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THE DIGITAL TRANSFORMATION OF ENTERPRISES AS A LEVER TO ENHANCE EXTROVERSION OF FOREIGN TRADE: THE CASE OF GREECE

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Abstract

Purpose: The present paper aims to capture the evolution of digital transformation in the sectors of the Greek economy, on the one hand. On the other hand, it investigates the existence of causal relationships between the extroversion of sectors of the economy towards foreign trade.

Methodology: Methodologically, by applying secondary research in international databases, indicators of digital transformation are extracted and certain indicators of the extroversion of the Greek economy are determined. By applying the method of multiple regression, linear correlation relationships between the examined variables are investigated.

Findings: The findings of the survey include: the improvement of the digital ranking of the Greek economy; and the improvement of extroversion in all sectors of the Greek economy, with stronger improvement in the sector of industrial products. Regarding the correlation between extroversion and digital maturity, indications emerge suggesting that digital transformation in the public sector can contribute to the development of foreign trade.

Originality: The contribution of this paper in terms of its originality lies in the fact that it fills the literature gap in the investigation of causal relationships between digitization and the extroversion of commercial sectors.

Research limitations: The limitations to this survey are the lack of data on digital

transformation by economic sector for each EU Member State, which occurs from the structural features of the index, and the time horizon of the sample, as the calculation of the indicator by the EU was introduced very recently.

Keywords: *Digital Transformation, Research & Development, Crises, Foreign Trade*

JEL Classification Codes: *O30, G01, F40*

1. Introduction

The unprecedented appearance of the COVID-19 virus and the subsequent outbreak and rapid transmission of the disease, which reached pandemic proportions, created suffocating pressures in all countries, and by extension also in Greece. This spread through health systems, supply networks and the business community, but also created a new reality for citizens. The measures implemented had direct and significant effects on all sectors of the economy and businesses. According to the international scientific literature, it is widely accepted that in cases of crises there are significant effects both on the main macroeconomic figures of an economy and on the terms of international foreign trade at a global level.

At both government and business level, there was an immediate effort to adapt to the new conditions through the use of innovative digital technologies and practices. The digital transformation has highlighted new trends in consumer behavior, the way businesses operate, working conditions and the services and daily lives of customers and citizens. In many countries, some changes seem to take on a more permanent character and are predicted to prevail in the long term, thus shaping a new reality in the social, economic, and business environment.

According to the international literature, strong research interest has been generated regarding mapping the digital situation and maturity of both the private and public sector, as well as the strategic decisions taken towards the digital transition. This article presents the concept of digital transformation as a practice in shaping business strategy, which seems to play a decisive role first in the survival and then in the growth of the financial data of businesses. Next, this paper attempts to investigate the degree of digital transformation of the Greek economy as well as to investigate causal relationships in the extroversion of the sectors towards foreign trade.

Specifically, the following research questions are investigated:

1. To what extent has digital maturity changed in the case of the Greek economy compared to the EU for the 2017–2022 period?
2. What is the change in intensity in Research and Development as a business strategy for the Greek economy in the 2017–2022 period?
3. How is the extroversion of businesses changing for each economic sector for the 2017–2022 period?

4. To what extent can the adoption of new digital practices in the Greek economy contribute to enhancing extroversion?

Methodologically, based on the international literature, secondary research is carried out using data from the Eurostat (European Statistical Authority), ELSTAT (Hellenic Statistical Authority), ECB (European Central Bank) and SEV (Hellenic Federation of Enterprises) databases. Indicators are extracted to capture the digital situation of the Greek business community (DESI); the extroversion of the sectors of the Greek economy (X/GDP) is determined by single-digit analysis (SITC1); the Greek reality in the field of Research and Development (R&D) by geographical classification (NUTS) is reflected; while linear correlation relationships between the examined variables are investigated through multiple regression. The results indicate the improvement of the digital ranking of the Greek economy and the improvement of extroversion in all sectors of the Greek economy, with the sector of industrial products to be further strengthened. In terms of the correlation between extroversion and digital maturity, there are indications that digital transformation in the public sector can contribute to the development of foreign trade.

In summary, this paper initially attempts to capture the current situation using the DESI digital ranking index for the case of Greece at the regional level, and then for the four additional synthetic indicators presenting comparative data for the rest of the EU Member States for the 2017–2022 period. Next, the degree of extroversion of Greece for the same period is extracted and analyzed and an attempt is made to investigate correlations between the country's digital ranking and the degree of extroversion. The results obtained provide elements that should be taken into account both by companies in the process of formulating their business strategy to enhance exports, and by the state in shaping the institutional framework for external relations and transactions. The novelty of the paper is that it provides quantitative data on the relationship between digital transformation and the extroversion of European countries, while these findings significantly increase our understanding of the impact of digital change on business activities and the shaping of the foreign policy framework.

2. Literature Review

Digital transformation is affecting corporate strategies, influencing business planning, innovation policies and marketing strategies, and steering the digital community along the wave of information technology (Verhoef et al., 2021). Evidence supports the hypothesis that global socioeconomic and market changes also force small and medium-sized enterprises' digital transformation. In addition, it can be assumed that the present speed of digital transformation is significantly influenced by the risks and uncertainties faced by businesses, which include pandemics that cause global supply chain disruptions (Papadopoulos et al., 2020).

Digital technology is becoming more and more ingrained in a wide range of fields,

businesses, and organizations. As a result, at this point enterprises' activities are changing in direct proportion to the digital transformation. The advancement of enterprise management, the active application of contemporary information technologies (including for the automation of business operations), and the introduction of new business models are all necessary to support the expansion of digital technologies on the basis of inventive development (Alla Vasilevna & Chernikova, 2019).

The digital economy is anticipated to have several drawbacks compared to the traditional economy, such as leading to the elimination of certain professions, growing digital divide in education and access to digital services, cybernetic threats, etc. However, its benefits include boosting corporate productivity and competitiveness, cutting expenses, and creating new professional specializations. Some scientists think that innovation has been superseded by the digital economy, but in our view, innovation and digitization are essential elements. Consequently, the issue of the economy's digitization on the basis of inventive development is highly pertinent at the current stage of business development (Alla Vasilevna & Chernikova, 2019).

The adoption of digital technology by a company to digitize non-digital operations, products, or services is known as digital transformation. Increasing value through innovation, invention, customer experience, or efficiency is the aim of its execution (Aslanov & Mirzagayeva, 2022; Vial, 2019). The application of digital technology by a company to digitize non-digital functions, products, or services is called digital transformation.

In addition, regarding the interest of the academic community and international research activity in this subject, it is noted that the field of digital transformation has been of increasing interest, especially in the last decade. The results of this interest indicate a significant lack of interconnection between academic findings and field application, and research in the field is fragmented. What is becoming clear is that the field of digital transformation has direct effects on the economy – both at the company and national level – as its effects have led to the implementation of new business models such as the circular economy and frugal innovation (Vaska et al., 2021).

The next section discusses the digital transformation of firms, and digital transition in the EU in general and in the Greek economy in particular.

2.1 Digital Transformation in Business

Various definitions and approaches have been attributed to the concept of digital transformation, which refers to the practices that the company is called upon to implement in the context of its strategies in order to be able to face the challenges posed by new technologies. Digital transformation is an investment in a digital transformation strategy that replaces the existing operational thinking of the firm in order to both address the risks and exploit the opportunities presented by new digital technologies (Singh & Hess, 2017).

Digital business transformation takes place when new technologies remove the barriers between people and businesses, bringing about radical changes in the areas in which a

business operates. With the evolution of their digital status, businesses develop innovative practices, become more efficient, and gain a competitive advantage (Shvertner, 2017).

Furthermore, there is an approach in which digital transformation is a strategy that brings about fundamental changes in the adoption of digital technologies, in an organization or in the organization's operating environment, in terms of the way of working, roles, and business offerings. These changes are focused on the process, organization, and business domain levels. They therefore represent radical changes in all areas of business activity (working conditions, production processes, distribution channels, marketing practices), which are mainly based on collaboration and intensive interactions (Parviainen et al., 2017).

Therefore, in the business world, the biggest challenge that businesses must meet in the face of digital Darwinism is the strategic decision to adopt new digital methods to evolve and survive, otherwise they are expected to drive their business activities to death (Kreutzer et al., 2018).

According to Priyono et al. (2020), who conducted qualitative research based on a questionnaire in the case of manufacturing SMEs in Indonesia, it is initially noted that digital transformation does not necessarily imply a radical transformation of the business model, while the digital transition can take place gradually and at various business levels. Furthermore, the digital transition has clearly made businesses more flexible in terms of resource allocation and management, but it is noted that this process has brought significant costs. At the same time, it is indicated that there is no optimal solution for choosing a strategy as it depends on various factors such as the digital maturity of the business, the existing technological infrastructure, the learning culture, the ability to develop with partners, etc. Although the research highlights some very important conclusions for the case of Indonesia, there are no comparative quantitative data for the case of other countries, while also no longitudinal data are presented.

At the same time, Rupeika-Apoga et al. (2022) attempted to investigate, among other things, causal relationships between digital transformation and the revenues of 246 SMEs in Latvia. Initially, in this case, there was a positive effect of digital transformation on business revenues – indeed, of both variables under consideration: digital orientation and digital capability. Moreover, the results show that digital transformation is not only imperative, but is also an opportunity for countries to increase not only their economic but also social and environmental benefits. Of course, although the aforementioned research presents some very important findings, the results are limited, as on the one hand comparative data of businesses in other countries are not presented, while data are taken from the side of businesses without considering factors such as the digital capability of consumers, the digital infrastructure of the country, the digital culture of citizens, etc.

