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Determination of Digital Density Efficiency by Data Envelopment Analysis: EU Member States

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ABSTRACT

This study aims to determine the digital intensity levels, which are an indicator of the digital transformation performance of the countries. With this scope, the digital intensity efficiency levels of the European Union member countries were calculated by data envelopment analysis (DEA). The input-oriented Charnes Cooper and Rhodes (CCR-O) Model has been used to determine the digital intensity of the countries. The input criteria of the DEA model were obtained from the digital skills data in The Digital Economy and Society Index-2021 (DESI), and the output criteria were obtained from the digital intensity data of the same index. Digital content creation communication and collaboration, online information and communication, information and data literacy, problem-solving, and safety skills are input criteria for digital skills. Very low, low, high, and very high data were used as output criteria for digital intensity. According to the findings, Hungary, Spain, Slovakia, and Ireland are not at the full efficiency level. It is also stated in the study that input variables should be directed to reach the full efficiency level of the countries that are not at the full efficiency level. Accordingly, it was observed that Hungary, Spain, Ireland and Slovakia are not at the full productivity level. it can be said that these countries have digital skills but their digital intensity is not high. In this respect, it can be concluded that they do not make use of these skills sufficiently.

Keywords: Digital Skills, Digital Intensity, DESI, EU Member States

Veri Zarflama Analizi ile Dijital Yoğunluk Etkinliğinin Belirlenmesi: AB Ülkeleri

ÖZ

Bu çalışma ülkelerin dijital dönüşüm başarımının bir göstergesi olan dijital yoğunluk düzeylerinin belirlenmesini amaçlamaktadır. Bu doğrultuda Avrupa Birliği üye ülkelerin dijital yoğunluk etkinlik seviyeleri veri zarflama analizi (VZA) ile hesaplanmıştır. Ülkelerin dijital yoğunluk etkinlik düzeylerinin tespit edilmesinde çıktı odaklı Charnes Cooper ve Rhodes (CCR) Modeli kullanılmıştır. VZA modelinin girdi kriterleri Dijital Ekonomi ve Toplum İndeksi-2021 (DESI) içinde yer alan dijital beceriler veri setinden, çıktı kriterleri ise aynı indeksin işletmeler için dijital yoğunluk veri setinden elde edilmiştir. İletişim ve işbirliği, enformasyon ve veri okuryazarlığı, problem çözme, dijital içerik yaratma, güvenlik ve çevrimiçi bilgi ve iletişim becerileri girdi kriterleri olarak kullanılmıştır. Çok düşük, düşük, yüksek ve çok yüksek çıktı kriterleri olarak kullanılmıştır. Elde edilen bulgulara göre Macaristan, İspanya, Slovakya ve İrlanda'nın tam etkinlik düzeyinde olmadıkları söylenebilir. Tam etkinlik düzeyinde olmayan ülkelerin tam etkinlik düzeyine ulaşabilmek için hangi girdi değişkenlerine yönelmeleri gerektiği çalışmada ayrıca belirtilmektedir. Bu doğrultuda Hungary, Spain, Ireland ve Slovakia'nın tam verimlilik düzeyinde olmadıkları görülmüştür. Bu ülkelerin dijital becerilere sahip oldukları ancak dijital yoğunluklarının yüksek olmadığı söylenebilir. Bu doğrultuda söz konusu ülkelerin dijital becerilerden yeterince yararlanamadıkları sonucuna varılabilir.

Anahtar Kelimeler: Dijital Beceri, Dijital Yoğunluk, DESI, AB Üye Ülkeleri

1. Introduction

Information and communication technologies (ICT) have led to advancements in this era and caused digitalism. Digitizalition has led businesses and countries to invest in technology and use these investments effectively. To extent to which businesses include technologies such as customer relationship management and Enterprise Resource Planning software, complex website management, artificial intelligence, cloud computing, and the things of internet, which are among today's common technologies, is called Digital Intensity (DI).

DI is related to the technology usage capacity of a business or country, and it is essential for the competitiveness of the businesses and the country in which they operate. The higher effectiveness of digital intensity of a business or country indicates the higher the digital competitiveness of that business or country. But digital investments are not only enough for high DI effectiveness levels. So individual's' technology usage and adaptability capacity are critical to achieving the targeted DI level. Therefore, it can be said that DI activity is related to effectively using individuals' digital skills.

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The term DS means the skills of individuals in basic information literacy, software, hardware, and network. It is the usage of information technologies in the context of working, learning, social networking, and amusement in a confident, creative and critical usage (Ferrari et al., 2012). They refer to abilities such as using technology effectively, constant communication with customers and employees and being close to customers to gain a competitive advantage through differentiation (Toduk, 2014). DS is essential for employees to add value to the organizations they work for and to adapt to the digital transformation in the organization quickly. Additionally, the high DS level of the employees accelerates the digital transformation of the enterprises as it will make it easier for them to adapt changing that come with the transformation and increase the organization's competitiveness. Without DS, a country's transformation into a digital economy will remain a remote possibility (Maji & Laha, 2021). So DS is not essential for organizations to develop but also crucial in a digital world of industry and digital society (OECD, 2020).

