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Enterprises' use of cloud computing services. Disparities and similarities in the European Union in 2021

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Abstract. The continuous adaptation to the changes brought by new technologies in society and the rapid integration of intelligent tools in the business processes are essential for obtaining the competitive advantage in the market by offering companies the ability to move from operations to innovation. Cloud computing provides the companies the innovative technologies for connected and smart businesses. Although the Internet access of companies in the European Union is high (98% of companies), the average use of cloud computing in 2021 was only 41%. The purpose of the article is to evaluate and compare the use by enterprises in European Union countries of cloud computing services. The results indicate that within the 27 Countries of the European Union, the stages of use of cloud computing services in enterprises recorded significantly different levels from one state to another, both in 2020 and 2021. A negative fact is to maintain the gap between the states with the highest shares of companies using cloud computing services, Sweden and Finland (75%), and those with the lowest shares, Romania (14%) and Bulgaria (13%).

Keywords: *cloud computing, digital strategy, European Union*

Introduction

The digitalization is profoundly changing companies' methods of producing and delivering goods and services and offering new perspectives for business and entrepreneurship. Trașcă et al. (2019) mention that digitalization is an important ingredient for increasing the added value generated by SMEs and digitalization tools contribute to the economic performance of firms.

The challenges posed by the large volume of data, the high costs related to the IT infrastructure (hardware, software, specialists) can be overcome by companies by joining cloud computing, which offers more accessibility, scalability and flexibility. With the help of cloud computing service providers, companies can access the computing applications and resources needed to run their activities by paying only for what they need.

Depending on the volume of management required by the customer and the level of security provided, there are the following types of cloud computing:

a) Public – the cloud provider offers at its headquarters the computing infrastructure and offers the services requested by the customer through the internet. The correct implementation of the public cloud leads to a level of Security similar to that of the private cloud
b) Private – the cloud provider offers, according to the customer's wishes, the computing infrastructure either on its premises or on-site. The level of Security and control is high.
c) Hybrid—the combination of the public and private clouds
d) Multi – cloud – the use of multiple cloud computing and storage devices in a single network architecture.

Depending on the services offered by the cloud computing provider to its client, the following models of cloud computing services meet:

a) On – premise – the data center is owned by the customer. The advantage is ensured by the maximum control over the IT infrastructure, but the service is expensive in terms of time and money.
b) Infrastructure-as-a-Service (IaaS) - the cloud computing provider owns the physical equipment, and the customer can use the resources and services shared via the Internet.
c) Platform-as-a-Service (PaaS) - the cloud computing provider manages and maintains the IT infrastructure, the user has access to the creation and implementation of applications.
d) Software-as-a-Service (SaaS) - the cloud computing provider provides customers with a fully managed application (development, maintenance, update) and payment is made according to use.

Moving away from traditional business models makes the cloud supportive in the digital transformation of the business, and the solutions offered involve minimizing costs, accessibility, effectiveness, reliability and competitive advantage.

The investments in the digitalization of the economic environment are undeniable given the support offered by digital solutions to economic and social progress. At EU level, in 2015, the Strategy for the creation of the Digital Single Market with a multiannual application was developed and which has as its main objectives the full exploitation of the digital economy, online access across Europe for consumers and businesses, suitable conditions for the development of digital networks and services (European Commission, 2015).

Despite the legal framework and the benefits of cloud computing, the use of cloud computing solutions in business among businesses in the European Union is not unanimously appreciated. In this context, the paper examines the adoption of cloud computing in the EU business environment through a cluster analysis that highlights the group of countries whose enterprises are hesitant to use cloud computing technology and investigating the reasons behind these hesitations. Thus, the first part of the study focused on identifying and analyzing the similarities and disparities between EU Member States in terms of the share of cloud computing services (CCS) use in 2020 and 2021, and the second part of the study aimed at identifying Romania's position and performance in relation to EU Member States on the use of cloud computing services.

