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Managing Efficiency in Digital Transformation – EU Member States Performance during the COVID-19 Pandemic

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Abstract

The COVID-19 pandemic context asserted the digitalization process in the European Union member countries five years forward (at least). The digital divide, a frequent debated issue was brought to the fore, and, under these circumstances, the proposed aim of the paper is to analyze the digitalization process, considering the data provided by Digital Economy and Society Index (DESI) and, additionally, the Stringency Index, that measure the governmental restrictions during the pandemic for 2020. From a methodological perspective, the empirical study focused on performing the Data Envelopment Analysis (DEA) non-parametric test. Measuring the digitalization efficiency or inefficiency of the European member states was conducted by using an output-oriented model, focused on output maximization for a given level of input, assuming Constant Returns to Scale (CRS). The results highlighted major discrepancies between the European countries. Solely eight countries out of 27 can be considered efficient in the digitalization processes during the COVID-19 pandemic. Based on the model, the most efficient EU countries could be considered peers/benchmarks for the inefficient ones, which should examine the best practices in order to improve their current situation.

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1. Introduction

Being a loudly debated topic over time, the digital transformation is currently considered one of the main pillars guiding the development of today's society and economy. Awareness of the importance of maximizing digitalization has been gradually intensified, as a result of identifying large clusters of undeniable benefits, often associated with increasing efficiency and the overall improvement of the processes carried out in any of the human being activities.

The concept of digital transformation is defined by complexity, given the context to which it is associated, through direct relationship with the Information and Communication Technology field, characterized by continuous and rapid development. The evolutionary definition has inevitably led to various meanings, as much as possible anchored in the existing reality at a certain moment in time. However, digital transformation as a process has been going on for more than three decades, since the late 1990's. A specific example in this regard is given by Schallmo et. al., which refer to the use of mass-media advertising campaigns between 1990 and 2000, as an important digital channel for the retail industry, even though the sale and purchase processes took place mainly in physical stores [1].

Naturally, the definition of digital transformation was initially focused on the use of digital technologies. Later, extended visions led to the usage of terms such as digitization or digitalization, which are often utilized today referring to digital transformation. Although the two terms mentioned are widely spread, it can be considered appropriate to focus on the concept of digitalization, the process itself being reflected by the pace of change in a society characterized by digital technological development, involving many technologies in different stages of maturity, which have the potential to converge and form new technologies [2].

Characteristics identified later led to changes in attempts to define the digital transformation, by overcoming the barrier given by the limitation to the simple use of digital technologies. This suggesting to the undoubted alignment of strategy and a wide range of factors, such as people, mentality, culture, leadership and talent development [3].

In their recent acceptance, encompassing multiple visions in an attempt to provide a unified definition, Gong and Ribiere described the concept of digital transformation as a fundamental change driven by digital technologies, with the main goal of improving and radically innovating an entity (referring to an organization, business network, industry or society). The authors also indicate the strategic capitalization of the key capabilities and resources of the mentioned entity through the digital transformation. Thus, digital transformation certainly represents a challenge, regardless of the area of development targeted [4].

Given the above-mentioned aspects, with a broad vision, the digital transformation process distinguish itself as a requirement whose fulfillment supports the progress and improvement of the competitive position in the activities and developments of the modern world. This statement is also determined by observing the current reality, highlighted by the constant efforts performed at countries level, aiming to obtain a favorable position in terms of digital progress.

Recent events that have affected the entire world, caused by the COVID-19 pandemic, have led, despite its adverse effects, to certain improvements in digitalization. Digital transformation has become, to some extent, a forced process, being, in some cases, the only possibility to ensure the continuity. The impetuous digital progress has definitely resulted as a main consequence of the restrictions imposed in a crisis defined by unpredictability and uncertainty. Undoubtedly, the association between the restrictions imposed in the context of the COVID-19 pandemic and the digital transformation represented and continues to represent a test of efficiency and capitalization of resources with the purpose of obtaining favorable results.

Under the previous discussed circumstances, the EU member states have undertaken considerable actions to maintain their digital position. Considering a declared competitive environment, the present research aims to measure the efficiency or inefficiency in terms of digitalization and to comparatively analyze the way in which the EU member states have managed to streamline their own resources (inputs) in order to maximize the targeted outputs, trying to improve their digital evolution.