This study aims to evaluate the digital intensity efficiency of EU member states with the DEA analysis. The input-oriented Charnes Cooper and Rhodes (CCR-O) Model has been used to determine the digital intensity of the EU states. Online information and communication skills; basic information and data literacy skills; basic communication and collaboration skills, and basic digital content creation skills are used as inputs of DS. The very low, low, high, and very high are used as the outputs of DI. The input and output datasets were gained from The Digital Economy and Society Index (DESI) that the EU published in 2021.

2. Conceptual Framework

2.1. Digital Skills

It is known as digitalization has constantly been changing in recent years, and these changes have a driving power in every sector. Therefore, qualified persons are needed to keep up with this change created by ICT, to use, develop, update and benefit from its services. Fast and widespread digitalization has transformed countries, organizations, and especially individuals by making DS a critical attribute for the current workforce with new skills that are called DS.

In other words, as digitalization influences, all stages of humanity and business, an employee with DS is required at all levels of an organization (Leahy & Dolan, 2014). As Westerman (2016) pointed out, "digital transformation needs a heart" and a vast majority of all jobs require at least DS on a fundamental level (Kane et al., 2015; Blount et al., 2016; Kluzer et al., 2020). DS provides businesses to be effective and efficient at R&D, marketing, sales, and distribution channels, enabling them to have an advantage over innovative competitors for quality, speed, and cost before, during, and after the production process (Schwab, 2017) and they drive organizations' competitiveness and innovation capacity (Van Laar, 2019). For that reason, individuals' DS in information and communication technology and their adaptation to technological developments in the businesses they work and in the societies in which they exist are of strategic importance for the economic and social growth of the countries. Also, the absence of DS can severely impact national production and the capability to innovate and adopt new technologies (Said, 2021). So DS is required at different levels for each individual, regardless of demographic characteristics, whether they are ICT professionals or not. They are also crucial in obtaining technology investments' expected benefit and efficiency.

DS subject is a new subject of academic literature, so the number of academic studies is limited. But the subject is interesting for international organizations, so some reports are based on international comparisons. The summary of these reports is below.

Table 1. Definitions of Digital Skills

Source	Skills
Ecorys UK (2016) Digital skills for the UK economy	Basic digital literacy skills, DS for the general workforce, DS for the ICT professions.
UNESCO Broadband Commission for Sustainable Development (2017)	Basic functional skills, Generic DS, Higher level skills
DigComp 2.1 (2017) (The Digital Competence Framework for Citizens-EU)	Information and data literacy; communication and collaboration; digital content creation; safety; problem-solving
OECD Skills Outlook 2019	Basic DS for citizens, e-business skills for entrepreneurs, professional DS for jobs in the technology sector, advanced DS for engineers, DS for policymakers and civil servants.
McKinsey The Future of Our Now (2020)	Technological skills, digital citizen skills, classical skills
PIAAC (2021) (Survey of Adult Skills)	Information-processing skills, literacy, numeracy, and problem-solving,
CEDEFOP (2021) (The European Skills and Jobs Survey)	Basic, moderate, and advanced skills
DESI (2021) (The Digital Economy and Society Index)	Basic skills; online information and communication; information and data literacy; communication and collaboration; digital content creation; safety, software domain, and problem-solving skills

Source: Created by the author

As seen from Table 1, the term "DS" is negotiable because measuring the skill is a combination of arduous and complex processes. These frameworks and indexes classify DS to usage levels as academic studies. For example, Wedlake et al. (2019) categorize the DS as communication, creation, gateway, information, online living, privacy and security skills with device ownership, and lifelong learning. According to Motyl et al. (2017), DS consists of all technology-linked skills, from main skills for all employees to special skills for ICT professionals. Van Laar et al. (2017) describe DS as a core that is technic, communication, teamwork, critical thinking, problem-solving, creativity skills, and conceptual that are ethical and cultural awareness, resilience, self-control, and lifelong learning. Also, each of these skills mentions the transfer of knowledge, mental and functional skills, and social and behavioral factors consisting of approaches, feelings, senses, views, and wishes (Ilomäki et al., 2011). Cunningham et al. (2022) classify DS as *basic* (usage of automated devices, sending-receiving e-mail, preparing for digital presentations, using basic spreadsheet functions, searching, managing, and storing digital and content), *intermediate* (using software for analytics, accounting, project management, marketing, social media, and big data analytics, web, and graphic design), and *advanced* (computer programming, cloud computing, managing network, AI, data science, cyber security, web development, search engine optimization) levels.

In line with these views, basic skills are considered fundamental to having DS. In the digital age, it is expected that everybody must have the basic skills required for daily life and employability routines. Concept also means the widely available and familiar technology applications. However, it should be noted that basic skills may change with the development of ICT. For example, twenty years ago, creating a website or using spreadsheets had been accepted as advanced skills, and their importance levels were very high but today, these skills are accepted as only basic skills. Also, traditional industries increasingly using digital technologies across different occupational categories will require new DS (Bashir & Miyamoto, 2020). So that with the development of ICT, different DS should be born, the importance-level of skills is changing and should change, and some of today's skills should die. Employees with a variety of digital competence and highly specialized degrees will require for both ICT and emerging ICT-intensive sectors, and it is a determinant of digital intensity.