1. Data series and methodology

Taking into account the objectives of the research, the main data sources used were the series of data on the share of enterprises using cloud computing services (CCS) in EU member states, as well as use of cloud computing services in enterprises, by type of cloud service, in enterprises using cloud (Eurostat, 2022).

On the basis of these data, two indicators were selected for benchmarking the results of EU Member States and their ranking on the share of the use of CCS in companies, as well as ten indicators (Table 1) for the analysis of similarities and disparities between EU Member States on the share of the use of CCS by type of services in companies using the cloud.

Table 1. The meanings and units of measurement of the analyzed variables

Variables	Significance of variables	Remarks	UT
UCC20	The share of enterprises using cloud computing in 2020	Total enterprises	%
UCC21	The share of enterprises using cloud computing in 2021		%
EM	E-mail	Total enterprises using the cloud computing services	%
FIL	Storage of files		%
SOFT	Office software		%
SEC	Security software applications		%
FACC	Financial or accounting software applications		%
DB	Hosting the enterprise's database(s)		%
CRM	CRM software applications		%
CPU	Computing power for enterprise's own software		%
ERP	ERP software applications		%
DEV	Platform for application development, testing or deployment		%

Table 2. The main characteristics of used variables in clusters analysis

	EM	FIL	SOFT	SEC	FACC	DB	CRM	CPU	ERP	DEV
Median	8.05	10.25	9.15	22.55	5.15	5.05	15.05	14.35	4.80	23.70
Mode	9.50	13.30	9.30	21.10	5.10	5.00	21.00	13.50	3.90	19.30
Kurtosis	-0.13	2.16	3.48	14.14	2.52	0.66	-0.83	-0.24	-0.60	1.50
Skewness	0.25	-0.57	-0.70	3.35	1.03	0.31	0.05	0.17	0.00	0.14
Max	0.0	1.1	0.0	13.5	0.0	0.0	7.6	6.9	0.0	5.1
Min	16.6	16.6	15.7	68.3	14.7	12	23.7	24.8	9.4	44.4

The results presented in Table 2 show a fairly large diversity of the values recorded in the EU countries at most of the analyzed indicators, diversity reflected by the differences between the Values of Median and Mode, as well as by the amplitude of the range of variation, resulting from the difference between the maximum values (Max) and minimums (Min) of each indicator.

Taking into account these, as well as the characteristics of the form of variable distributions (Kurtosis and Skewness), which, at least in the case of FIL, SOFT, SEC and FACC indicators, reveal deviations from the normal distribution, for the analysis of similarities and disparities between EU states regarding the shares of CCS by type of cloud services in enterprises using cloud in 2021, the methodology of hierarchical clusters was used.

Within the methodology used, the proximity matrix was obtained using Euclidian distance (Rotaru, 2006), and for cluster generation Ward's method was used (Marinoiu, 2016):

To test the statistical significance of the variables' belonging to clusters, it was used Robust Tests of Equality of Means (Welch's Test and Brown-Forsythe's Test).

The null hypothesis is:

$$H_0 : m_1 = m_2 = m_3 = \ldots = m_r \quad (3)$$

The condition of acceptance of the null hypothesis (H_0) is $Sig.F > \alpha$.

The significance threshold used to validate or invalidate the null hypothesis is α=0.05, corresponding to the level of confidence of 95%.

2. Results and discussions

The results of the research undertaken are aimed, on the one hand, at highlighting Romania's stage regarding the share of CCS in enterprises, and on the other hand, at identifying the positive and negative aspects regarding the share of CCS by type of cloud services in enterprises using cloud.

2.1. Stages of using CCS by enterprises, in 2021 versus 2020

In the 27 countries of the European Union, the stages of use of cloud computing services in enterprises recorded significantly different levels from one state to another, both in 2020 and 2021 (Figure 1).

