies and processes.

- Manage data effectively: Data and analytics are critical for unlocking the full potential of digital technologies.
- Develop new business models: Digital transformation often requires businesses to develop new business models that leverage digital technologies.
- Invest in reskilling and upskilling programs: The rise of digital technologies has led to the displacement of workers in traditional industries.

In order to quantify the impact of scientific research centers on the digital transformation at the EU level, we further used as variables the number of publications from each year and the DESI composite index value for the 2017–2022 temporal interval.

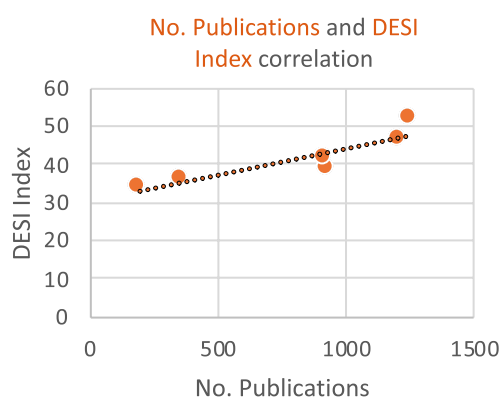


Figure 5. Correlation between DESI Index and No. of Publications (source: own computation)

In summary, the relationship between the evolution of digital transformation and the number of scientific articles on this domain may have a strong correlation (see Figure 5), there is likely a strong relationship between the two. Scientific research plays an important role in advancing the field of digital transformation, and the insights and findings presented in scientific articles can inform and shape the direction of future research and the development of digital technologies and practices.

Conclusions and discussion

Digital transformation is a complex process that involves leveraging digital technologies to transform business operations and customer experiences. The aim is to optimize processes, improve productivity, reduce costs, and enhance the overall customer experience. The process of digital transformation is not just about implementing new technologies but also involves changing organizational structures, processes, and culture to align with the digital landscape.

The digital landscape is rapidly evolving, and businesses need to keep up with the changes to remain competitive. The rise of digital technologies such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain has created new opportunities for businesses

to improve their operations and enhance customer experiences. However, implementing these technologies requires significant changes in organizational structures, processes, and culture.

Scientific research on digital transformation is essential to understand the impact of digital technologies on businesses, economies, and society as a whole. This research seeks to explore the factors that drive digital transformation, identify the challenges organizations face during the process, and develop effective strategies to manage and implement digital transformation initiatives successfully. This study has several limitations. Firstly, it is restricted to data collected from the WebOf-Science database, which limits the number of articles available from previous years. Secondly, the number of articles analyzed only includes those related to digital transformation, potentially excluding relevant research. Lastly, the correlation analysis used EU average indicators, including the DESI index, which may not accurately reflect the data.

Future directions of research should address these limitations by conducting a more comprehensive study, including data from multiple databases. Furthermore, a classification of articles by fields of interest and countries could provide additional insights.

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