DS is one of the main pillars of business strategy in increasing the competitiveness of employees by using ICT to access information and increase efficiency in business processes. It is about both using digital technologies and conveying to businesses what they need to know to handle the challenges and use the opportunities of the digital age (Friederici, 2022). It is also a person's competence determinant in applying ICT. Employees with DS will have a higher potential to adopt new technologies in the manufacturing sector (Marinas et al., 2021). DS is effective in 33% of digital transformation (Corejova & Chinoracky, 2021). So, the DS of the 21st century is the proficiency of ICT to deal with analytical and emotional tasks in organizations (Claro et al., 2012).

The increment in DS is significant for the economies of businesses and countries. For this reason, the national DS rising strategy is urgently need for improved labor participation, international competitiveness, female empowerment, and inclusive and fair access to digital economy gains (Chetty et al., 2017).

Thriving in e-business intensity, employees need DS, and businesses need digital-skilled employees. The skilled women workforce is essential to gain a competitive advantage for businesses and countries. Because according to The Gender Skills Gap Report 2021, women have less DS than men, and gender gaps are more likely in fields that require disruptive DS (Global Gender Gap, 2021). Men are four times more likely than women to know computer programming, and they are 25% times more likely to know how to use digital technology for essential purposes (UNESCO, 2019). The rate of women in the cloud-computing workforce is 14%, engineering is 20%, and data and AI-based workforce is 32% (WEF, 2021). With this view, OECD (2019) says that women work in more ICT task-intensive jobs, on average than men in most OECD countries. Therefore, when women's ICT skills increase, they will quickly adapt to these professions and be productive.

2.2. Digital Intensity

Digital intensity (DI) explains the relationship between the advanced usage of digital technologies and higher productivity. It is a measure to describe the ratio of digital applications and devices used in the routine to the entire applications and devices used in the routine (Gaskin et al., 2012) but measuring it is challenging because digitalization is a complex process and multifaceted phenomenon (Liu, 2021). It combines digital technologies with products, services, and processes to increase industrial and economic performance, gain a competitive advantage from existing resources, and reach extra capacity (Koch & Windsperger, 2017; Tamannum, 2021). It is assessed based on the technological components of digitalization, the human capital required to embed technology in production, and how digital technology impacts how businesses interface with the market (OECD, 2018). Their high DI determines the characteristics of digital businesses, which develop business activities, make different business models, and produce expansion and activities (Herman, 2022).

DI is also a measure of how much an organization invests in digital innovations. It identifies and explores how many digital opportunities businesses have identified and explored and also shows the community's skills to link rising and developing technologies (Nwankpa & Datta, 2017). DI has a tremendously positive effect on digital transformation, and technology-based acquisitions and digital investments have a highly positive effect on digital intensity (Mucha & Seppälä, 2021). DI provides communities and businesses with the necessary framework and potential to tap into to address the differences brought on by digital transformation and increase their efficiency. The degree of DI can illustrate how a state can mount and completely implement digital resorts into its activities (Datta & Nwankpa, 2021). However, DS changes and diversifies as the digital densities of businesses and countries increase in parallel with ICT. Therefore, ICT is driving an attractive force in the relationship between DS and DI.

2.3. The Digital Economy and Society Index

DESI measures the DS and DI of EU member states by indicators since 2014. Generally, DESI outlines significant indicators of EU member states' digital performance. It tracks their transformation across connectedness, human capital, internet use, digital technology integration, and automated public services dimensions (DESI, 2021). These dimensions are as follows;

Connectivity evaluates the distribution of broadband framework and capacity by fixed and mobile ADSL, broadband speed, and prices.

Human Capital measures the skills needed to adapt to the innovations brought by digital technology by internet users' skills, advanced skills, and development. DS is a sub-dimension of human capital and measures the skills required to be valuable possibilities suggested by digital society (Kamberidou & Pascall, 2020).

Use of internet describes various online actions, such as using online content.

Integration of digital technology calculates businesses' digitalization and e-commerce capacities.

Digital public services measure electronic administration, e-government, and public health.

Telecom sector, broadband take-up and coverage, broadband speeds and prices, mobile market, internet usage, audiovisual & media content, take-up of internet services, e-government, e-commerce, e-business, women in digital, ICT specialist, e-health, security and privacy, ICT sector, EU research and development programs, background variables, discontinued indicators and DS are the indicators that are divided into thematic groups that show some of the five critical dimensions of DESI. These indicators compare progress between European countries, and multiple interactive charts support states to check themselves (DESI, 2021).

DESI was used in some studies, especially for benchmarking the capabilities of countries. But they generally compare countries according to DESI dimensions or GDP per capita in EU economies (Vyshnevskyi et al., 2020; Parra et al., 2021; Yalçın, 2021; Turuk, 2021). Kiseľáková et al. (2021) examined the internet density of Hungary, Poland, the Czech Republic, and Slovakia. They found that Hungary, Poland, and Slovakia had the minimum intensity rates of digital technology; the human capital and connectivity dimensions are the frequently expressed dimensions of the DESI in these states (Kiseľáková et al. (2021). Chaaben & Mansouri (2017) used the i-DESI index for Tunisia to compare EU countries with the same indicators of DESI and measured the level of economic, digital, and social development of Tunisia. They found a score of 0.39 which shows that Tunisia is digitally poor performed comparing to the average of the EU member states (Chaaben & Mansouri (2017). Bánhidi et al. compared the Digital Economy in Russia with common-weights DEA models by DESI. According to this study, Russia is part of the last third of EU countries in digital intensity (Bánhidi et al., 2019).