2.2 The Digital Transition in the European Union

The high-tech sector could be defined as a very important, complex, and multifaceted

part of the modern economy and the system of social and economic life in the world today in general and in the European area in particular. According to Melnikas (2013), this means that the intensive development and further modernization of the high-tech sector should be defined as the most important prerequisite for the creation and development of the knowledge society and the knowledge economy, as well as a particularly important priority of social, economic, and technological development in the European Union.

EU cohesion policy programming is part of the overall coordination of EU economic policy. The digital transition of the Member States is one of the EU's broader reforms. Indeed, the links between cohesion policy and reforms were strong enough for the European Commission to decide to suspend funding for regions in any EU Member State that does not follow its economic conditionality.

The fact is that digital technology is evolving rapidly and will continue to change people's everyday lives. The EU, through its digital policy, intends to make this transformation work for people and businesses. The European Commission aims initially to enrich the EU's digital dominance and to define its own standards, rather than adopting those of others, with particular emphasis on data, technology, and infrastructure.

Improving regional productivity and competitiveness can be achieved through Information and Communication Technologies (ICT), as their innovations offer businesses opportunities. It is considered that the digital transition will offer the potential to achieve EU policy objectives in a number of areas. Indicative areas where the digital transition can be applied are health, security, transport, energy, etc. However, the benefits of digital technologies come with risks or extra costs. There is widespread concern about digital challenges, access to people's personal data, and malicious cyber activity.

Based on international literature it is clear that European SMEs are experiencing the effects of digital transformation. Primarily, what is being examined is customers' relationships with SMEs in digital transformation studies focusing on SMEs, while SMEs use digital technologies to produce new digital products and services, expand the consumer base, and improve business performance (Khin & Ho, 2019). Europe's competitiveness in global markets is significantly influenced by SMEs' speed and degree of digitization. Therefore, exceptional prospects for European SMEs and economic growth are expected as digital technologies change market dynamics. This expansion is intensifying, and the technology industry is growing five times faster than the rest of the European economy. As a result, SMEs are competing, scaling, and disrupting unimaginably due to the rapid technological transformation (European Investment Bank, 2019).

In a similar study conducted by Vinnychuk et al. (2014), data was taken from Ukraine, Poland, Lithuania and Germany, and similar indicators were then used to investigate causal relationships between the knowledge economy and economic growth. The results of the survey indicate that the knowledge and information production industry and the integration of innovation is a critical factor for the economic prosperity and competitiveness of a country. At the same time, for the Ukrainian economy, the orientation towards innovation and digitalization is highlighted as a long-term growth strategy, while the importance of

implementing this policy to enhance extroversion at the global level is underlined.

According to Jurčević et al. (2020), who used the DESI index to study Croatia's digital situation compared to the other EU Member States, it was found that the country lags significantly behind the European Union average. The findings of the survey included low digital maturity of businesses and very low integration of digital transformation into business models and business strategy in the case of Croatia. However, this research does not delve deeper into the additional components of DESI, and does not investigate possible causal relationships between digital transformation and the other factors examined.

According to Mishchuk et al. (2019), the importance of ICT integration and digitalization is recognized as a source of competitive advantage and as a lever primarily of the economic, but also social, development of an economy. Applying a mathematical simulation model with international statistics in the case of Ukraine, they confirmed the existence of positive links between GDP per capita and ICT and demonstrated the importance of ICT integration in the economic performance of enterprises. Indeed, the country's case study has similar characteristics to the Greek economy, as Greece also highly appreciates the benefits of digitalization, but still shows a low degree of digital maturity.

The COVID-19 crisis affected the use of various digital technologies and, in particular, accelerated the digital transition. Many employees increased their use of digital technologies if they worked from home (teleworking), while many pupils and students increased their use of distance learning. Finally, the way people communicated with each other was affected by travel restrictions, which increased online conversations and meetings between people, as was the traditional method of shopping, which was reduced by online ordering (Eurostat, n.d.-b).

2.3 Digital Maturity in the Greek Economy

According to a survey conducted by SEV (Hellenic Federation of Enterprises) on the digital maturity of Greek businesses, it is noted that a very small percentage, around 3%, has adopted artificial intelligence technologies, in contrast to other developed countries where this figure is around 40%. Furthermore, cloud solutions are used by around 7% of the population in Greece, compared to 26% in the EU. For the 2020–2022 period, according to the survey, the digital maturity of the Greek economy has improved, but it still remains among the lowest in the EU. This improvement seems to be due in large part to the emergence of the COVID-19 pandemic, which seems to have accelerated and intensified investments towards digital transformation in both the private and public sectors. Of course, it should be noted that despite the increase in investment in digital practices, these are more focused on technologies with outdated capabilities, with the result that the digital maturity of Greek enterprises is still at a low level compared to the EU (SEV Observatory, 2022).

In a corresponding National Documentation Centre (2022) survey on the adoption of Digital Transformation as a "continuous and comprehensive growth strategy" in the 2020–2022 period, it was found that a significant part of Greek business (40.2%) considers

Digital Transformation as a growth strategy to be of major importance, while it is also evident that the number of companies adopting this view has increased compared to the 2016–2018 period (33.5%). Between the geographical regions of the country (NUTS1: Attica, Northern Greece, Central Greece, and Aegean Islands, Crete), digital transformation is largely considered a very important ongoing business development strategy. However, in the region of Attica, it is more strongly prevalent, with a rate of 42.7%.

Kazantzidou (2022), through qualitative research conducted for the fashion industry, highlighted the necessity of digital transformation in the industry's businesses, especially as a strategy to cope with the effects of the pandemic. At the same time, it is noted that industries that were mainly retailers faced greater challenges and subsequently appeared to have realized earlier that the use of digital tools can compensate for economic losses. Furthermore, it is noted that the impact on businesses in the sector that had already adopted digital technologies to a greater extent was significantly lower. It should be noted, however, that the survey does not take broad industry data or data from other industries.

Potouris (2017) investigated five sectors of the Greek economy, conducted a case study of 10 representative companies in each sector, and found that the majority of the firms that led the digital transformation of the sectors were start-ups and introduced some kind of innovation. Increased competition and a lack of consumer education in new technologies were listed as major problems, while the following were noted as benefits: responsiveness to competition, increased consumers, reduced costs, and an improved customer experience. However, this research was based on qualitative data and did not show correlations with the economic results of companies.

Finally, research results show that, on the one hand, the percentage of businesses that recognize the importance of digital transition is still low in Greece; on the other hand, a very large percentage of the business world relies on EU funds for the adoption of digital practices. Consequently, EU policy is crucial and of great importance as regards the allocation of funds in similar digital directions. In particular, regarding the challenges and ways of dealing with developments in the business world, it is recorded that 52% of companies have strategic growth as a key expectation. In fact, of this group of businesses, 71% use EU resources for investment support, while only 23.2% invest in digital and green transformation. Moreover, a significant proportion of businesses with an upward-looking expectation (constituting 35% of the total amount) are tapping into EU resources, albeit more for working capital than as an investment incentive (SEV, Flash Report, 2023).

Summarizing, the literature review shows that digital transformation can bring about radical changes in business activities and the way business processes are organized by giving competitive advantages and highlighting related risks. Previous studies have focused on new technology adoption, innovation, added value and dynamic capabilities (Skare et al., 2023). However, it is still unclear how digital transformation can affect both the economic figures of businesses such as access to finance, increasing input costs, shortages of skilled labor, various regulatory issues, etc., as well as the macroeconomic aggregates of countries. The majority of previous studies apply qualitative research or case study methods, while a

smaller number of studies conduct quantitative research, mainly by collecting data from businesses. The contribution of this paper lies in the effort to fill this research gap by using DESI, while at the same time it attempts to investigate if and how digital transformation is related to certain macroeconomic aggregates.

2.4 The Extroversion of the Greek Economy

One of the main macroeconomic aggregates studied in the international literature when attempting to outline a country's economy is trade flows. Traditionally, countries' main goal has been to increase exports over imports, which leads to an improvement in the trade balance and a strengthening of the economy. Next, export performance, export coverage and extroversion are some of the key indicators studied in the international literature on exports and the extroversion of an economy. Extroversion indicators are often the subject of research related to the productive composition of an economy, the formation of competitive advantages, the deeper understanding of trade relations and the formation of an institutional framework for external trade policy. In the case of Greece, one of the most important aspects of the economy's deficit is exports, whose stunted performance is reflected both in their low share of the country's GDP and in their chronic trade deficit (Magoulios & Chouliaras, 2014; Moskofidis & Magoulios, 2022).

According to the international literature, the factors affecting the extroversion of an economy are, in most cases, multidimensional and complex, and may vary depending on the geographical approach and the time period. In the case of the Greek economy, according to Magoulios et al. (2021), Greek exports are particularly vulnerable in times of crisis.

Regarding the forecasts of the Greek economy for the 2020–2022 pandemic period, according to an OECD study, losses in the country's GDP may reach the level of –35% due to the partial or total closure of commercial activity. The tourism sector also appears to be severely affected, especially in places where the sector supports many jobs and businesses. Estimates of the impact of COVID-19 show a 60% decline in international tourism. Certainly, domestic tourism will recover faster, but it cannot fully compensate for the decline in international tourism (OECD, 2020)

At the same time, the decline in consumer spending is expected to be around 30% in many major advanced economies, including Greece. Fiscal conditions in Greece and globally deteriorated rapidly in 2020 (estimated primary fiscal deficit in Greece above –7% of GDP, compared to a surplus of +3.5% in 2019), and the fiscal situation remained difficult in 2021. In this context, Greek public debt as a percentage of GDP will approach 200%, the highest in the Eurozone, posing a medium-term threat to fiscal stability and the country's growth dynamics (Karamouzis, 2020).