In order to achieve the proposed aim, the article will be structured by taking into consideration a progressive research flow. Firstly, a brief review of the literature related to the digital transformation within the European Union will be carry out. Therefore, an empirical study based on Data Envelopment Analysis (DEA) method, will be performed, measuring the performance in terms of digitalization of the selected countries in the context of COVID-19 pandemic, by using two relevant indicators: the Digital Economy and Society Index (DESI) and the Stringency Index.
2. The Digital Transformation in the European Union

A phenomenon of real interest, digital transformation is one of the main objectives set for the development of the European Union, multiple measures and regulations being implemented in this regard. Unitary and individual actions, at country level, are continuously involved to streamline the digital progress of EU member states. According to the European Commission, the EU's digital strategy aims to ensure the transition process and the smooth running of digital transformation for both individuals and businesses, while contributing to the formation of climate-neutral Europe by 2050 [5].

In the context of the challenges caused by the COVID-19 pandemic, the relevance of the aforementioned goal is increasingly evident, the aim in question being presented in a different form in the 2030 Digital Compass: the European way for the Digital Decade, as represented by the pursuit of digital policies designed to empower individuals and businesses to benefit from a sustainable, more prosperous and human-centered digital future [6].

The European Commission's proposal to achieve the goals established for digitalization was to set up a Digital Compass, designed to monitor the EU's digital trajectory, as well as to identify the main challenges and gaps. The Digital Compass is formed by four cardinal points, the first two being related to digital capabilities in education & skills and infrastructure, and the other two taking into account the digital transformation in public services and business.

However, at European level, the digital progress of the member countries has been constantly monitored and analyzed, since 2014, through a well-known indicator, namely the Digital Economy and Society Index – the DESI Index. Initially focused on five key areas, in the most recent available report the DESI Index was adjusted, analyzing four dimensions four that match the four points of Digital Compass, namely: Human capital, Connectivity, Integration of digital technology and Digital public services [7]. The results obtained, based on data from 2020, certainly show progress in the digital transformation of all EU member states, but also highlighted an immense pressure on the capacity of digital connectivity networks due to the intensification of the use of public and private online services in the context of the COVID-19 pandemic [5].

The DESI ranking for 2021, based on 2020 data, characterizes Denmark, Finland, Sweden, and the Netherlands as leaders in digital progress in the EU, while Romania, Bulgaria and Greece are in the last positions. Figure 1 depicts the DESI overall index score per country based on the aggregate scores, considering the weighted score from 0 to 100.

An interesting aspect of the ranking refers to the fact that, despite the digital progress compared to the previous year, i.e. 2020 (based on 2019 data), some EU member states registered overall score was lower than the previous ones in the DESI ranking. Unquestionably, this may be due to the fact that the index has been adjusted and recalculated but can also bring into question the ability to digitally progress for countries such as Romania and Hungary, which requires the concomitant analysis of the ability to target existing resources aiming to improve digitalization. Considering the previous mentioned aspects, a starting point in understanding the actual situation of the analyzed countries can be represented by measuring the efficiency or inefficiency scores, using an empirical instrument that quantify the relative performance (in our case, data envelopment analysis).

![Fig. 1. The Digital Economy and Society Index 2021, by Aggregate scores – Data available at [7]](image-url)
3. Methodology

Building the research methodology had as starting point the main objective of the present research article, namely, to measure and compare the performance levels in terms of digitalization within the European Union countries (27 member states), in the context of the COVID-19 pandemic. Considering the specialty literature, applying Data Envelopment Analysis (DEA non-parametric test) can be considered advisable, as it provides relative efficiency of decision-making units (DMU) [8] [9] [10]. DEA represents a linear programming model, based on two types of data (inputs and outputs), that calculate the relative performance of similar units. Actually, by using the DEA method, it can be stated how much input reduction and/or output increase in inactive decision-making units [11], even if the parameters have different units [12]. By taking into account the research aim and the theoretical issues related to the DEA method, the present research was focused on performing an output-oriented model, considering an output maximization for a given level of input, while also assuming Constant Returns to Scale (CRS).