3. Methodology

3.1. Units of Analysis

This research aims to establish the effectiveness of digital intensity in countries. The EU full member states are the sample of this research. Because their datasets about DS and DI are accessible. The 27 countries have been determined as decision-making units (DMU). The tables of the digital capabilities of these countries for 2021 were used to determine the digital intensity levels of 2021

Input and output criteria are selected from DESI 2021 index. Input criteria are indicators of DS indicator group. Below are indicators showing the capacity of the technological adaption of individuals between 16-74.

Communication and collaboration skills refer to communicating over the internet via e-mail, video calling, messaging, social networks, conveying political and personal opinions, and taking part in online consultations.

Information and data literacy skills involve reading online news sites, newspapers, or news magazines, verifying the information and resources written in these channels, and searching for health information.

Problem-solving skills indicate downloading and installing applications; changing the application's settings or device; online purchases in the past year; online learning resources used; use of internet banking, including capabilities for job search or job submission.

Digital content creation skills involve using a word processor and spreadsheet software; editing photo, video, or audio files; copying or moving files across folders, devices, or the cloud; creating files containing text, images, tables, charts, animations, or sound; editing, analyzing, structuring dataset, and writing code in a programming language.

Safety skills mean being able to check the website's safety, read and understand privacy statements, restrict access to current geolocation, limit access to profiles or content on social networking sites, refuse to allow the use of personal data for advertising purposes, prevent cookies, and change internet browser settings.

Online information and communication skills include a minimum of one variable from the information and data literacy and communication and collaboration skills.

Output criteria are one of the indicators called DI score for Enterprises of the e-business indicator group. As an output criteria DI indicator that is about how many of the technologies as using ERP and

CRM software, having a website, having a website with some complex functions, supplying a portable device to at least 20% of its employees, persons employed, which were provided a portable device by their employer, using two or more social media, using and buying sophisticated or intermediate cloud computing services, using AI technologies are used by enterprises (Leogrande et al., 2022). Regarding the number of uses of these technologies by businesses, countries were graded according to four clusters. Their digital intensity is calculated as very low (scores 0-3), low (scores 4-6), high (scores 7-9), and very high (scores 10-12) (DESI, 2021).

3.2. Data Envelopment Analysis

In this study, Data Envelopment Analysis is used to calculate efficiency values based on inputs and outputs and output-oriented DEA was preferred. DEA is a non-parametric mathematical programming method that provides information about the relative efficiency of decision-making units (Polat et al., 2022). The main reason for this preference is to ensure maximum output in determining the digital intensity activities of countries. Output-oriented CCR analysis (Charnes Cooper and Rhodes) aims to maximize the ratio of outputs to inputs (Kara, 2022). In addition, weighted data are used in calculations (Charnes et al., 1978).

The objective function of the output-oriented CCR model is in Equation 1, and the Dual model is in Equation 2.

$$\min e_k = \sum_{i=1}^{m} v_i x_{ik} \tag{1}$$
$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} \geq 0 \quad j = 1, \dots, n$$
$$\sum_{r=1}^{s} u_r y_{rk} = 0$$
$$u_r, v_i \geq 0; \; r = 1, \dots, s; \; i = 1, \dots, m$$
$$Max\ Z_k \tag{2}$$
$$\sum_{j=1}^{n} \varphi_{jk} x_{ij} - x_{ik} \leq 0$$
$$z_k y_{rk} - \sum_{r=1}^{s} \varphi_{jk} y_{rj} - x_{ik} \leq 0$$
$$\varphi_{jk} \geq 0; \; r = 1, \dots, s; \; i = 1, \dots, m; j = 1, \dots, n$$

Six input and four output variables were used to calculate the digital density efficiency level of the countries. The indices and parameters of the DEA model are as follows:

Indices:

i	Digital skills input	i = 1,…,m (m=6)
r	Digital intensity output	r = 1,…,s (s=4)
j	Countries	j = 1,2…,n (n=27)

Parameters:

v_i : "i" weight given to Digital skills input.

u_r : "r" weight given to Digital intensity output.

x_{ik} : "k" score of the "i" Digital skills input of the decision unit.

y_{rk} : "k" score of the "r" Digital intensity output of the decision unit.

$v_i x_{ij}$: "j" Countries weighted input score.

$u_r y_{rj}$: "j" Countries weighted output score.

3.3. Results

To determine the DI efficiency of the countries, a DEA model was created based on the DS of individuals. The input variables of the DEA model were determined as individuals' digital abilities, and the output variables were accepted as the digital intensity scores of the countries. The output-oriented CCR model was applied in the empirical research. The features of the CCR-O model are in Table 2.

Table 2. Features of the DEA Model

	Model Features
Model Name	Efficiency analysis of DS on e-businesses' digital intensity (EU Member States)
Model Type	CCR-O
Model Orientation	Output-Oriented
Model Efficiency Type	Tech
Model RTS	Constant
Model Description	The Charnes Cooper and Rhodes Model is called CCR.