Antonaios (2022) notes in his research that in the case of the Greek economy, in terms of extroversion, there is a long-standing negative impact of imports on the Greek economy. Moreover, he points out the significant contribution of domestic demand and consumer spending, except during the years of economic recession. At the same time, he stresses the

importance of distinguishing export activity, both including and excluding the oil sector. Finally, his study points to the minimal participation of Greek trade in international trade – Greek exports participate in international trade at an approximate rate of 0.2%, while imports participate at a slightly higher rate of 0.5% (Antonaios, 2022).

Moreover, Moskofidis & Magoulios (2022), in a comparative study conducted during the economic recession of 2008 and the pandemic period of 2019–2021, point out the restructuring in Greece's foreign trade, with a significant increase in intra-community trade. Among other things, they attribute this change to the existence of an institutional framework in intra-community trade, the formation of free trade conditions, the existence of trade confidence and creditworthiness, the absence of restrictive measures, the security of trade, and knowledge of the supply chain developed through European integration.

Finally, regarding the long-standing problems in Greek foreign trade, a report by the National Bank of Greece (2022) points out that the problem is not only quantitative but also qualitative, as SMEs export their products mainly to the Balkan and Eastern European countries, as opposed to large companies that have better access to Western Europe, where profit margins are higher. While, according Magoulios and Athianos (2013), the Greek economy continues to exhibit characteristics of an emerging economy, where there are strong comparative advantages, it lacks the characteristics of a developed country in terms of the structure of production and foreign trade.

3. Methodology

Based on similar research efforts (Jurčević et al., 2020; Skare et al., 2023), the Digital Economy and Society Index (DESI) is used to study the evolution of the digital status of Greek entrepreneurship. DESI is composed of a set of qualitative and quantitative dimensions that reflect the digital evolution of the European Union member states. DESI, which was established and adopted by the EU in its annual reports, ranks the Member States according to their level of digitization and analyzes their relative progress based on four sub-indices: a) Connectivity, b) Human Capital, c) Digital Technology Integration, and d) Digital Public Services European Commission, n.d.). Existing literature on digital transformation focuses on changes in structure and value creation, use of digital technologies, dynamic capabilities, consumer behavior, and strategic responses (Kraus et al., 2022). However, the empirical link between digital transformation and the business activities of European SMEs remains unclear. Studies on how digital transformation impacts European SMEs with regards to customers, input costs, access to finance, regulatory burden, exogenous shocks, and skilled labor shortages are not available. Fewer studies use the DESI to explore digital transformation in Europe. DESI is a composite index that tracks economies' digital transformation by connectivity, human capital, Internet use, digital technology integration, and digital public services. DESI allows us to explore the impact of a country's digital transformation on SMEs' main business issues (Skare et al., 2023)

At the same time, research in international databases presents Greece's exports for the 2017–2022 period, extracts the degree of extroversion (X/GDP) by international sector classification (SITC1), and studies the structure of Greek exports by extracting the degree of contribution or the specific weight of each sector in total exports (X/X Total). Next, in order to observe the situation of the Greek economy in terms of R&D, the R&D intensity indicator is extracted, which is included in the auxiliary indicators of the Macroeconomic Imbalance Procedure (MIP) Scoreboard, used by the European Commission for early warning in monitoring the macroeconomic imbalances of the EU Member States. Note that the R&D indicator is one of the nine headline indicators of the EU2020 strategy, relating to the R&D expenditure target of 3% of EU GDP, the achievement of which is maintained with a new time horizon of 2030. Based on the suggestions of the international literature, the comparative data analysis approach was chosen for the case of Greece's foreign trade for the 2017–2019 and 2020–2022 periods, with the main criterion of separation being the occurrence of the COVID-19 pandemic.

Finally, an attempt is made to investigate the existence of linear correlations between the examined variables through data panel analysis using E-Views. Panel data regression is a powerful way to control dependencies of unobserved, independent variables on a dependent variable, which can lead to biased estimators in traditional linear regression models. In particular, it is examined whether there is a link between the degree of extroversion of an economy and the four factors that make up the digital ranking of the country. This approach is based on quantitative data for the 27 countries of the European Union for the 2017–2022 period, as the literature review revealed that similar attempts have been made with qualitative survey data, but either quantitative data were not used, they were not based on internationally accepted indicators, or there was the wide retrieval of quantitative data from a multitude of countries.

Next, the added value of the present research, apart from describing the current situation of the Greek economy in terms of digital maturity and export trade, lies in identifying the weaknesses of the structure of Greece's foreign trade, highlighting new challenges due to the digital transformation of Greek business and suggesting the digital practices that can be an enhancing factor in Greece's foreign trade.

3.1 Mapping the Digital Status of Greece

By way of introduction, a survey conducted by the National Documentation Centre (2021) highlights the extent and intensity of the impact of the pandemic on Greek business activities (90% of businesses were affected by the pandemic, 22% to a significant extent). Furthermore, according to the findings, it appears that there are no differences in terms of the size of these enterprises (micro-small, medium, or large) nor in terms of the main sector of their economic activity (industry and services). However, no results are presented in a higher classification (single or double-digit) by the economic activity sector. Subsequently, differences in intensity are noted by geographical region, with Crete and the Aegean

Islands being the most affected. Importantly, the main strategy adopted to deal with the impact of this phenomenon is the adoption of developmental practices, with an emphasis on digital transformation (National Documentation Centre, 2021).

Figure 1 shows the ranking of European Union countries according to DESI in 2022. What can be observed is that Greece ranks among the EU's laggards in terms of digital maturity, occupying 25th position out of 27 EU countries with a score of 38.9%, compared to the EU average of 52.3%. In fact, looking at the individual indicators, it can be observed that Greece is in an even worse position in terms of Digital Public Services compared to the EU, with a score of only 9.85% compared to the EU average of 16.8%. Regarding Digital Technology Integration, Greece's share is 6.66% compared to 9.02% in the EU, indicating that the Greek economy is lagging behind in this indicator. Regarding the factor of Connectivity, Greece achieves a rate of 12.4% compared to 15% in the EU. Finally, regarding Human Capital, Greece has the lowest deviation, with a rate of 10% compared to 11.4% in the EU. Overall, what should be noted is the fact that Greece lags behind the EU in terms of digital maturity, both overall and in individual factors, but this lag is smaller in the Human Capital factor, while it achieves the best performance in the Connectivity factor.

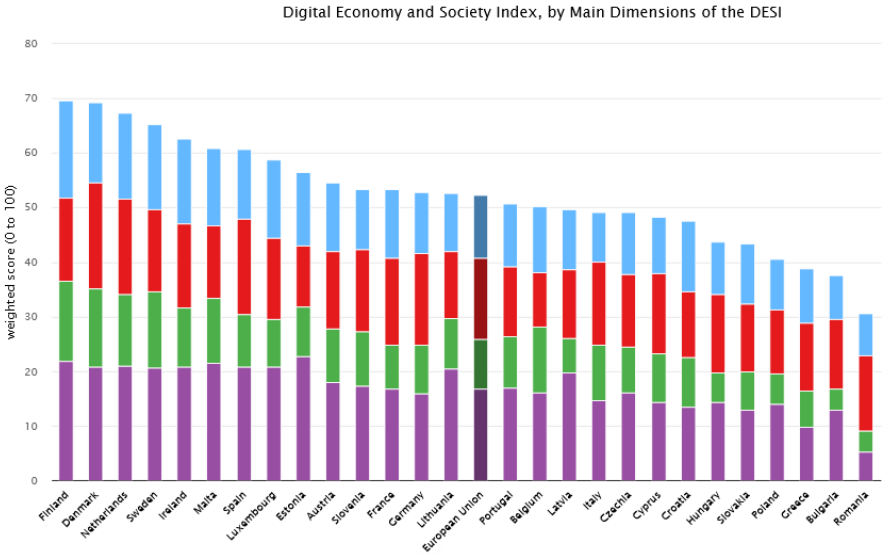

Figure 1. DESI for EU countries in 2022

Source: European Commission (n.d.), DESI (n.d.)

Table 1 presents the evolution over time of the DESI and the main individual actors that constitute it. What can be observed is that DESI shows a steady upward trend over time, with a value of 22.4% in 2017, which is continuously improving; for 2022, its value is 38.9%. What should be noted is that for 2017–2019, the change in the index was positive

by 14.17%, while for 2020–2022, the change was significantly more pronounced, as DESI improved by 41.2%. This indicates that the emergence of the pandemic significantly accelerated the process of digital transformation.

Table 1. DESI for Greece for the 2017–2022 period

	2017	**2018**	**2019**	**2020**	**2021**	**2022**	**% change 2017–2019**	**% change 2020–2022**
Human Capital	9.05	8.94	9.13	9.60	10.25	10.03	0.93	4.46
Connectivity	3.16	3.35	4.07	4.78	7.77	12.39	28.54	158.99
Integration of Digital Technology	4.14	4.56	4.97	5.05	5.50	6.65	20.17	31.76
Digital Public Services	5.99	6.67	7.34	8.12	8.97	9.84	22.43	21.15
DESI Total	22.4%	23.5%	25.5%	27.6%	32.5%	38.9%	14.17%	41.20%

Source: European Commission (n.d.), DESI (n.d.)

