DIGITAL LEARNING IN A POST-PANDEMIC ECONOMY: EVIDENCE FROM EUROPEAN COUNTRIES

Marajn Angeleski[1],
Olivera Kostoska[2]

Abstract: Background: The Covid-19 pandemic has enabled countries to jump faster into the future of digital learning. However, the question arises as to what the lasting effects of the pandemic would be, in terms of what education will look like in the post-Covid era; will this way of learning become the 'new normal' or should the world immediately be returned to pre-pandemic mode of physical classroom.

Purpose: This article aims to address the above-mentioned challenge by examining trends, shifts, and changes in doing online courses or using online learning materials across European countries prior to the outbreak of the pandemic until the time when many countries removed the measures.

Methods: The analysis is based on Eurostat statistical data for 37 European countries regarding Internet use by individuals doing online courses and Internet use in general from 2019 to 2022. Aside from descriptive statistical analysis and distribution of data and trends, a cluster analysis is performed to examine how different groups of countries respond to pandemic-induced changes and how they can move forward in terms of digital learning practices. All statistical measurements are performed in the Python programming language using diverse set of libraries, including algorithm for conducting a cluster analysis.

Results/conclusions: The results suggest that during the temporary physical closures due to the pandemic, online courses were considered a safe backup system for learning and training, but the popularity of virtual courses declined as social restrictions began to ease. At the same time, the composition of clusters evolves over time, which points to changes in the dynamics of engagement in online courses among

[1] University St. Kliment Ohridski – Bitola, Faculty of Economics – Prilep, Republic of North Macedonia, e-mail: marjan.angeleski@uklo.edu.mk, ORCID: 0000-0002-4250-3517

[2] University St. Kliment Ohridski – Bitola, Faculty of Economics – Prilep, Republic of North Macedonia, e-mail: olivera.kostoska@uklo.edu.mk, ORCID: 0000-0002-4794-635X

various groups of countries. Overall, the analysis made here represents a useful guide for formulating strategies to further promote and support digital inclusion and online education initiatives.

Key words: Covid-19, digital learning, education, Europe, cluster analysis, programming models

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1. Introduction

Since the institutionalization of global modern education systems, there has been no event with such a disruptive capacity as the Covid-19 pandemic. The disease has strongly affected the daily routine of institutions, leading to a series of school and university closures, and forced countries to massively engage in virtual learning. In higher education, around 220 million students worldwide have been affected by isolation and social distancing measures (Farnell et al., 2021), which in turn has raised numerous challenges for policymakers on how to ease the learning losses, how to implement distance learning and how to safely reopen institutions when appropriate conditions exist. By definition, any online learning environment is seen as a framework that uses the Internet to enable some form of instruction to students separated by time, distance, or both (Dempsey & Van Eck, 2002). However, many educational institutions were not adequately prepared for the emerging situation caused by the pandemic and were not sufficiently familiar with the suitability of methodologies and technologies in terms of security, effectiveness, and access to learning (Cachia et al., 2021). Initially, students had to rely on their own resources to continue learning, while teachers had to immediately adapt to new teaching modalities for which they had neither sufficient knowledge nor adequate training (Schleicher, 2020). Past school disruptions have shown that, in most cases, it is very difficult to recover from learning losses, which may keep going and grow even when students return to physical education. And while online and distance learning has previously been implemented to preserve continuity in education (for instance, after an earthquake (Mackey et al., 2012)), this crisis is unprecedented in many ways. Many studies have already shown that there are substantial deficiencies in effective formal education and distortions in curricula, all of which led to significant learning

losses (Cerna et al., 2020; Di Pietro et al., 2020; Hanushek & Wößmann, 2020), primarily in math and reading (Maldonado & De Witte, 2022).

When it comes to Europe, obviously, the continent was preoccupied with other issues (e.g. Brexit and migration), so the pandemic was not considered to be a priority and was not perceived as an outstanding risk for European leaders. Education systems were not prepared to deal with the pandemic, as well. Even though digital learning was a policy option pursued by most countries in Europe during the pandemic, not all students had full access to this mode of education. For example, 19% of students in Romania do not have access to any kind of Internet connection. Schools were closed for an average of 32 weeks between 2020 and 2021, and only 6 in 10 students were offered online education. Although most of these students were located in rural areas, however, even in urban areas, 10% of students did not have access to the Internet (Ndondo, 2022). Even though educational institutions managed to adapt more quickly to e-learning, the level of availability and learning quality was still insufficient and varied significantly across the European countries. For example, Norway and Sweden were much more willing to implement digital learning compared to other European countries. As a matter of fact, the Government in Sweden had already developed distance and hybrid forms of education even before the outbreak of the pandemic. The digital divide also included the skills gap, with students lacking the basic skills needed for digital learning. According to the European Commission, around 44% of Europeans between the ages of 16 and 74 do not possess basic digital skills. All this would suggest that the pandemic has exacerbated existing inequalities in education between European countries and highlights the harmful effects of closures and distance learning on students who have little access to digital resources, those from backward regions, or students who have trouble learning on their own (Hanushek & Wößmann, 2020; Blaskó et al., 2021; Engzell et al., 2021; Grewenig et al., 2021).