The raw data of the input and output variables in the DEA model are in Table 3. The input variables are; online information and communication skills (I1), information and data literacy skills (I2), communication and collaboration skills (I3), digital content creation skills (I4), safety skills (I5), and problem-solving skills (I6). The output variables are: Very low (O1), low (O2), high (O3), and very high (O4). The data of the input variables were obtained from the DS Indicator group of DESI. The data of the output variables were obtained from the e-Business Indicator group of DESI.

Table 3. Raw Data of Inputs and Outputs

DMU Name	I1	I2	I3	I4	I5	I6	O1	O2	O3	O4
Austria (AT)	1.40	82.10	89.52	72.62	75.53	90.64	34.64	36.88	22.49	5.97
Belgium (BE)	1.87	84.25	90.84	64.16	63.63	93.82	33.69	38.09	25.92	2.28
Bulgaria (BG)	8.63	64.34	72.07	43.29	48.17	64.85	73.91	17.66	7.58	0.83
Cyprus (CY)	5.94	87.74	89.45	61.67	69.65	82.49	33.15	41.07	22.95	2.81
Czechia (CZ)	1.48	87.30	87.27	65.27	74.87	95.07	45.97	33.50	16.92	3.59
Denmark (DK)	0.22	96.70	98.73	72.32	84.37	98.82	20.08	36.71	33.22	9.97
Estonia (EE)	1.44	88.74	88.54	66.19	67.13	95.27	45.20	35.93	16.54	2.31
Finland (FI)	0.55	96.23	96.12	83.43	91.10	98.83	17.78	35.42	36.29	10.49
France (FR)	0.78	82.56	90.33	76.83	75.05	95.26	51.92	34.29	13.04	0.73
Germany (DE)	1.82	75.6	86.02	62.32	65.81	89.09	40.10	34.73	20.90	4.25
Greece (EL)	4.99	75.93	76.08	61.29	59.17	83.55	60.75	22.17	13.98	3.07
Hungary (HU)	4.55	85.38	87.48	57.04	66.10	85.49	64.21	24.05	10.11	1.57
Ireland (IE)	3.26	96.28	98.53	77.20	82.18	95.25	34.91	36.52	23.79	4.76
Italy (IT)	3.95	70.42	78.83	55.06	57.64	82.83	39.19	40.77	17.73	2.298
Latvia (LV)	1.80	86.68	89.11	65.49	64.48	94.38	60.73	25.50	11.87	1.88
Lithuania (LT)	5.42	85.42	84.33	61.84	59.01	88.82	42.20	36.38	17.65	3.75
Luxembourg (LU)	0.76	86.82	95.23	76.8	75.01	93.97	44.93	33.59	19.37	2.09
Malta (MT)	1.42	84.90	86.56	70.47	74.92	89.81	26.87	33.32	30.21	9.59
Netherlands (NL)	0.15	93.67	94.89	81.64	86.68	98.90	23.96	39.41	34.46	2.15
Norway (NO)	0.24	97.94	99.00	85.68	86.37	98.90	22.38	39.41	31.30	6.89
Poland (PL)	5.01	80.66	79.31	55.52	51.59	84.90	58.47	27.10	12.07	2.34
Portugal (PT)	2.87	76.14	80.02	60.86	71.40	83.40	47.10	32.34	17.53	3.012
Romania (RO)	10.79	64.58	81.31	39.30	46.30	59.27	76.53	17.32	5.52	0.61
Slovakia (SK)	2.95	82.90	85.67	70.99	61.58	89.53	55.73	27.71	13.97	2.57
Slovenia (SI)	3.78	85.54	86.26	66.99	57.28	88.75	43.65	31.29	20.31	4.72
Spain (ES)	2.71	87.23	93.20	72.33	76.4	89.28	39.56	35.02	21.95	3.46
Sweden (SE)	0.54	91.52	94.79	75.98	77.04	98.13	13.61	38.96	37.93	9.48

The correlation relationship between the input and output variables used in the DEA model is shown in Table 4. It is seen that the relationship between all input variables and output variables is significant. The correlation relationships are as follows:

- The relation between I1 and O1 is positive, and the relations between I1 and the other outputs are negative. The highest correlation is between I1 and O1 (0.717).
- The relation between I2 and O1 is negative, and the relations between I2 and the other outputs are positive. The highest correlation is between I2 and O1 (- 0.727).
- The relation between I3 and O1 is negative, and the relations between I3 and the other outputs are positive. The highest correlation is between I3 and O1 (- 0.719).
- The relation between I4 and O1 is negative, and the relations between I4 and the other outputs are positive. The highest correlation is between I4 and O1 (- 0.752).

- The relation between I5 and O1 is negative, relations between I5 and the other outputs are positive. The highest correlation is between I5 and O3 (0.788).
- The relation between I6 and O1 is negative, relations between I6 and the other outputs are positive. The highest correlation is between I6 and O1 (- 0.728).