Then, observing each factor separately, it can be seen that the Human Capital factor traditionally presents the largest share in the composition of the index. In fact, what should be noted at the same time is that, over time, this factor shows the lowest improvement (almost stable) compared to the other factors, except in 2018, where it shows a marginal deterioration. As for the Connectivity factor, it is noted that it is the lowest factor, particularly for the 2017–2019 period, with a rate of only 3.16% for 2017. However, for the 2020–2022 period, a very significant improvement is observed, as in 2022 the value of the indicator reaches 12.39%, marking an improvement of 158.99% (2020–2022). Regarding the Integration of Digital Technology factor, it is noted that it contributes the lowest percentage to the DESI. It also traditionally improves over time, but in the 2020–2022 period the improvement was more pronounced. Finally, the Digital Public Services indicator for 2017 reached a value of 5.99%, while it reached a value of 9.84% for 2022; therefore, it improved over time, but for the 2017–2019 period it improved more strongly.

In summary, the changes in the individual factors are more pronounced in the 2020–2022 period, which indicates that the emergence of the pandemic contributed decisively to the acceleration of the adoption of digital practices. This is especially pronounced in the Connectivity factor, which shows the highest sensitivity, in contrast to Human Capital

which, although it now contributes a higher percentage, has remained almost neutral since the emergence of the pandemic. This is due to the way that the indicator is compiled, and indicates that significantly more time is needed for investment to pay off in terms of the change in digital maturity.

Table 2 presents a comparison of DESI and its four individual factors for the EU and Greece over time. What can be observed from the comparative presentation is that Greece is consistently below the EU average, even though its digital maturity is improving. In more detail regarding the individual factors, it should be noted that, as far as Human Capital is concerned, the lag from the EU is very small, which means that Greece seems to maintain a satisfactory level of digital maturity concerning this factor. Then, the gap for the Connectivity factor is much more significant, as for 2017 Greece showed 3.17%, almost half that of the EU (6.19%). Connectivity is improving over time in both cases; however, in Greece, this improvement is more significant. Regarding the Integration of Digital Technology, it is observed that both in the EU and in Greece it is improving; however, in the EU it is improving more strongly. Finally, Digital Public Services show a significant lag for Greece compared to the EU, which indicates that the Greek economy has particular weaknesses in the adoption of digital practices in public services.

Table 2. DESI and its constituent factors for the EU and Greece (2017–2022)

	2017		**2018**		**2019**		**2020**		**2021**		**2022**	
	EU	EL	EU	EL	EU	EL	EU	EL	EU	EL	EU	EL
HC	10.38	9.05	10.45	8.94	10.71	9.14	10.99	9.61	11.16	10.25	11.44	10.03
Con	6.19	3.17	6.65	3.35	7.65	4.07	8.78	4.79	11.07	7.78	14.98	12.39
IDT	5.46	4.14	6.14	4.56	6.73	4.98	7.32	5.05	8.18	5.50	9.02	6.66
DPS	11.68	6.00	12.68	6.67	13.55	7.34	14.58	8.13	15.79	8.98	16.84	9.85
DESI	33.72	22.36	35.92	23.53	38.64	25.53	41.67	27.57	46.20	32.51	52.28	38.93

Source: European Commission (n.d.), DESI (n.d.)

Figures 2–5 graphically illustrate the data in Table 2, specifically presenting the evolution over time of the factors that make up DESI for the 2017–2022 period for Greece and the EU.

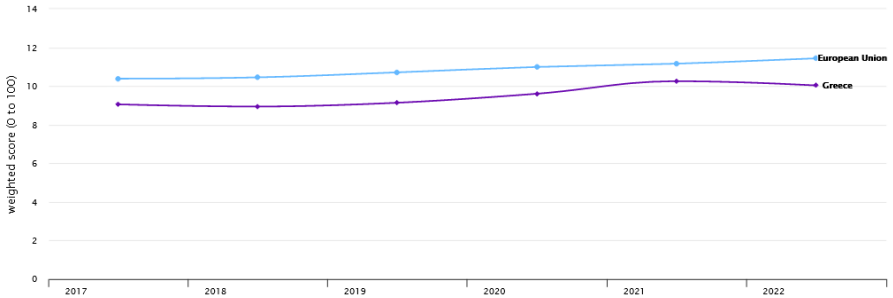

Figure 2. DESI by Human Capital for the EU and Greece (2017–2022)
Source: European Commission (n.d.), DESI (n.d.)

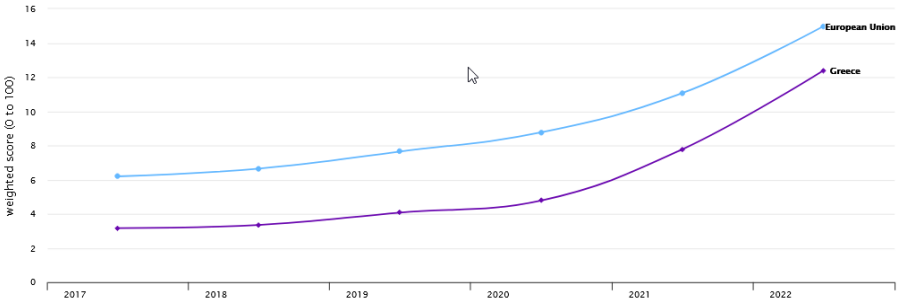

Figure 3. DESI by Connectivity for the EU and Greece (2017–2022)
Source: European Commission (n.d.), DESI (n.d.)

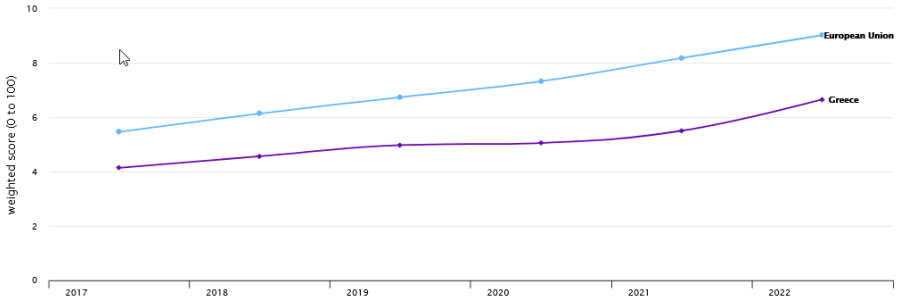

Figure 4. DESI by Integration of Digital Technology for the EU and Greece (2017–2022)
Source: European Commission (n.d.), DESI (n.d.)

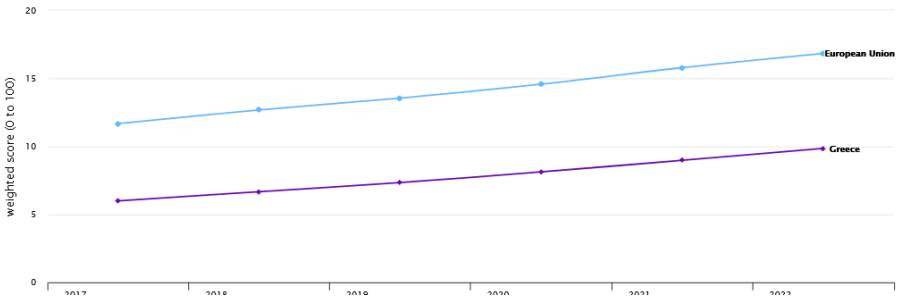

Figure 5. DESI by Integration of Digital Technology for the EU and Greece (2017–2022)
Source: European Commission (n.d.), DESI (n.d.)

3.1.1 The Greek reality in terms of key R&D indicators

In the following section, the current situation of the Greek economy in the field of R&D is presented. This analysis presents the ranking of Greece compared to the other EU countries, the evolution of R&D expenditure in the Greek economy over time by sector of execution for the 2017–2021 period, and the R&D intensity indicator for the 2017–2021 period by geographical region.

Table 3 shows the ranking of countries by the level of R&D expenditure for 2021. It can be seen that Greece is ranked 15th, with an amount of €2,635.2 million. Among the leaders in absolute terms, Germany is ranked 1st with €112,850 million, France is 2nd with €55,317.1 million, and Italy is 3rd with €26,516.9 million. Next come the Netherlands, Sweden, Spain, Austria, Belgium, Denmark, Finland, the Czech Republic, Ireland, Portugal, and the Netherlands. Croatia, Lithuania, and Estonia are ranked below Greece and at the bottom of the list.

Table 3. R&D expenditure (in million €) in Greece and EU27 countries, preliminary data from 2021

EU Member States	R&D (million €)	EU Member States	R&D (million €)
Germany	112,850.0	Greece	2,635.2
France	55,317.1	Hungary	2,531.1
Italy	26,516.9	Romania	1,141.2
Netherlands	19,316.0	Slovenia	1,117.0
Sweden	18,033.1	Slovakia	918.4
Spain	17,249.3	Luxembourg	739.4
Austria	12,951.8	Croatia	725.1
Belgium	16,151.9	Lithuania	622.4
Denmark	9,470.6	Estonia	551.0
Poland	8,252.9	Bulgaria	549.1
Finland	7,491.1	Latvia	232.2
Czechia	4,755.5	Cyprus	208.0
Ireland	4,501.5	Malta	95.0
Portugal	3,564.9		

Source: Eurostat (n.d.-a)

Next, Figure 6 shows R&D expenditure as a percentage of GDP for 2021. This is considered a more representative indicator, as it takes into account not only absolute expenditure but also the economy of each country. As far as Greece is concerned, it shows 1.45% in the R&D intensity index, and its ranking remains the same, in 15th place. However, there is a change in the leading countries, as Sweden ranks 1st with 3.36% (5th in absolute R&D expenditure), Belgium 2nd with 3.32% (8th in absolute R&D expenditure), and Austria 3rd with 3.19% (7th in absolute R&D expenditure), while Germany ranks 4th with 3.13%. This is followed by Finland, Denmark, the Netherlands, France (2nd according to Table 3), Slovenia, the Czech Republic, Estonia, Portugal, Hungary, and Italy (3rd in absolute R&D expenditure), while Bulgaria, Latvia, Malta, and Romania rank at the bottom.