Thus, in 2020 at EU level, the share of the use of cloud computing services was 36%. Only 12 of the 27 states (44%) were above this value, while in the other 15 states (56%) there were differences from the EU value of between 1 percentage point (Cyprus) and 25 percentage points (Bulgaria).

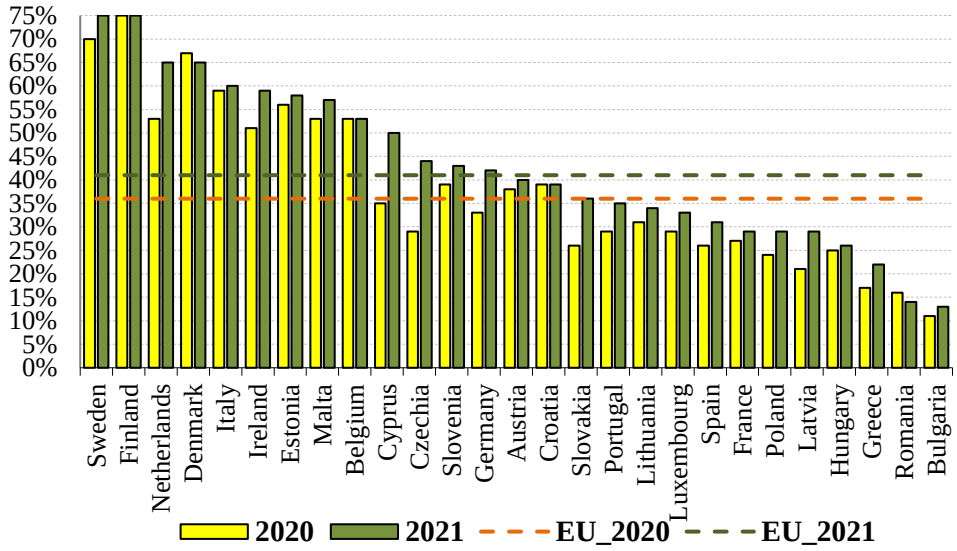

Figure 1 The share of enterprises using cloud computing in the EU27, in 20200 and 2021

Of the 12 countries with values of UCC20 above the EU27 average, the highest value was recorded in Finland (75%), followed by Sweden (70%) and Denmark (67%), with more than 30 percentage points compared to the EU27 level. Also, with significant values above the EU average of between 17 and 23 percentage points were Italy (59%), Estonia (56%) and the group of Netherland, Malta and Belgium, with 53%.

Large differences also exist between states whose share of use of cloud services is below the EU average. Thus, while in three of these countries the differences from the EU average (36%) are between -1 and -5 percentage points (Cyprus 35%, Germany 33% and Lithuania (31%), are countries where the difference is over 15 percentage points (Latvia 21%, Greece 17%, Romania, 16% and Bulgaria 11%).

In 2021, at EU level, the value of UCC21, compared to UCC20, was higher by 5 percentage points, reaching 41%. Increases were also recorded in most EU Member States. Of these, the most significant increases were 15 percentage points in Cyprus (from 35% to 50%) and Czech (from 29% to 44%), both exceeding the EU level by 9 and 3 percentage points respectively. There were also significant increases in Netherlands (12 percentage points, from 53% to 65%), as well as in Slovakia (10 percentage points, from 26% to 36%), as well as in Germany (9 percentage points, from 33% to 42%).

At the same time, in three states (Finland, Belgium and Croatia) the values of UCC21 remained constant, and in two it decreased by 2 percentage points. This is the case for Denmark (from 67% in 2020 to 65% in 2021) and Romania (from 16% in 2020 to 14% in 2021).

The result of these developments was the fact that in 2021 the number of states where the share of enterprises using cloud computing services increased to 13, with the transition of Cyprus, Czech and Germany to this group and the exit of Austria and Croatia from this group.

On the other hand, a negative fact is to maintain the gap between the states with the highest shares of companies using cloud computing services, Sweden and Finland (75%), and those with the lowest shares, Romania (14%) and Bulgaria (13%).