Based on the literature, the research proposal was oriented on identifying the extent to which a country can increase its outputs for a given level of input. The COVID-19 pandemic context imposed a fast digitalization process in the European countries (and not only). For analyzing the digitalization process, the data provided by Digital Economy and Society Index [5] was considered and, additionally, the Stringency Index [13], that measure the governmental restrictions during the pandemic for 2020. The selected variables were divided in two groups: (1) inputs (Stringency Index, Human Capital and Connectivity) and (2) outputs (Integration of Digital Technology and Digital Public Services). In order to perform the DEA method, an academic solution provided by University of Valencia was used (deaR: Data Envelopment Analysis in R) [14].

4. Results and Discussions

The new normality determined by the COVID-19 pandemic, bring to the fore the digitalization issues. In this context, the situation of the 27 EU member states in 2020 will be analyzed, by performing a data envelopment analysis (DEA). The research results will illustrate how efficient or inefficient are the European countries in managing the available inputs (Stringency Index, Human Capital and Connectivity), by analyzing the obtained outputs (Integration of Digital Technology and Digital Public Services). The information provided by DESI Index, discussed in the section 2 (The Digital Transformation in the European Union), are mapping the portrait of the digitalization in EU countries, while the Stringency Index provides an overview on the governmental regulations during the pandemic, that affected the digitalization process.

By calculating the efficiency scores based on the inputs and outputs, it can be decided if one DMU (country, in our case) is efficient or inefficient. A DMU’s efficiency is defined as the ratio of the sum of its weighted outputs to the sum of its weighted inputs, or, shortly, the report is equal with 1 [15]. When the result of input-output ratio is higher or lower than 1, the DMU is considered inefficient.

Table 1 illustrates the output-oriented efficiencies scores and, additionally, the optimal lambdas with benchmarks, for inefficient countries. The set of benchmarks provided by the R output suggests which other countries’ processes need to be taken into consideration in order to improve the practices of one inefficient country. In the RTS column (Returns to scale), recommendations regarding the future actions of each country in order to improve the efficiency score can be observed. Therefore, the countries considered efficient are highlighted with Constant on the mentioned column, in contrast to the inefficient ones (that must increase or decrease its scale (or size) aiming to minimize the average cost) [16].

Table 1. Efficiency scores and optimal Lambdas with Benchmarks.

| DMU | Output oriented efficiency | Efficiency Score (%) | Lambda Sum | RTS | Optimal Lambdas with Benchmarks |
|-----|---------------------------|----------------------|------------|-----|---------------------------------|
| AT  | 1.15731                   | 86.41                | 1.172      | Decreasing | 0.0422 IT 0.1737 LV 0.7486 LT 0.2075 MT |
| BE  | 1.0000                    | 100.00               | 1.0000     | Constant   | 1.0000 BE |
| BG  | 1.1032                    | 90.65                | 0.7792     | Increasing | 0.6458 LV 0.1334 LT |
| HR  | 1.17653                   | 85.00                | 0.9828     | Increasing | 0.3511 BE 0.1863 FI 0.4454 IT |
Considering the selected sample, based on data from 2020, only eight countries out of 27 can be considered efficient in terms of digitalization, by taking into account the research results (Figure 2a). The countries that used efficiently the input-output ratio are Belgium, Denmark, Estonia, Finland, Italy, Latvia, Lithuania and Malta. These efficiency optimal benchmarks or, in other words, examples, which should be seen as models oriented towards increasing the efficiency.

At the opposite pole, the most inefficient countries are Romania (61.03% efficiency), Hungary (65.01% efficiency) and Germany (69.78% efficiency). According to the existent reports, Germany face serious difficulties related to the integration of digital technologies, issue that is not related to the financial or economic dimension \[17\]. The Romanian situation represents a sum of factors: low level in human capital indicator, insufficient integration of digital technologies, issue that is not related to the financial or economic dimension \[17\]. The Romanian case. The Slovak and Greek examples fulfill the dashboard of inefficiency \[5\].

Additionally, each efficient DMU in a reference set can record different weights or intensities (lambda) \[14\]. Figure 2b, that highlights the efficient DMU’s references, provides a hierarchy of role models. The first rank is claimed by Italy, who can be marked as reference to 15 European countries in the process of implementing the digitalization. Malta, Latvia and Lithuania are also references for 13, 12 and, respectively, 11 other countries. The information related to the efficient benchmarks for each inefficient country are also available in Table 1, section Optimal Lambdas with Benchmarks, that highlights the models to be followed in with respect to increasing the efficiency in terms of using the existent inputs for the outputs maximization.