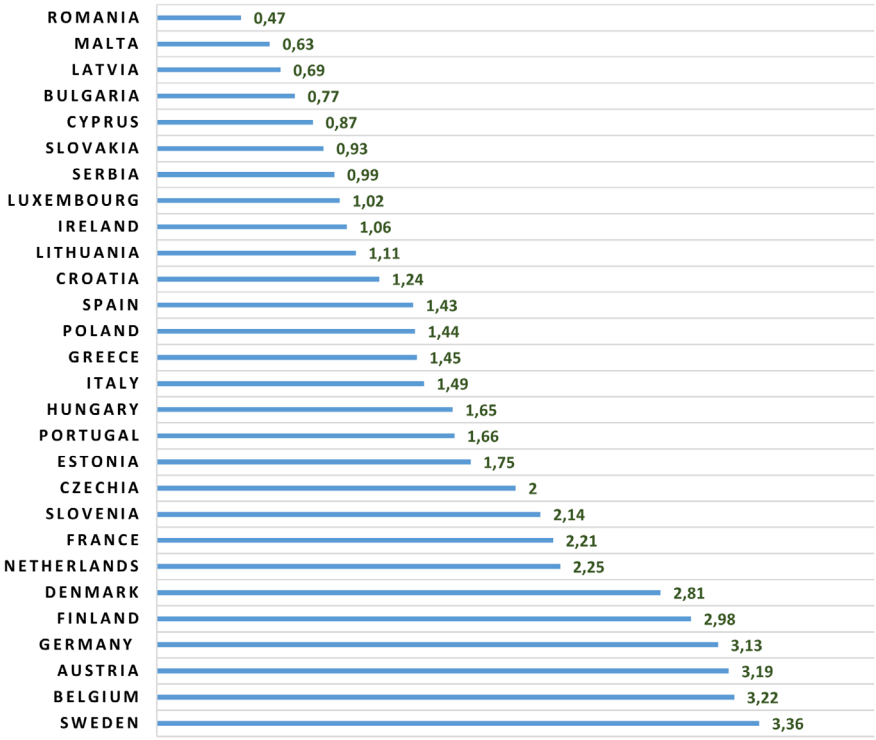

Figure 6. R&D expenditure as a percentage (%) of GDP in Greece and EU27 countries, preliminary data from 2021

Source: Eurostat (n.d.-a)

Table 4 shows R&D expenditure in the Greek economy by sector of execution for the 2017–2021 period. It should be noted that the Business Enterprise Sector (BES) shows the highest intensity over time in terms of expenditure levels – around 47.3% on average (Figure 7). The BES sector shows the same change for both the pre-pandemic and post-pandemic periods, suggesting a low degree of sensitivity. The tertiary and postsecondary education (HES) sector is the second-most intensive in terms of expenditure, at an average of 29.9% (Figure 7). The HES sector shows an increase of 24.13% for the 2017–2019 period, but remains stagnant for the 2020–2021 period. Then, the Government Sector (GOV) comprises 22.1% on average (Figure 7), ranking third in terms of the intensity of R&D spending. In this case, the change for the 2017–2019 period is positive by 16.14%. For the 2020–2021 period it is again positive, but at a much lower rate of 7.77%. Finally, the Private Non-Profit Institutions (PNP) sector shows very low R&D expenditure, contributing only 0.8% to total expenditure.

Table 4. R&D expenditure by sector of implementation (in million €), 2017–2021

R&D expenditure by implementing sector	2017	2018	2019	2020	2021	% change 2017-2019	% change 2020-2021
Country total	2,038.4	2,179.3	2,337.7	2,494.2	2,635.2	14.68%	5.65%
BES	994.0	1,049.5	1,077.9	1,149.9	1,245.2	8.44%	8.29%
GOV	451.1	488.1	523.9	537.2	579.0	16.14%	7.77%
HES	576.9	618.6	716.1	792.6	795.8	24.13%	0.40%
PNP	16.4	23.1	19.8	14.5	15.2	20.43%	5.12%

Source: National Documentation Centre (2022); https://metrics.ekt.gr/research-development/datatables

In summary, R&D expenditure for the whole 2017–2021 period shows an upward trend, which is more pronounced for the 2017–2019 period. At the same time, the BES sector, which is the main sector in terms of its contribution to the total, shows no variation due to the occurrence of the pandemic, suggesting that R&D-related expenditure is largely inelastic, unlike the HES sector, where expenditure is highly sensitive.

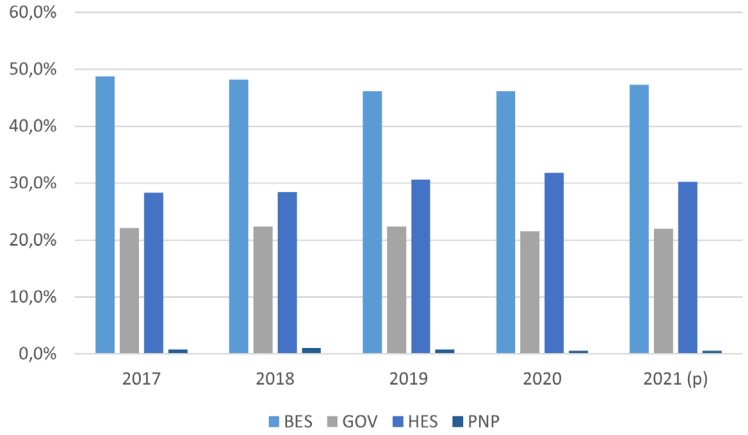

Figure 7. Structure of R&D expenditure in Greece by sector of implementation (2017–2021)

Source: National Documentation Centre (2022)

Table 5 shows R&D expenditure for the 13 NUTS2 regions of Greece for 2017–2020. First of all, it should be noted that Greece has been increasing its R&D expenditure throughout the period under consideration; in fact, for 2020 (with 2017 as a base year), it increased by 22.4%. Moreover, as regards the R&D intensity indicator, there has been an

improvement over time, with the highest value of 1.51% in 2020. It should be noted that this indicator reflects the actual improvement in terms of R&D, as both absolute expenditure and the GDP of the country improve for the years 2017–2019; however, for 2020, the most pronounced improvement of the indicator is due to the increase in R&D expenditure on the one hand and the decrease in GDP on the other.

Table 5. R&D expenditure in Greece by regions (2017–2020, in million €)

R&D by region	**2017**	**2018**	**2019**	**2020**	**% change 2017–2020**
GDP	176,903.40	179,557.70	183,250.40	165,326.40	---
Greece	2,038.430	2,179.310	2,337.66	2,494.20	22.4%
R&D Index	1.15%	1.21%	1.38%	1.51%	---
Attika	1,242.3	1,333.9	1,428.4	1,475.5	18.8%
Central Macedonia	280.9	276.1	282.6	311.8	11.0%
Crete	128.8	133.4	140.6	153.7	19.3%
Western Greece	106.8	104.4	113.0	118.7	11.1%
Thessaly	60.0	74.7	90.0	104.5	74.1%
Epirus	58.5	52.7	59.0	63.3	8.3%
East Macedonia and Thrace	49.2	51.2	54.5	65.0	32.2%
Central Greece	37.9	42.4	55.5	71.2	87.9%
Peloponnese	24.7	51.7	51.9	60.8	146.0%
North Aegean	16.7	16.8	18.3	20.6	22.9%
Western Macedonia	14.3	19.3	16.3	20.2	41.3%
South Aegean	10.6	11.8	14.7	14.8	39.9%
Ionian Islands	7.7	10.9	12.8	14.1	82.3%

Source: Eurostat (n.d.-a)

Then, based on the regional approach, it can be seen that in terms of absolute expenditure, the region of Attica ranks first, with €1,242.3 million for 2017 and €1,475.5 million for 2020, i.e., an increase of 18.8%. Central Macedonia is in 2nd place, with a much lower absolute expenditure of €280.9 million for 2017, rising to €311.8 million for 2020. This is followed by the 3rd place region of Crete, with €128.8 million for 2017 and €153.7 million for 2020, which is followed in order by the regions of Western Greece, Thessaly, Epirus, East Macedonia and Thrace, Central Greece, Peloponnese, the North Aegean, West

Macedonia, the South Aegean, and lastly, the Ionian Islands. What should be noted in terms of the improvement in the R&D expenditure of the regions is that all regions are improving their R&D expenditure; however, some are improving much more significantly. In fact, lower-ranked regions show a higher increase in absolute R&D expenditure. In particular, Thessaly shows an increase of 74.1% in R&D expenditure, Central Greece 87.9%, and Peloponnese 146%. In contrast, Attica and Central Macedonia increased by 18.8% and 11%, respectively.