2.2. Stages of enterprises using CCS by type of cloud services in 2021

In order to identify and analyze the similarities and differences between the Member States of the European Union in terms of the shares of the use of cloud computing services by enterprises, in 2021, by type of cloud services, the methodology of the hierarchical clusters was used starting from the 10 indicators presented in Table 1, group Total enterprises using the cloud computing services.

Thus, the tests and analyses carried out resulted in a structure with eight clusters (Table 3), of which two clusters contain only one element each, the states in these clusters (Estonia and Poland) being exceptions under the conditions of the analyses carried out.

Table 3. The structure of clusters

Cluster	Cluster members
A	Belgium, Denmark, Spain, Netherlands
B	Bulgaria, France, Latvia, Romania
C	Czech, Ireland, Italy, Cyprus, Slovakia
D	Germany, Lithuania, Hungary, Austria
E	Greece, Croatia, Luxemburg, Portugal, Slovenia
F	Malta, Finland, Sweden
G	Estonia
H	Poland

The cluster generation dendrogram is illustrated in Figure 2.

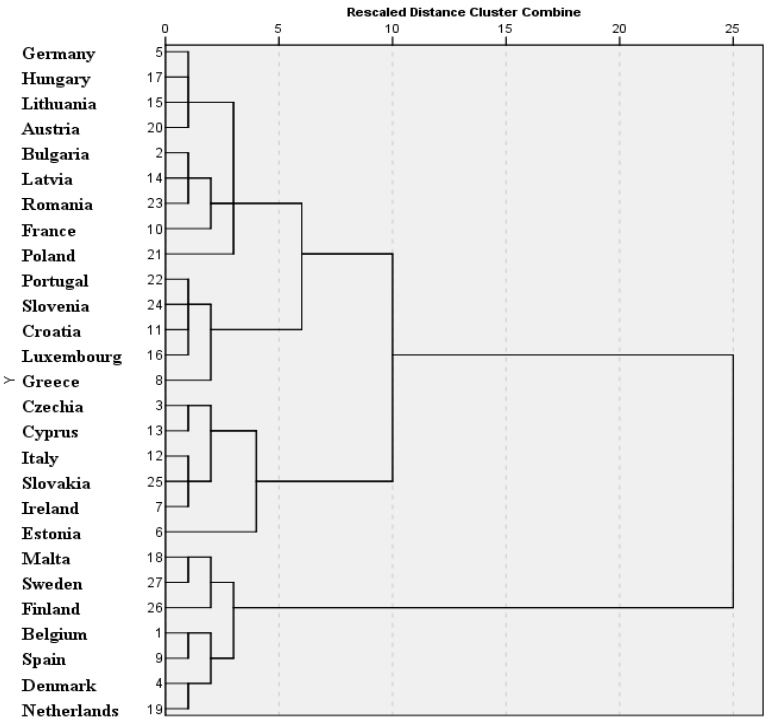

Figure 2. Dendrogram using Ward Linkage

The testing of the statistical significance of the variables belonging to the clusters was carried out using Robust Tests of Equality of Means (Table 4). As can be seen all Sig.F values, for both Welch's Test and Brown-Forsythe's Test are lower than the materiality threshold (α=0.05).

In conclusion, for all ten variables, the null hypothesis H_0 is rejected and the alternative hypothesis is accepted. Consequently, the average values recorded at the level of the clusters are statistically significant, the cluster structure obtained, as a whole is statistically significant.