| Country | Lambda | Decreasing | Constant | Increasing | Country | Lambda | Decreasing | Constant | Increasing |
|---------|--------|------------|----------|------------|---------|--------|------------|----------|------------|
| CY      | 1.14375|            |          |            | FI      | 1.0000 |            |          |            |
| CZ      | 1.20154|            |          |            | EE      | 1.0000 |            |          |            |
| DK      | 1.0000 | 1.0000     | Constant |            | FI      | 1.0000 |            |          |            |
| EE      | 1.0000 | 1.0000     | Constant |            | FR      | 1.12472| 1.0006     | Decreasing|            |
| FI      | 1.0000 | 1.0000     | Constant |            | GR      | 1.40595| 0.8191     | Increasing|            |
| FR      | 1.12472| 1.0006     | Decreasing|            | HU      | 1.53824| 1.0398     | Decreasing|            |
| DE      | 1.43315| 1.2298     | Decreasing|            | IE      | 1.12603| 1.1945     | Decreasing|            |
| GR      | 1.40595| 0.8191     | Increasing|            | IT      | 1.0000 | 1.0000     | Constant  |            |
| HU      | 1.53824| 1.0398     | Decreasing|            | IT      | 1.0000 | 1.0000     | Constant  |            |
| IE      | 1.12603| 1.1945     | Decreasing|            | LT      | 1.0000 | 1.0000     | Constant  |            |
| IT      | 1.0000 | 1.0000     | Constant  |            | LV      | 1.0000 | 1.0000     | Constant  |            |
| IT      | 1.0000 | 1.0000     | Constant  |            | MT      | 1.0000 | 1.0000     | Constant  |            |
| NL      | 1.28186| 0.8191     | Increasing|            | MT      | 1.0000 | 1.0000     | Constant  |            |
| PL      | 1.27901| 0.9757     | Increasing|            | MT      | 1.0000 | 1.0000     | Constant  |            |
| PT      | 1.1572 | 0.9985     | Increasing|            | MT      | 1.0000 | 1.0000     | Constant  |            |
| RO      | 1.6385 | 0.9367     | Increasing|            | MT      | 1.0000 | 1.0000     | Constant  |            |
| SK      | 1.4157 | 0.9375     | Increasing|            | MT      | 1.0000 | 1.0000     | Constant  |            |
| SI      | 1.21753| 1.1449     | Decreasing|            | MT      | 1.0000 | 1.0000     | Constant  |            |
| ES      | 1.10737| 1.1901     | Decreasing|            | MT      | 1.0000 | 1.0000     | Constant  |            |
| SE      | 1.08125| 1.1314     | Decreasing|            | MT      | 1.0000 | 1.0000     | Constant  |            |
Clarifying the previous information, Figure 3 illustrates a network connection between the efficient (highlighted with green) and inefficient decision-making units (highlighted with red). This network brings out how the efficient countries can be seen as benchmarks by the inefficient ones, by comparing the reference set, described in Table 1. The countries that are efficiently using their inputs can be considered benchmarks (or peers) by the inefficient ones, since they represent the projection point on the efficient frontier to eliminate the inefficiency [13].

By analyzing the situation of the efficient countries, the inefficient ones can identify best practices in the process of reducing the inefficiency. For this reason, according to the specialty literature, performing a data envelopment analysis (DEA) is, consequently, a very strong benchmarking method [18]. The lambda intensity (weight), which can be observed in Table 1, associated with each benchmark (peer) match/correspond to its relative importance among the peer group. Therefore, the peers or the optimal benchmarks for the inefficient countries can be identified considering Figure 3, but also by the information provided by Table 1. Accordingly, Italy embodies the strongest significant influence, being a peer for 15 of 19 inefficient European countries. In this case, the most influent power should be exerted on Romania (lambda = 0.9252), Slovenia (lambda = 0.6176), Czech Republic (lambda = 0.6181) and Hungary (lambda = 0.4524). The second benchmark is Malta, with 13 inefficient countries that must follow its example. The highest lambda values related to Maltese influence are registered in Luxembourg (1.0656) and Netherlands (1.0038). All three Baltic states are digitally efficient. 13 European member states must consider Latvia a peer in their process of improving the digitalization process, especially Bulgaria (0.6458) and Spain (0.5789). Unlike Lithuania, which is a benchmark for 11 countries, including Austria (0.7486) and Germany (0.4964), Estonia quality of peer is very low.
and just for 2: France (0.1723) and Luxembourg (0.0587). Despite its efficient digitalization according to DEA results, Denmark does not represent a peer for others inefficient countries.