Table 6 presents the R&D intensity index as a percentage (%) of GDP for each region of Greece (by NUTS2 classification) for the 2017–2022 period. First of all, it should be noted that, similar to the absolute R&D expenditure in Table 5, the R&D ratio over time in Greece as a whole shows an increasing trend for the entire 2017–2020 period; however, the increase is more pronounced in the 2019–2020 period. More specifically, for each region, it is observed that Epirus shows the highest value of the index, 0.26 above the average of Greece for 2017, while for 2020 it ranks 3rd, showing an increase of 12.6% for the whole period. Then Attica, which had a value of 1.47 in 2017, significantly improves its index value by 28.6% and ranks first for 2020. A significant improvement is also observed for the region of Crete, which improved its ranking by one place (from 3rd in 2017 to 2nd in 2020) by obtaining a value of 1.88 in the E7A index for 2020. Then, in order of ranking (based on 2017), the region of Western Greece follows, followed by Central Macedonia in 5th place, East Macedonia and Thrace 6th, North Aegean 7th, Thessaly 8th, Central Greece 9th, and West Macedonia 10th, while the last positions are occupied by the Peloponnese, the Ionian Islands, and the South Aegean. What should be noted is that from East Macedonia and Thrace onward, there is a very significant deviation from the Greek average in terms of R&D index values. Only 5 out of 13 regions are above the average for 2017, while for 2020, the number regions with a value above the average reduces to 4.

Table 6. R&D intensity as a percentage of GDP, by region (2017–2020)

R&D intensity as % of GDP	**2017**	**2018**	**2019**	**2020**	**% change 2017–2020**
Epirus	1.51	1.34	1.46	1.70	12.6
Attica	1.47	1.56	1.63	1.89	28.6
Crete	1.46	1.48	1.52	1.88	28.8
Western Greece	1.36	1.31	1.39	1.60	17.6
Central Macedonia	1.17	1.12	1.12	1.37	17.1
East Macedonia and Thrace	0.72	0.74	0.78	1.00	38.9
North Aegean	0.69	0.68	0.72	0.88	27.5

Thessaly	0.67	0.82	0.96	1.20	79.1
Central Greece	0.46	0.5	0.65	0.85	84.8
Western Macedonia	0.33	0.46	0.43	0.61	84.8
Peloponnese	0.31	0.64	0.63	0.79	154.8
Ionian Islands	0.25	0.35	0.39	0.50	100.0
South Aegean	0.18	0.19	0.23	0.27	50.0
Greece	**1.15**	**1.21**	**1.28**	**1.51**	**31.3**

Source: Eurostat (n.d.-a)

Furthermore, it is observed that the improvement in the index is much more pronounced for the regions ranked at the bottom – for example, the Peloponnese region improved its R&D index by 154%, the Ionian Islands by 100%, and Central Greece and Thessaly by 84.8%. However, despite the fact that these regions improved their R&D intensity, the deviation from the average in Greece as a whole remains significant, suggesting that the specific weight of these regions is relatively low. On the other hand, it is noted that the leading regions have improved their values of this indicator, but at much lower rates, while for no region was a deterioration observed throughout the period considered.

In summary, it should be noted that there are significant divergences in R&D intensity between regions, which, although they seem to be convergent, remain significant. Moreover, it appears that the more developed regions also show better values for this indicator, while the specific weight of the developed regions in relation to the Greek average is also higher.

3.1.2 The extroversion of the Greek economy for the 2017–2022 period

Table 7 presents the extroversion of the sectors (Exports/GDP) of the Greek economy for the 2017–2022 period. For better presentation of the results, a grouping of individual one-digit codes (SITC1) of trade composition into three main sectors is conducted. First, it is observed that the Industrial Products sector has a significant specific weight in shaping the extroversion of Greece's foreign trade over time. In fact, the sector's extroversion formed at 0.070 in 2017,while the following years shows constant improvement. In more detail, it can be observed that for the individual groups of the sector (5, 6, 7, and 8), extroversion improves for the whole period considered.

Table 7. Degree of extroversion of Greek exports (X/GDP) by sector SITC1 (2017–2022)

	2017	2018	2019	2020	2021	2022	% change 2017–2022
Agricultural Products	**0.032**	**0.034**	**0.033**	**0.040**	**0.042**	**0.044**	**30.24**
0 Food & Live Animals	0.025	0.026	0.026	0.032	0.032	0.033	31.35
1 Beverages & Tobacco	0.004	0.004	0.004	0.005	0.005	0.006	25.78
4 Oils & Fats	0.003	0.004	0.002	0.003	0.004	0.005	27.37
Raw Materials & Fuels	**0.058**	**0.072**	**0.066**	**0.048**	**0.072**	**0.106**	**24.59**
2 Non-food raw materials other than fuels	0.007	0.008	0.008	0.008	0.010	0.009	41.46
3 Minerals, Fuels, Lubricants	0.051	0.064	0.058	0.041	0.062	0.097	22.15
Industrial Products	**0.070**	**0.078**	**0.083**	**0.095**	**0.103**	**0.110**	**47.04**
5 Chemical products and related products	0.017	0.019	0.022	0.031	0.031	0.029	79.37
6 Industrial goods	0.026	0.029	0.027	0.030	0.034	0.039	30.92
7 Machinery & Hardware	0.015	0.016	0.017	0.020	0.021	0.024	46.42
8 Miscellaneous manufactured goods	0.012	0.013	0.016	0.015	0.016	0.018	36.16

Source: Eurostat (n.d.-a)

Regarding the Raw Materials & Fuels sector, on the one hand it shows a lower specific weight than the previous sector. On the other hand, there is a significant improvement in extroversion from 0.058 in 2017 to 0.106 in 2022, with the exception of the deterioration to 0.048 in 2020. At the same time, it is clear that Group 3 (Minerals, Fuels, Lubricants) is the one that determines the sector's extroversion to a greater extent.

Finally, the Agricultural Products sector has the lowest specific weight in Greek exports, while it appears that Food & Live Animals is the main group in the composition of the sector. It is noted that the degree of extroversion of the sector and of the individual groups improves over time, but for the 2019–2020 period it improved more strongly.

Overall, what should be noted is that all three foreign trade sectors with their constituent subgroups shows a significant improvement in extroversion for the 2017–2022 period, to a greater extent than in the other periods. For the 2018–2019 period, there is a stabilization of the degree of extroversion, and in some cases a marginal improvement: for the 2020–2021 period, the Raw Materials & Fuels sector initially deteriorates and then improves, while the other sectors with their individual groups essentially improve.

Table 8 presents the specific weights of the sectors of Greece's export trade in a one-digit classification (SITC1). It should be noted that industrial products, in the case of Greek

exports, have the highest specific weight as they constitute 47.6% of export trade transactions. Group 6 makes the largest contribution to the sector, accounting for 35% of exports. Then, the Raw Materials & Fuels sector is ranked second in terms of specific weight, since it represents 32.9% of transactions, with Group 3 being the most important in the sector (86.5%). Finally, the Agricultural Products sector occupied 19.5% of exports. Over time, this sector has become more stable, with an upward variation in 2020.

Table 8. Special weight of Greek exports (X/Total X) in single-digit breakdown by SITC1

	2008	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**average**
Agricultural Products	**19.5**	**19.9**	**18.4**	**18.0**	**22.1**	**19.2**	**16.9**	**19.5**
0 Food & Live Animals	75.4	77.3	76.4	80.4	79.5	77.9	76.0	77.8
1 Beverages & Tobacco	15.4	12.7	12.0	12.5	11.9	12.2	12.6	12.8
4 Oils & Fats	9.2	10.1	11.7	7.0	8.6	9.9	11.5	9.4
Raw Materials & Fuels	**26.2**	**36.3**	**39.1**	**36.4**	**26.4**	**33.3**	**40.8**	**32.9**
2 Non-food raw materials other than fuels	15.5	12.6	10.7	12.2	15.8	14.3	8.8	13.5
3 Minerals, Fuels, Lubricants	84.5	87.4	89.3	87.8	84.2	85.7	91.2	86.5
Industrial Products	**54.3**	**43.8**	**42.6**	**45.6**	**51.6**	**47.5**	**42.3**	**47.6**
5 Chemical products and related products	21.6	24.8	24.9	27.0	32.3	30.2	26.4	26.8
6 Industrial goods	37.6	37.4	37.4	33.1	31.2	33.3	35.5	35.0
7 Machinery & Hardware	22.4	20.8	20.9	20.9	20.9	20.7	21.7	21.1
8 Miscellaneous manufactured goods	18.5	17.1	16.7	18.9	15.6	15.8	16.4	17.1

Source: ELSTAT (n.d.)

In summary, it should be noted with regard to the specific weight of sectors and individual groups that over time there is a stable distribution of export trade flows, which seems to change somewhat during the pandemic period, but then there is a clear tendency to return to pre-COVID-19 levels. Moreover, it is noted that Greece appears to have a higher specific weight of exports in low value-added and labor-intensive sectors. In contrast, it has a lower specific weight in high value-added and capital-intensive sectors.

3.2 The adoption of new digital practices as a factor in enhancing extroversion

In this section, linear correlation relationships between the variables under consideration are investigated by conducting data panel analysis using the E-Views software. Panel

data regression gives the opportunity to control dependencies of unobserved, independent variables on the dependent variable. Specifically, in order to investigate the extent to which the digital ranking of a country can contribute to changes in extroversion, data on exports, GDP, and the DESI index from the 27 countries of the European Union for the 2017–2022 period are taken. The main research question is: To what extent can the adoption of new digital practices be a supporting factor in shaping a country's extroversion? Next, the null hypothesis (H0) is posed as follows:

- H0: "The digital ranking of an economy cannot be a supporting factor in its extroversion in terms of trade."