Table 4. Robust Tests of Equality of Means

		Statistic[a]	df_1	df_2	Sig.F
EM	Welch	4.411	5	8.526	0.029
	Brown-Forsythe	4.759	5	15.074	0.008
FIL	Welch	28.475	5	7.681	0.000
	Brown-Forsythe	10.432	5	8.051	0.002
SOFT	Welch	10.020	5	8.229	0.002
	Brown-Forsythe	7.294	5	11.952	0.002
SEC	Welch	8.490	5	8.147	0.004
	Brown-Forsythe	7.920	5	15.932	0.001
FACC	Welch	3.881	5	7.784	0.046
	Brown-Forsythe	4.755	5	10.626	0.016
DB	Welch	8.914	5	8.393	0.003
	Brown-Forsythe	12.429	5	16.861	0.000
CRM	Welch	12.599	5	8.196	0.001
	Brown-Forsythe	14.697	5	15.765	0.000
CPU	Welch	7.101	5	7.090	0.011
	Brown-Forsythe	5.785	5	5.591	0.031
ERP	Welch	44.086	5	7.766	0.000
	Brown-Forsythe	6.303	5	7.184	0.015
DEV	Welch	5.326	5	8.205	0.018
	Brown-Forsythe	7.709	5	15.770	0.001

a. Asymptotically F distributed.

The main characteristics of the clusters are presented in Table 5. Analyzing the results, respectively the limits of the confidence intervals (LB,UB) for the 95% confidence level, due to the fact that for each cluster, they have the same sign, it follows that the average values are statistically significant for all six clusters containing more than one element.

Table 5. The average values recorded at the clusters level and their confidence intervals for 95% confidence level

Cluster		EM	FIL	SOFT	SEC	FACC	DB	CRM	CPU	ERP	DEV
A	Mean	83.00	81.25	69.00	67.75	55.25	69.25	42.75	36.50	34.75	31.25
	LB	79.82	79.25	61.77	54.60	35.32	55.91	33.81	26.07	32.75	21.76
	UB	86.18	83.25	76.23	80.90	75.18	82.59	51.69	46.93	36.75	40.74
B	Mean	76.50	64.00	57.25	47.00	39.00	53.25	23.75	21.75	25.00	21.25
	LB	66.39	48.19	53.27	38.48	29.45	45.86	14.44	20.95	13.31	15.99
	UB	86.61	79.81	61.23	55.52	48.55	60.64	33.06	22.55	36.69	26.51
C	Mean	85.60	61.80	69.80	68.20	50.60	34.60	21.60	14.80	17.00	11.80
	LB	77.43	56.50	57.28	57.29	45.22	25.62	16.15	7.59	13.60	5.69
	UB	93.77	67.10	82.32	79.11	55.98	43.58	27.05	22.01	20.40	17.91

Cluster		EM	FIL	SOFT	SEC	FACC	DB	CRM	CPU	ERP	DEV
D	Mean	71.75	62.75	54.75	48.50	38.50	36.25	20.50	28.50	16.25	22.50
	LB	61.82	53.71	47.59	43.91	25.61	22.98	16.50	21.09	12.49	15.32
	UB	81.68	71.79	61.91	53.09	51.39	49.52	24.50	35.91	20.01	29.68
E	Mean	83.00	68.60	65.80	62.80	41.20	49.80	25.60	29.80	25.60	27.00
	LB	75.00	65.25	59.51	52.66	32.90	37.59	18.99	22.92	18.22	19.92
	UB	91.00	71.95	72.09	72.94	49.50	62.01	32.21	36.68	32.98	34.08
F	Mean	87.00	81.00	75.33	61.33	62.67	54.67	37.33	34.67	26.67	23.33
	LB	82.03	70.17	64.13	47.65	35.19	40.99	27.29	3.02	4.40	9.65
	UB	91.97	91.83	86.53	75.01	90.14	68.35	47.37	66.32	48.93	37.01

LB: Lower Bound of 95% confidence interval for Mean
UB: Upper Bound of 95% confidence interval for Mean