Table 4. Correlation Between Variables

Var.	Mean	Std. Dev.	I1	I2	I3	I4	I5	I6	O1	O2	O3	O4
I1	2.94	2.61	1									
I2	84.36	8.86	- 0.718**	1								
I3	88.13	7.06	- 0.698**	0.884**	1							
I4	66.77	11.07	- 0.864**	0.848**	0.830**	1						
I5	69.20	11.87	- 0.800**	0.820**	0.845**	0.885**	1					
I6	89.23	9.49	- 0.935**	0.867**	0.768**	0.889**	0.783**	1				
O1	42.64	16.52	0.717**	- 0.727**	- 0.719**	- 0.752**	- 0.787**	- 0.728**	1			
O2	32.78	6.63	- 0.663**	0.613**	0.626**	0.651**	0.651**	0.696**	- 0.867**	1		
O3	20.58	8.79	- 0.680**	0.718**	0.712**	0.743**	0.788**	0.679**	- 0.969**	0.734**	1	
O4	3.98	2.90	- 0.503**	0.562**	0.503**	0.542**	0.608**	0.492**	- 0.774**	0.422*	0.805**	1

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Twenty-seven countries were used as the empirical sampling area. The OSDEA program was used to test the efficiency scores of the countries' DI. The DI levels of countries are shown in Table 5 according to DEA results. According to this table, it has been determined that a total of 23 countries are at full efficiency level and Hungary, Ireland, Slovakia, and Spain are not at full efficiency level.

Table 5. Digital Intensity Efficiency Levels of Countries

Country	Objective Value	Efficient
Austria (AT)	1	Yes
Belgium (BE)	1	Yes
Bulgaria (BG)	1	Yes
Cyprus (CY)	1	Yes
Czechia (CZ)	1	Yes
Denmark (DK)	1	Yes
Estonia (EE)	1	Yes
Finland (FI)	1	Yes
France (FR)	1	Yes
Germany (DE)	1	Yes
Greece (EL)	1	Yes
Hungary (HU)	0.996957321	
Ireland (IE)	0.904194571	
Italy (IT)	1	Yes
Latvia (LV)	1	Yes
Lithuania (LT)	1	Yes
Luxembourg (LU)	1	Yes
Malta (MT)	1	Yes
Netherlands (NL)	1	Yes
Norway (NO)	1	Yes
Poland (PL)	1	Yes
Portugal (PT)	1	Yes
Romania (RO)	1	Yes
Slovakia (SK)	0.994652724	
Slovenia (SI)	1	Yes
Spain (ES)	0.966601649	
Sweden (SE)	1	Yes

For Hungary, Ireland, Slovakia, and Spain to reach the full efficiency level, there must be changes in the scores of the input and output variables. These values are accepted as the countries' targets shown in Table 6.

Table 6. Projection Values of Input and Output Values

DMU Name	I1	I2	I3	I4	I5	I6	O1	O2	O3	O4
HU	4.551	77.992	82.827	57.045	58.743	83.408	64.408	24.132	10.929	1.580
IE	3.266	86.907	92.957	70.048	74.357	95.252	38.617	40.390	26.317	5.270
SK	2.958	81.542	85.676	61.530	61.584	89.532	56.038	27.860	14.155	2.583
ES	2.713	81.591	85.936	66.287	73.403	89.280	40.928	36.234	22.710	3.580

According to Table 6, countries should do the following to reach full efficiency.

- Hungary needs to reduce the I2 (approximately 10%), the I3 (approximately 5%), the I5 (approximately 12%), and the I6 (approximately 3%) to reach full efficiency. Accordingly, approximately a 1% increase will be achieved in the O1, O2, and O4, and approximately 8% in the O3.
- Ireland needs to reduce the I2 (approximately 10%), the I3 (approximately 5%), the I4 (approximately 10%), and the I5 (approximately 10%) to reach full efficiency. Accordingly, approximately a 10% increase will be achieved in the O1, O2, O3, and O4.
- Slovakia needs to reduce the I2 (approximately 2%) and the I4 (approximately 14%) to reach full efficiency. Accordingly, approximately a 1% increase will be achieved in the O1, O2, O3, and O4.
- Spain needs to reduce the I2 (approximately 7%), the I3 (approximately 8%), I4 (approximately 9%), and the I5 (approximately 4%) to reach full efficiency. Accordingly, approximately a 4 % increase will be achieved in the O1, O2, O3, and O4.

Reference countries are determined for countries to reach their digital densities to full efficiency level. Reference countries and Lambda (λ) values are in Table 7.

Table 7. Lambdas (λ) and Peer Groups of Countries

DMU Name	BG	CY	CZ	DE	IT	LV	MT	NL	PL	PT	RO	Peer Groups
HU	0.37		0.02		0.07	0.53					0.06	BG, CZ IT,LV, RO
IE		0.007			0.48		0.39	0.15				CY, IT, MT, NL
SK	0.07			0.25		0.46	0.007		0.19	0.0002		BG,DE, LV,MT, PL, PT
ES	0.03				0.21		0.13	0.19		0.45		BG, IT, MT, NL, PT

As a result of the DEA model analysis, the weights of the input and output variables are shown in Table 8.