With the corresponding alternative (H1):

- H1: "The digital ranking of an economy can be a supporting factor in its extroversion in terms of trade."

Then, to test the null hypothesis, multiple regression is conducted in which the dependent variable is defined as the degree of extroversion of an economy (X/GDP) and the four independent variables are the four factors that compose DESI, namely Human Capital (HC), Connectivity (CON), Integration of Digital Technology (IDT), Digital Public Services (DPS).

The results are presented in Table 9, and what should be noted first of all is that the value of the significance statistic F is considered statistically significant at 0.000981, hence we can proceed to further analysis. By examining the $R^2 = 0.127258$, it is found that the explanatory power of the model is low, which is confirmed by the adjusted R^2, which takes a value of 0.101399. As mentioned above, the sample size consists of 140 observations (27 EU countries and the EU as an individual, for the five years of 2017–2022). Looking at the values of each factor separately, it should be noted that the p value for the three factors, HC, CON, and IDT, is greater than 0.05% (marginal value for IDT = 0.065). Subsequently, these factors are not considered statistically significant and do not contribute to the explanatory power of the model. For DPS ($p = 0.0037$, i.e., <0.05), it is found to be statistically significant and is the main determinant in the interpretation of the model. Essentially, the interpretation of the DPS coefficient reveals the positive correlation between the dependent and independent variables and implies that a 1% change in the DPS factor can change the dependent variable by 4.2367%.

Table 9. Multiple Regression and variance results for testing the null hypothesis (H0)

Dependent Variable: X_GDP
Method: Panel Least Squares
Date: 11/12/23 Time: 10:33
Sample: 2017 2021
Periods included: 5
Cross-sections included: 28
Total panel (balanced) observations: 140

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CON01	-0.545088	1.661510	-0.328068	0.7434
DPS	4.236762	1.436050	2.950289	0.0037
HC	2.542457	2.586516	0.982966	0.3274
IDT	-4.521287	2.431201	-1.859693	0.0651
C	19.01084	18.48958	1.028192	0.3057

R-squared	0.127258	Mean dependent var	69.76714
Adjusted R-squared	0.101399	S.D. dependent var	39.15185
S.E. of regression	37.11383	Akaike info criterion	10.10092
Sum squared resid	185954.0	Schwarz criterion	10.20598
Log likelihood	-702.0642	Hannan-Quinn criter.	10.14361
F-statistic	4.921212	Durbin-Watson stat	0.017434
Prob(F-statistic)	0.000981		

Source: European Commission (n.d.), DESI (n.d.), Eurostat (n.d.-a)

Finally, by examining the degree of correlation in Table 10, it is noted that there is a very low degree of correlation between the dependent variable and independent variables HC, CON, IDT (value of <0.3), which confirms that no correlation, or at least no linear correlation, is evident. On the contrary, for the DPS index (value of 0.3177, i.e., >0.30), it is observed that there is some degree of correlation, however low.

Table 10. Multiple Regression and variance results for testing the null hypothesis (H0)

Covariance Analysis: Ordinary
Date: 11/12/23 Time: 10:07
Sample: 2017 2021
Included observations: 140

Correlation t-Statistic Probability	CON01	DPS	HC	IDT	X_GDP
CON01	1.000000 ----- -----				
DPS	0.597229 8.747173 0.0000	1.000000 ----- -----			
HC	0.393861 5.033693 0.0000	0.754509 13.50544 0.0000	1.000000 ----- -----		
IDT	0.510798 6.979769 0.0000	0.732860 12.65345 0.0000	0.796713 15.48630 0.0000	1.000000 ----- -----	
X_GDP	0.139826 1.658879 0.0994	0.317755 3.936813 0.0001	0.239387 2.896369 0.0044	0.141469 1.678763 0.0955	1.000000 ----- -----

Source: European Commission (n.d.), DESI (n.d.), Eurostat (n.d.-a)

The findings of the research to a certain extent reinforce the results of corresponding research in the literature. For example, Skare et al. (2023) reported that a high level of digital ranking seems to present better crisis management conditions, better funding opportunities, and easier access to new markets. Correspondingly, from the above study there are indications that funding and investment in R&D spending have an impact on shaping the extroversion of an economy. Moreover, as indicated by Jurčević et al. (2020), countries with low digital ranking indices that are below the EU average in terms of digital transformation have weaknesses in macroeconomic aggregates, unfavorable trading conditions and low competitive advantages in their trade.

In summary, it should be noted that in light of the data and the results obtained through the hypothesis testing carried out, there is insufficient evidence to reject the null hypothesis for the three factors of HC, CON, and IDT. However , the null hypothesis is rejected for the DPS factor. Therefore, what emerges is that the digital ranking of an economy in terms of the public sector factor can influence changes in its extroversion and thus contribute positively to the growth of its external trade.

4. Conclusions and Proposals

In summary, it should be noted, concerning the change in digital maturity in the case of the Greek economy, that the emergence of the pandemic seems to have had a significant and positive impact on the adoption of digital practices. Of course, it should be noted regarding the structure of the digital maturity index that, for the case of Greece, all factors except Human Capital are particularly sensitive for the 2019–2022 period, unlike the Human Capital index which shows stability over time. This fact indicates that investment in the improvement of digital maturity indicators, on the one hand, requires a different time horizon per indicator to perform accordingly. On the other hand, it identifies the deeper changes on which the country should focus to keep up with European standards. Finally, it is clear that the impact of the pandemic restrictions, the introduction of distance transactions, and the introduction of new service practices without physical presence forced the Greek economy to improve twice as rapidly as the EU average – not because of the additional infrastructure, but mainly because of the significant lag in the previous period.

At the same time, it is noted that in both DESI and the Digital Transformation Scorecard, Greece lags behind its European partners in most areas related to digitization and digital workforce training, while it scores relatively highly in individual indicators related to businesses. The gradual increase in their digital maturity and the decrease in their distance from the European average is encouraging, and may indicate that Greek enterprises have already started their digital transformation. As regards the regional approach, the existence of significant differences in R&D intensity between regions is reported. Although they seem to be converging, these differences remain significant. The formulation of regional development policy, which has secured co-financed funds to support similar activities in the less developed regions, seems to have helped in this direction. Clearly, there is much room for improvement, as it is clear from the analysis that the more developed regions have better values for this index and that the specific weight of the developed regions in relation to the Greek average is also greater.

Next, it is clear that the rapid speed of technological change combined with Greece's low digital maturity creates an urgent need for the country to act immediately on multiple axes, in a synchronized manner, and within a limited time horizon, through the implementation of a holistic digital approach. Steps have already been taken in this direction, such as the important technological solutions developed very rapidly by the Ministry of Digital Governance to deal with the consequences of the COVID-19 pandemic. Therefore, it is crucial to formulate an immediate, coordinated, and organized approach through which Greece will be able to accelerate its digital transformation, thus improving its position in technology and innovation-related indicators.

In fact, given its low digital performance, Greece lacks valuable time to implement gradual and evolutionary digital strategies, as other digitally developed countries (e.g., Norway, Finland, the UK, etc.) have done. These countries started their digital transformation several years ago, when the pace of technological developments was still slow, by

implementing incremental steps that were periodically redefined to meet their changing national objectives and incorporate emerging digital technologies.

Next, with regard to the extroversion and specific weight of groups and individual industries, a stable allocation of export trade flows over time is shown, which seems to change somewhat during the pandemic period, but then there is a clear tendency to return to pre-COVID-19 levels. Moreover, it is noted that Greece appears to have a higher specific weight of exports in low-value-added and labor-intensive sectors, while in contrast, it has a lower specific weight in high-value-added and capital-intensive sectors. This fact explains to a certain extent one of the long-standing intersectional problems of the Greek economy, the so-called twin deficits,[1] as the deviation in the specific weight of high-value-added sectors may aggravate the already existing situation as, according to international literature, twin deficits are expected to remain high in 2022.

This work has a number of limitations. In principle, the data obtained refer to the 2017–2022 period, while there can be no data behind this period as the indicator has been transformed and applied uniformly for the EU from 2017 onwards. So, there is no historical data and no data from third countries. In addition, it is accepted that the digital ranking of a country also reflects the digital status of businesses, but this sometimes differs due to the presence of international enterprises, which incorporate high digital transformation practices in their business operation in countries with low digital rankings for other reasons, such as low tax burden, cheaper labor, cheaper raw materials, etc.

Of particular interest for future research is the examination of other macroeconomic aggregates in relation to a country's digital ranking indices, as well as the study of foreign trade policy formulation in relation to the degree of digital transformation. Another research approach could investigate the correlations between countries with a high degree of trade connections and their level of digital ranking.

In conclusion, digital technologies are radically changing all sectors of the economy, as the implementation and adoption of digital practices and the development of digital skills are no longer optional actions for businesses but key factors for survival. From the empirical results of the present research, it is evident that the degree of adoption of digital practices in the Greek economy, as far as the public sector is concerned, can be a decisive factor and a springboard for the strengthening of foreign trade in the Greek economy. The importance of this situation has even been recognized by the EU, which has already had a specific strategy for digitizing European industry since 2016 (Digitizing European Industry-DEI Strategy). This strategy aims to strengthen the EU's competitiveness in digital technologies and ensure that all European economic sectors will be able to take full advantage of digital innovations.