Cluster A (consisting of Belgium, Denmark, Spain and Netherlands), through the values of the analyzed indicators, is practically the leading cluster in terms of the share of CCS use in enterprises. Of the ten indicators, at six of them (FIL, DB, CRM, CPU, ERP and DEV), this cluster has the highest values ahead of the immediately following clusters with values ranging from 0.25 to 14.85 percentage points. The largest difference between cluster A and the next cluster (F) was recorded at DB (Hosting the enterprise's database), respectively between 69.24% (average of cluster A) and 54.67% (average of cluster F).At the same time, however, cluster A was overtaken by clusters F and C in Email services (by 3 percentage points) and Office software (by 6.33 percentage points).The largest gap, of -19.75 percentage points, was recorded at Financial or accounting software applications (FACC), where Estonia (75%) was in first place, followed by cluster F (62.67%), the average value of cluster A being only 55.25%.

The second cluster, in terms of CCS values, was cluster F consisting of Malta, Finland and Sweden. This is where the highest values were recorded for Email services (87.0%) and Office software (75.31%). Cluster F ranked the second position in six types of CCS (FIL, FACC, DB, CRM, CPU and ERP). Of these, the largest gap (-12.33 percentage points compared to Estonia) was recorded in Financial or accounting software applications services. Also, relatively large gaps were recorded in ERP software applications, of -8.08 percentage points compared to cluster A, and Platform for application development, testing or deployment (DEV), of -7.92 percentage points compared to the same cluster, and -3.67 percentage points compared to cluster E.

In third place, after the performance of CCS by type of cloud services, was cluster E, consisting of Greece, Croatia, Luxembourg, Portugal and Slovenia. According to CCS's shares in enterprises, cluster E ranked second in DEV (Platform for application development, testing or deployment) with 27.0% (4.25 percentage points less than cluster A), in third place in four types of cloud services (FIL, SEC, CRM and ERP), in fourth place in E-mail services, Hosting the enterprise's database and Computing power for enterprise's own software, and in fifth place for the other two types of services cloud (SOFT and FACC).

According to the same classification criterion, cluster C, consisting of Czech, Ireland, Italy, Cyprus and Slovakia, can be considered in fourth place. Characteristic of this cluster is the fact that, while in the SEC, SOFT and EM indicators it was on the first or second place, in the case of the other indicators it occupied much more unfavorable places. Cluster C ranked first in Security software applications services (68.20%) and second place in cloud email services (85%), 1.4 percentage points less than in the case of cluster F, and in cloud services of Office software (69.8%), with 5.53 percentage points less than the same cluster. On the other hand, cluster C shares the last places together with clusters B and D, as well as with Poland and Estonia in six CCS indicators (FIL, DB, CRM, CPU, ERP and DEV), indicators in which cluster A is on first place. Thus, cluster C ranked fifth in the CRM indicator with the value of 21.6% (-21.15 percentage points), the sixth place in the DB indicator with the value of 34.60% (-34.56 percentage points), the seventh place in the FIL

indicators (61.80%; -19.45 percentage points), CPU (14.8%; -21.75 percentage points) and ERP (17%; -17.75 percentage points), respectively the eighth place in the DEV indicator with the value of 11.8% (-19.15 percentage points).

Clusters B (Bulgaria, France, Latvia and Romania) and D (Germany, Lithuania, Hungary and Austria), in terms of CCS by type of cloud services in enterprises, share together, for most indicators, the places in the last part of the rankings. Cluster B overtook cluster D for the values of seven indicators. Thus, at the DB indicator, cluster B was in 3rd place with 53.25%, and D in sixth place with 36.25%; for CRM and ERP indicators, cluster B was on the fourth place (with 23.75% and 25%), and D on the sixth and eighth places (with 20.5% and 16.25%); for the FIL indicator, the cluster B was in fifth place with 64%, and D in sixth place with 62.75%; for EM, SOFT and FACC indicators, cluster B was in seventh place (with 76.50%, 57.25% and 39.0%), and B on the 8th place (with 71.75%, 54.75% and 38.5%).