Table 8. Weights of Input and Output Variables

Country	I1	I2	I3	I4	I5	I6	O1	O2	O3	O4
AT	0.04526	0	0	0	0.00218	0.00850	0.01076	0.01256	0	0.0274051
BE	0.03601	0	0	0	0.00256	0.00819	0.00840	0.00996	0.01264	0.0041442
BG	0.04253	0	0	0	0.00216	0.00814	0.01036	0.01195	0	0.0271377
CY	0.01764	0	0	0	0	0.01085	0.00752	0.01038	0.01411	0
CZ	0.04567	0	0.00574	0	0.00187	0.00305	0.01041	0.01235	0	0.0297644
DK	0.03399	0	0	0.00055	0	0.00963	0.00372	0.01869	0	0.0239638
EE	0.04317	0	0.00789	0	0.00236	0.00083	0.01038	0.01217	0.00231	0.0237283
FI	0.02508	0	0	0	0	0.00997	0.00048	0.01296	0	0.0507278
FR	0.04482	0	0	0	0.00216	0.00842	0.01065	0.01244	0	0.0271386
DE	0.04597	0	0	0	0.00222	0.00863	0.01092	0.01276	0	0.0278347
EL	0.04146	0.00503	0.00247	0	0	0.00266	0.01159	0.00818	0	0.0370054
HU	0.04788	0	0	0.01376	0	0	0.01059	0.01155	0	0.0264122
IE	0.01834	0	0	0	0	0.01098	0.00770	0.01029	0.01426	0.0032630
IT	0.04270	0	0.00051	0	0.00251	0.00779	0.01059	0.01288	0	0.02582003
LV	0.04412	0	0	0	0.00213	0.00829	0.01048	0.01225	0	0.026716876
LT	0	0	0.00301	0.00146	0.01110	0	0.00644	0.01404	0	0.0578303

LU	0.053465	0	0	0	0.00083	0.00953	0.01065	0.01016	0.00774	0.0142242
MT	0.035478	0.0111	0	0	0	0	0.00379	0.01719	0	0.0338671
NL	0.073826	0.0105	0	0	0	0	0	0.02524	0	0.0023180
NO	0.050219	0	0	0	0	0.00998	0.00736	0.01305	0.00829	0.0088627
PL	0.037778	0	0.00291	0	0.00261	0.00523	0.01034	0.01201	0	0.0296500
PT	0.045446	0	0	0	0.00219	0.00853	0.01080	0.01261	0	0.0275167
RO	0.035024	0	0	0	0	0.01049	0.00959	0.01486	0.00142	0
SK	0.038268	0	0.00315	0	0.00257	0.00517	0.01056	0.01189	0	0.0317790
SI	0.033269	0	0	0	0.00672	0.00550	0.00966	0.00973	0.00850	0.0213639
ES	0.023511	0	0	0	0	0.01087	0.00842	0.01014	0.01363	0.0035108
SE	0.031272	0	0	0	0	0.01001	0.00352	0.01865	0	0.0237315

According to Table 8, the input and output variables used to maximize the CCR-O objective function are as follows:

- I1 is not considered for calculating Lithuania's efficiency level but I1 is used calculating the efficiency level of other countries.
- I2 is used for calculating the efficiency level of Greece, Malta, and the Netherlands but I2 is not considered for calculating the efficiency level of other countries.
- I3 is used for calculating the efficiency level of Czechia, Estonia, Greece, Italy, Lithuania, Poland, and Slovakia but I3 is not considered for calculating the efficiency level of other countries.
- I4 is used for calculating the efficiency level of Denmark, Hungary, Lithuania, Italy, and Lithuania but I4 is not considered for calculating the efficiency level of other countries.
- I5 is not considered for calculating the efficiency level of Cyprus, Denmark, Finland, Greece, Hungary, Ireland, Malta, Netherlands, Norway, Romania, Spain, and Sweden but I5 is considered for calculating the efficiency level of other countries.
- I6 is not considered for calculating the efficiency level of Hungary, Lithuania, Malta, and the Netherlands but I6 is considered for calculating the efficiency level of other countries.
- O1 is not considered for calculation of the efficiency value of the Netherlands but it is used for calculating the efficiency level of other countries.
- O2 is used for calculating the efficiency level of all countries.
- O3 is used for calculation of the efficiency value of Belgium, Cyprus, Estonia, Ireland, Luxembourg, Norway, Romania, Slovenia, and Spain but it is not considered for calculating the efficiency level of other countries.
- O4 is not considered for calculation of the efficiency value of Cyprus and Romania but it is used for calculating the efficiency level of other countries.

4. Conclusion

DS of individuals has a strategic role in increasing the DI activities of the businesses and countries where they work and in accelerating the digital transformation processes. In other words, investing in digital technologies to increase DI, and increase DS is related to the strategic actions of countries and it is a characteristic of strong organizations and countries with high DS (D'Aveni, 1989). According to the results of this study, it has been concluded that the DI of 24 EU member states is effective. These results are compatible with the value of digital skills grew between 2016 and 2021 by an amount equal to 14.28% in Europe (Leogrande, 2022). However, Hungary, Ireland, Slovakia, and Spain which cannot reach full efficiency levels. Studies that cluster EU countries according to their digital skills indicate that Hungary, Spain and Slovakia are in the same DS group (Aniela et al., 2019; Leogrande, 2022). These results confirm the conclusion that while Europe outperforms other world regions in digital skills on average, significant intra- and inter-country disparities persist (Kessel, et al., 2022).