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1 Twin deficits can occur both in periods of increasing domestic economic activity and in periods of contraction. In the first case, the dominant factors are the increase in domestic demand (partly based on fiscal expansion) and low competitiveness; in the second case, the decline in exports is dominant (with fiscal expansion holding back recession to some extent) (Magoulios, 2007).

References

1. Alla Vasilevna, C., & Chernikova, N. M. (2019). Innovative Approaches to Determination of Economic Digitization in the Modern Stage of Enterprise Development. *Intellectual Economics*, *13*(2), 116–121. https://doi.org/10.13165/IE-19-13-2-02
2. Antonaios, D. (2022). *Extroversion of Greek economy-Exports* [Doctoral dissertation, University of Piraeus]. http://dx.doi.org/10.26267/unipi_dione/2066
3. Aslanov, H., & Mirzagayeva, S. (2022). The digitalization process: what has it led to, and what can we expect in the future? *Metafizika*, *5*(4), 10–21.
4. DESI. (n.d.). *Digital Scoreboard – Data & Indicators*. Retrieved February 9, 2023, from https://digital-agenda-data.eu/datasets/desi/visualizations
5. ELSTAT. (2022). *Foreign Trade / November 2022*. https://www.statistics.gr/el/statistics/-/publication/SFC02/2022-M11
6. European Commission. (n.d.). *The Digital Economy and Society Index (DESI)*. Shaping Europe's digital future. Retrieved February 5, 2023, from https://digital-strategy.ec.europa.eu/en/policies/desi
7. European Investment Bank. (2019). *Financing the Digitalisation of Small and Medium-sized Enterprises*. European Investment Bank. https://www.eib.org/en/publications/financing-the-digitalisation-of-smes-executive-summary
8. Eurostat. (n.d.-a). *Database*. Retrieved January 23, 2023, from https://ec.europa.eu/eurostat/data/database
9. Eurostat. (n.d.-b). *GERD by sector of performance*. Retrieved February 13, 2023, from https://ec.europa.eu/eurostat/databrowser/view/RD_E_GERDTOT__custom_4925860/default/table?lang=en
10. Eurostat. (2022). *Eurostat regional yearbook, 2022 edition, KS-HA-22-001-EN-N*. Luxembourg: Publications Office of the European Union.
11. Jurčević, M., Lulić, L., & Mostarac, V. (2020). The digital transformation of the Croatian economy compared with EU member countries. *Ekonomski Vjesnik*, *33*(1), 151–164. https://www.proquest.com/scholarly-journals/digital-transformation-croatian-economy-compared/docview/2422403017/se-2
12. Karamouzis, N. (2020, November 10). *Pandemic & economic recovery: The challenges ahead*. Grant Thornton Greece. https://www.grant-thornton.gr/insights/article/pandimia-kai-oikonomiki-anakampsi/
13. Kazantzidou, A. (2022). *Digital entrepreneurship at the post Covid-19 period. Development of digital versus traditional entrepreneurship, digitization and digital transformation of traditional industries. Multiple case studies in the fashion industry* [Unpublished master's thesis]. University of Macedonia. https://dspace.lib.uom.gr/handle/2159/26446
14. Khin, S., & Ho, T. C. (2019). Digital technology, digital capability and organizational performance: a mediating role of digital innovation. *International Journal of Innovation Science*, *11*(2), 177–195. https://doi.org.10.1108/IJIS-08-2018-0083.
15. Kraus, S., Durst, S., Ferreira, J. J., Veiga, P., Kailer, N., & Weinmann, A. (2022). Digital transformation in business and management research: An overview of the current status quo. *International Journal of Information Management*, *63*, 102466. https://doi.org/10.1016/J.IJINFOMGT.2021.102466

16. Kreutzer, R., Neugebauer, T., & Pattloch, A. (2018). Best Practices in Building a Digital Business Leadership. In *Digital Business Leadership* (pp. 219–260). Springer.
17. Magoulios, G. (2010). Foreign trade of Greece with the third countries of the Euro-Mediterranean partnership. *SPOUDAI-Journal of Economics and Business*, *60*(3–4), 7–34.
18. Magoulios, G., & Athianos, S. (2013). The trade balance of Greece in the Euro era. *Europe Journal of Economics*, *2*, 187–216.
19. Magoulios, G., & Chouliaras, V. (2014). The repercussions of the financial crisis (2008) on the foreign trade between Greece and the Balkan countries (BCs). In: A. Karasavvoglou & P. Polychronidou (eds.), *Economic crisis in Europe and the Balkans* (pp. 51–64). Springer. https://doi.org/10.1007/978-3-319-00494-5_4
20. Magoulios, G., Polychronidou, P., & Laskaridou, E. (2021). The Greek-Balkan economic cooperation during and after the economic crisis (2008–2018). A Comparative Analysis of GDP, Foreign Direct Investment. *Scientific Bulletin – Economic Sciences*, *20*(1).
21. Melnikas, B. (2013). Intellectualisation processes in the context of European integration: Needs and priorities for the development of the high technologies sector. *Intellectual Economics*, *7*(3), 275–288. https://doi.org/10.13165/IE-13-7-3-01
22. Mishchuk, H., Samoliuk, N., & Grishnova, O. (2019). ICT and economic growth: Links and possibilities of engaging. *Intellectual Economics*, *13*(1). https://ojs.mruni.eu/ojs/intellectual-economics/article/view/5066
23. Moskofidis, A., & Magoulios, G. (2022). View of the foreign trade of Greece and the EU during the economic crisis (2008) and the health crisis (2020). *Oeconomica Jadertina*, *12*(2), 65–87. https://morepress.unizd.hr/journals/index.php/oeconomicajadertina/article/view/3968/4750
24. National Bank of Greece. (2022). *Annual Financial Report for the Group and the Bank 31.12.2021*. https://www.nbg.gr/en/group/investor-relations/reports/annual-financial-report-for-the-group-and-the-bank-31-12-2021
25. National Documentation Centre. (2021). *Digital Transformation of Greek enterprises.* Athens: NDC.
26. National Documentation Centre. (2022). *The Digital Transformation of Greek Enterprises, 2018–2020: leading edge technologies.* Athens: National Centre for Documentation and Electronic Content.
27. OECD. (2020). *Regional Policy for Greece Post-2020.* Paris: OECD Territorial Reviews. https://doi.org/10.1787/cedf09a5-en
28. Papadopoulos, T., Baltas, K. N., & Balta, M. E. (2020). The use of digital technologies by small and medium enterprises during COVID-19: Implications for theory and practice. *International Journal of Information Management*, *55*, Article 102192. https://doi.org/10.1016/j.ijinfomgt.2020.102192
29. Parviainen, P., Tihinen, M., Kääriäinen, J., & Teppola, Susanna. (2017). Tackling the digitalization challenge: How to benefit from digitalization in practice. *International Journal of Information Systems and Project Management*, *5*, 63–77.
30. Potouris, P. (2017). *Digital transformation of business industries: Case study research* [Unpublished graduate thesis]. University of Macedonia. https://dspace.lib.uom.gr/bitstream/2159/20110/5/PotourisPanagiotisMsc2017.pdf
31. Priyono, A., Moin, A., & Putri, V. N. A. O. (2020). Identifying digital transformation paths in

the business model of SMEs during the COVID-19 pandemic. Journal of Open Innovation: Technology, Market, and Complexity, *6*(4), 104. https://doi.org/10.3390/joitmc6040104
32. Rupeika-Apoga, R., Petrovska, K., & Bule, L. (2022). The effect of digital orientation and digital capability on digital transformation of SMEs during the COVID-19 pandemic. Journal of Theoretical and Applied Electronic Commerce Research, *17*(2), 669–685. https://doi.org/10.3390/jtaer17020035
33. Shvertner, K. (2017). Digital transformation of business. *Trakia Journal of Science*, *15*, 388–393.
34. Skare, M., de Obesso, M. M., & Ribeiro-Navarrete, S. (2023). Digital transformation, and European small and medium enterprises (SMEs): A comparative study using digital economy and society index data. *International Journal of Information Management*, *68*, 102594. https://doi.org/10.1016/j.ijinfomgt.2022.102594
35. Singh, A., & Hess, T. (2017). How chief digital officers promote the digital transformation of their companies. *MIS Quarterly Executive*, *16*(1), 5.
36. SEV Observatory. (2022). *Digital and Technological Maturity of Economy and Enterprises.* Athens: 3rd annual edition. https://www.sev.org.gr/ekdoseis/psifiaki-kai-technologiki-orimotita-oikonomias-kai-epicheiriseon-3i-etisia-ekdosi-paratiritiriou-psifiakou-metaschimatismou-sev/
37. SEV, Flash Report. (2023). *Business Pulse 2022.* Athens: SEV. Retrieved from https://www.sev.org.gr/wp-content/uploads/2023/01/FlashReport_BP_2022_final.pdf
38. Vaska, S., Massaro, M., Bagarotto, E. M., & and Dal Mas, F. (2021). The digital transformation of business model innovation: A structured literature review. *Frontiers in Psychology*, *11*, 539363. https://doi.org/10.3389/fpsyg.2020.539363
39. Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Qi Dong, J., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, *122*, 889–901. https://doi.org/10.1016/j.jbusres.2019.09.022
40. Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, *28*(2), 118–144. https://doi.org/10.1016/J.JSIS.2019.01.003
41. Vinnychuk, O., Skrashchuk, L., & Vinnychuk, I. (2014). Research of Economic Growth in the Context of Knowledge Economy. *Intellectual Economics*, *8*(1), 116–127. https://doi.org/10.13165/IE-14-8-1-08