Romania, component of cluster B, although it takes over its characteristics, it should be highlighted that in the case of the SEC, FACC and ERP indicators, the share of these services was 5 percentage points above the average of cluster B, but for the FIL and DB indicators, their share was 6 and 3.25 percentage points below the average value of cluster B, respectively. On the other hand, comparing the CCS values by type of cloud services in enterprises registered in Romania with the highest values of the respective indicators recorded in the EU, as well as the places occupied by Romania, we find that, although in terms of the used of CCS in the total enterprises, it was in 2021 on the penultimate place (26th place). In the case of the values of the ten indicators included in the cluster analysis, we find that the results are better (Table 6)

Table 6.CCS shares by type of cloud services in enterprises and places occupied by Romania between EU member states in 2021

2021		EM	FIL	SOFT	SEC	FACC	DB	CRM	CPU	ERP	DEV
EU	%	79	66	61	58	47	46	27	24	24	21
RO	%	80	58	58	52	44	50	27	22	30	22
	Rank	19	25	22	18	15	11	12	20	8	16
%Maximum		96	84	85	80	75	78	49	43	37	40
%Minimum		65	41	51	41	27	23	17	10	13	7

Thus, Romania recorded values above the EU average in terms of the shares of CCS in enterprises at four type of cloud services, namely E-mail (EM), Hosting the enterprise's database (DB), ERP software applications and Platform for application development, testing or deployment (DEV), and at an indicator (CRM software applications) the recorded value is equal to the EU average.

In the hierarchy of EU member states, from the point of view of CCS, the best place occupied by Romania is in ERP software applications services (8th place) ahead of a number of more developed countries including Sweden (14th place, with a share of 21%) and Germany (19th place, with a share of 18%). In hosting services the enterprise's database(s), Romania ranks 11th, ahead of countries such as Finland (13th place, with a share of 49%), Germany (22nd place, with a share of 33%) or Austria (26th place, with a share of 22%). Also, for CRM software applications services, Romania is on the 12th place, ahead of Austria (15th place, with a share of 23%) and Germany (17th place, with a share of 21%).

On the other hand, Romania records poor results in Storage of files (IDF) services, where it ranks 25th, while Bulgaria with 68% is in 13th place and Hungary with 61%, is on the 19th place, as well as in services and Office software (SOFT) where it ranks 22nd, while Hungary with 61% is on the 18th place, and Bulgaria, with 60%, is in 20th place. Finally, in terms of the gap with the EU average, the worst results were recorded for Storage of files (-8 percentage points) and Security software applications (-6 percentage points).

3. Conclusions

A first conclusion is that, in terms of the share of companies using CCS Romania, it is not only on the penultimate place, but even tends to reach the last place among the EU states if the decrease in the share of companies using CCS recorded in the period 2020-2021 is maintained in 2022.On the other hand, in the case of enterprises that already use CCS, Romania has registered relatively good results on some indicators, including ERP software applications services, but also poor and very poor results in the case of others, including Storage of files services.

The results of an empirical study carried out for the 2010-2016 period that covering 25 industries in 25 European countries (Andrews et al., 2018) shows that adoption of digital technologies is limited by low managerial quality, lack of ICT skills and poor matching of workers to jobs curb.

Buhr and Stehnken (2018) consider that a key priority of European economic policies must be a sustainable and inclusive growth in order to fully exploit the potential of digital transformation and everyone profits from the digital dividend. Moreover, EU cohesion policy supports the three priorities of the Europe 2020 strategy: smart, sustainable and inclusive growth, and Member States are expected to implement national reform programs that set out how these priorities will be achieved.

The recommendations of the Digital & Data Working Group of the CEPS Industrial Policy Task Force, in order that technologies can become a driving force to support the digital transformation within the EU value system are for defining in more detail of the role of emerging projects such as GAIA-X and the European Alliance for industrial data, cloud and edge and clarification of the links between data spaces and IoT/edge data ecosystems.

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