According to Corejova & Chinoracky (2021) a high potential for digital transformation was observed at the turn of 2010/2011 in Hungary. But the structural changes in skills, occupations are not sufficient today's digital transformation (Cserhati & Pirisi, 2020). Hungary underperforms in digitization and is well below the EU average (Endrodi-Kovacs & Stukovszky, 2022). When information and data literacy (approximately 10%), communication and collaboration (approximately 5%), safety (approximately 12%), and problem-solving (approximately 3%) skills in Hungary are reduced, the output of high will rise. So the DI of Hungary will reach the expected full efficiency level. The rise of Hungary's digital intensity will make a more significant contribution to national exports (Trască et al., 2019) and increase its competitive power with other EU countries in digital transformation and will adapt Industry 4.0. In this context, it can be said that women have information and data literacy, communication and collaboration, safety, and problem-solving skills, but these abilities are not used effectively enough in Hungary. In other words, the digital abilities of women are too high for Hungary's current digital intensity level. In addition, Hungary should take precedence in Bulgaria, Czechia, Italy, Latvia, and Romania to achieve full efficiency.

When information and data literacy (approximately 10%), communication and collaboration (approximately 5%), digital content creation (approximately 10%), and safety (approximately 10%) skills in Ireland are reduced, all outputs will rise. In other words, it can be said that women in Ireland have more skills in information and data literacy, communication and collaboration, digital content creation, and safety than in current technology usage. Despite the ups and downs of the Irish economy, there are gradual dramatic changes in the evolving picture of women in the IT sector (Trauth, 1995; Synnott et al., 2020; Trauth & Connolly, 2021). With this scope Ireland can achieve full efficiency level as well, Cyprus, Italy, Malta and the Netherlands need to prioritize the reference levels.

For Slovakia to reach full efficiency, information and data literacy needs to be reduced by about 2% and digital content creation skills by 14%. Accordingly, all output levels will increase by 1%, and the DI of Slovakia will increase. In this case, it can be said that the information and data literacy and digital content creation skills of women in Slovakia are above the current digital density. Slovakians have a good level of digital skills (Ondrejkova, 2015) and there was a decrease in basic digital skills in 2020 (Stofkova et al., 2022).

Malta, Bulgaria, Germany, Latvia, Poland and Portugal should prioritize reference levels in order for Slovakia to reach full productivity levels.

For Spain to reach full efficiency, information and data literacy needs to be reduced by 7%, communication and collaboration by 8%, digital content creation by 9%, and safety skills by 4%. Accordingly, all output levels will increase by 4%, and this country will use the criteria that determine the DI level more effectively. Also, low-educated women are however more disadvantaged than men as regards digital skills in Spain (Prieto & Valenduc, 2016) and the gender gap in basic and pervasive DS is minimal, but women are significantly disadvantaged in more complex and less generalized tasks (Martinez-Cantos, 2017). So Spain should take precedence Malta, Bulgaria, Italy, the Netherlands, and Portugal to reach full efficiency level and give importance for women education.

In general, the information and data literacy skills of women in all countries except Greece, Malta, and the Netherlands are complete. Also, the digital content creation skills of women in Denmark, Hungary, Italy, Lithuania, Poland, and Slovakia are complete, too. With this context, it can be stated that these abilities are common in the EU compared to other abilities. The information and communication skills are not effective except in Lithuania, so it can be said that women in these countries are not fully skilled in seeking health-related information; reading online news sites, newspapers or news magazines, activities related to online fact-checking information and its sources, sending/receiving e-mails, telephoning/video calls over the internet; instant messaging, participating in social networks, expressing opinions on civic or political issues on websites or in social media, taking part in online consultations or voting to define civic or political issues.

According to their arrangement on DESI, Ireland is 10th, Spain is 12th, Slovakia is 22th, and Hungary is 26th. These countries have more digital skills than the other EU countries, but their DI efficiency levels are low. So they should prefer that instead of improving women's digital skills, they should increase their use of technologies that determine DI. As Krchová and Höesová (2021) pointed out although digital transformation is fundamentally changing the content and nature of jobs and the skills needed to perform them, in many developed economies, there is still a significant gender gap in the access, use, and ownership of digital technologies, which limits the equitable use of the benefits of digital transformation. This opinion is in line with the view that, although Europeans have the right and sufficient technological infrastructure, they do not have the necessary digital skills to take full advantage of digital transformation (Porubčinová & Novotná, 2020).

This study is limited to EU member countries only, and it is among the limitations. This is because other countries' DS and DI data are not accessible. The research datasets have been obtained from the DESI index for 2021. The number of studies that used DESI is insufficient. So it is a limitation for referencing and comparing the results. It is recommended that countries considering expanding their operations worldwide increase their digital intensities and digital skills enabling the use of digitalization tools. Also it is suggested to evaluate the existence of a difference between men and women and whether these differences affect DI effectiveness. DI effectiveness can be compared before and after the Covid-19 pandemic.

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Yazarların çalışmadaki katkı oranları %100 şeklindedir.
The authors' contribution rates in the study are %100 form.

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Çalışmada herhangi bir kurum veya kişi ile çıkar çatışması bulunmamaktadır.
There is no conflict of interest with any institution or person in the study.

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