Taking into account the cases of the most three inefficient countries from the selected sample, based on the DEA, Romanian peers are Italy (0.9252) and Malta (0.0115), which means that, aiming at increasing its efficiency, Romania must consider the best practices used by the countries previously mentioned. The most significant influence is the Italian one, because registered the higher lambda intensity. For Hungary, the two strongest peer influences are exerted by Latvia (0.5313) and Italy (0.4524) and the weakest, by Malta (0.0561). Germany’s peers are Lithuania (0.4964), Malta (0.3719), Latvia (0.2318), and Italy (0.1297). Under these assumptions, the higher significance in the process of increasing the German efficiency in terms of digitalization is represented by following the Lithuanian and Maltese benchmarks.

Performing the data envelopment analysis (DEA) on measuring the digitalization process within the European Union during the COVID-19 pandemic, substantial discrepancies between the countries have been identified, discrepancies that were highlighted in the literature over the time [19]. Kamolov and Stepnov suggested that cohesion and inclusiveness should represent the main directions in developing an EU digitalization strategy [20]. The current research endeavor showed that, with only one exception (namely, Germany), the differences resulted from the digitalization level are translated in the economic gains and, furthermore, economic development [21].

An empirical study that proposed a divide between countries taking into consideration the digitalization level and the economic development identified four quadrants: the first quadrant is represented by the Eastern economies with a lower level of GDP than the average, but with a higher digitalization degree than that of most developing countries. The countries included in this category are Estonia, Czech Republic, Lithuania, and the Slovak Republic. The second quadrant, included in a list of countries with lower GDP values and lower levels in terms of digitalization and some Eastern countries (ex. Romania, Bulgaria). The next category is represented by countries with GDP and digital levels higher than the mean, as Denmark, Sweden, Italy, Finland etc. The last quadrant includes the countries with an above average GDP level but with a below average digitalization index [22]. Similar results are identified, also, by Yalcin [23].

Even though the COVID-19 pandemic accelerated the digitalization process five years forward [24] and a significant part of these changes will be kept in the future, the digital divide [25] is still an important debate subject, especially within European Union. In the specialty literature, a previous similar study that compares the digitalization process in United Europe member states with Russia, mainly identified similar results regarding the discrepancies between the European member-countries [26].

Summarizing the above exposed findings resulted by performing the Data Envelopment Analysis (DEA) within the European Union, it can be concluded that only 29.63% of the countries are efficient in output maximization for a given level of input, assuming Constant Returns to Scale (CRS). These eight countries represent benchmarks for the inefficient ones that should improve their results, following the recommended optimal peers.

5. Conclusions and Future Research Directions

With a broad view, it can be stated that the development of society and the global economy has as its main determining factor the ability to streamline resources in order to maximize the intended results. The previous-mentioned situation characterizes, among many other processes, the digital transformation.

The need to achieve digital performance currently represents a key condition for increasing the competitiveness of EU member states. In this regard, the efforts undertaken by decision makers, individuals, and the society, cannot be denied. However, transforming the EU into a unified digital environment is still a challenge. In an attempt to determine whether or not EU member states are digitally efficient in a context of crisis, the results of the present research can be summarized as follows:

- Despite the efforts performed over time at the EU level, only 8 member states managed to efficiently progress in terms of digitalization in the context of the COVID-19, while 70.37% faced challenging situations with respect to maximizing their digitalization results.
- Based on the data envelopment analysis (DEA) performed it was highlighted that the eight EU countries that are efficient in terms of digital transformation represent peers/benchmarks to other member states, and their actions can be considered examples of good practice.
• The gaps and challenges that have stood in the way of digitalization differ to some extent from one EU member state to another, which determines the need to adapt future measures implemented according to individual characteristics in the country.

The results of the present research can be considered both a starting point for practitioners in the field and a contribution in terms of research. However, the research limitations are being realized, consisting in the use of a single analysis method and the impossibility of determining, through it, the potential causes that have led to inefficiency in most EU member states. Under these circumstances, future research directions are shaping up with the aim of deepening research in order to identify as closely as possible the factors that should be improved and the methods of improvement needed to maximize the digital transformation in all EU countries.

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