With all being said, it is clear that pandemic has forced the world to take a leap into the pervasive use of virtual learning. Covid-19 has been an overhaul for societies and economies, bringing about a period of reflection, and perhaps a revision of established approaches. Speculation has now begun as to what the future of education will be, whether this forced shift to digital learning represents educational change momentum and time to revise the way instruction is delivered, or whether the world should return to

traditional physical education. This article gives a discourse on this issue by assessing the trends, shifts, and changes in attending online courses or using online learning materials across European countries before and during the pandemic until the time when many countries lifted the measures. More specifically, the objective is to find out whether European countries have witnessed a significant increase in online course interest and the use of online learning materials during the pandemic and what trend has been observed in such activities in post-Covid times. In addition, the study investigates the impact of coronavirus disease on internet usage trends in European countries, primarily as a means of facilitating various forms of online learning. At the same time, the analyses made here highlight certain aspects of e-readiness for online learning in European countries as one of the main prerequisites for their competitiveness in the global e-environment (Angeleski et al., 2010).

The rest of the paper is organized as follows. Section 2 highlights the background of online learning in general and especially during the Covid-19 pandemic. Section 3 refers to data and applied methods. Section 4 reveals the results obtained from various measurements. Discussions and conclusions are provided in Section 5.

2. Background

2.1. Looking back to online learning

Digital technologies, such as artificial intelligence, cloud computing, video broadcasting, to name but a few, have profoundly changed education from a traditional to a modernized approach (Liu et al., 2009; Sumak et al., 2011; Angeleski & Kostoska, 2022). Although traditional classrooms and face-to-face communication are still considered to have a key role in the educational process (Baker, 2004; Saba, 2007), the use of different learning models, including online learning, has a long history in education (Clark, 1983). While both approaches have their own pros and cons, the purported advantages of online education include reduced tuition (De La Varre et al., 2011), increased engagement in assignments (Kapp, 2012), and augmented affinity for collaboration (Hermann et al., 2001). Moreover, the effectiveness of distance learning, to a large extent, depends on a sound infrastructure (Zhang et al., 2004; Teo et al., 2020) and access to the

Internet (Balfanz & Byrnes, 2006), but also on professional course management and professor's attitude (Liaw et al., 2007; Selim, 2007; Costa & Silva, 2010). Physical classroom, on the other hand, is preferred in situations where the focus is on practical applications and where lessons may be more difficult to deliver using methods through online platforms (Glodowska et al., 2022). Since evidence of superiority of online learning over traditional paradigms is difficult to find, a combination of both methods is most appropriate in majority of cases or situations (Shallcross & Harrison, 2007).

2.2. Online learning during the Covid-19 pandemic

Traditionally, online learning has been considered an alternative way, especially suitable for adults looking for educational opportunities. However, the case of the Covid-19 pandemic has shown that, in exceptional situations, online education can be considered as a backup educational system that will allow continuity in the learning process. Crises do represent points of disequilibrium that disrupt normal operating procedures and produce a series of changes in existing policies. However, it is not yet clear what policy change (radical, incremental or a more moderate form of change) a crisis like the coronavirus pandemic can prompt in the educational process (Beland & Powell, 2016). One of the key factors that can determine the intensity of changes is the exogenous or endogenous origin of the crisis. When it comes to education, exogenous crises are produced by a political conflict, a financial distress, a natural disaster or a global epidemic. On the other hand, endogenous crises in education may be triggered by demand-side dissatisfaction with the existing educational offer, inadequate working conditions for teachers, or poor performance in international evaluations (Zancajo et al., 2022). The crisis produced by Covid-19 pandemic entails elements of both scenarios. It is more than evident that this crisis stems from factors outside the realm of education, giving rise to significant health, social, and economic challenges, which education can help to address. However, the coronavirus disease has exposed many of the shortcomings of existing educational systems in delivering high-quality education under changing circumstances and has also made more visible the pre-existing deficiencies in educational offer (Zancajo et al., 2022). Fast forward to 2020 and various educational innovations have taken place to make the universal adoption of distance

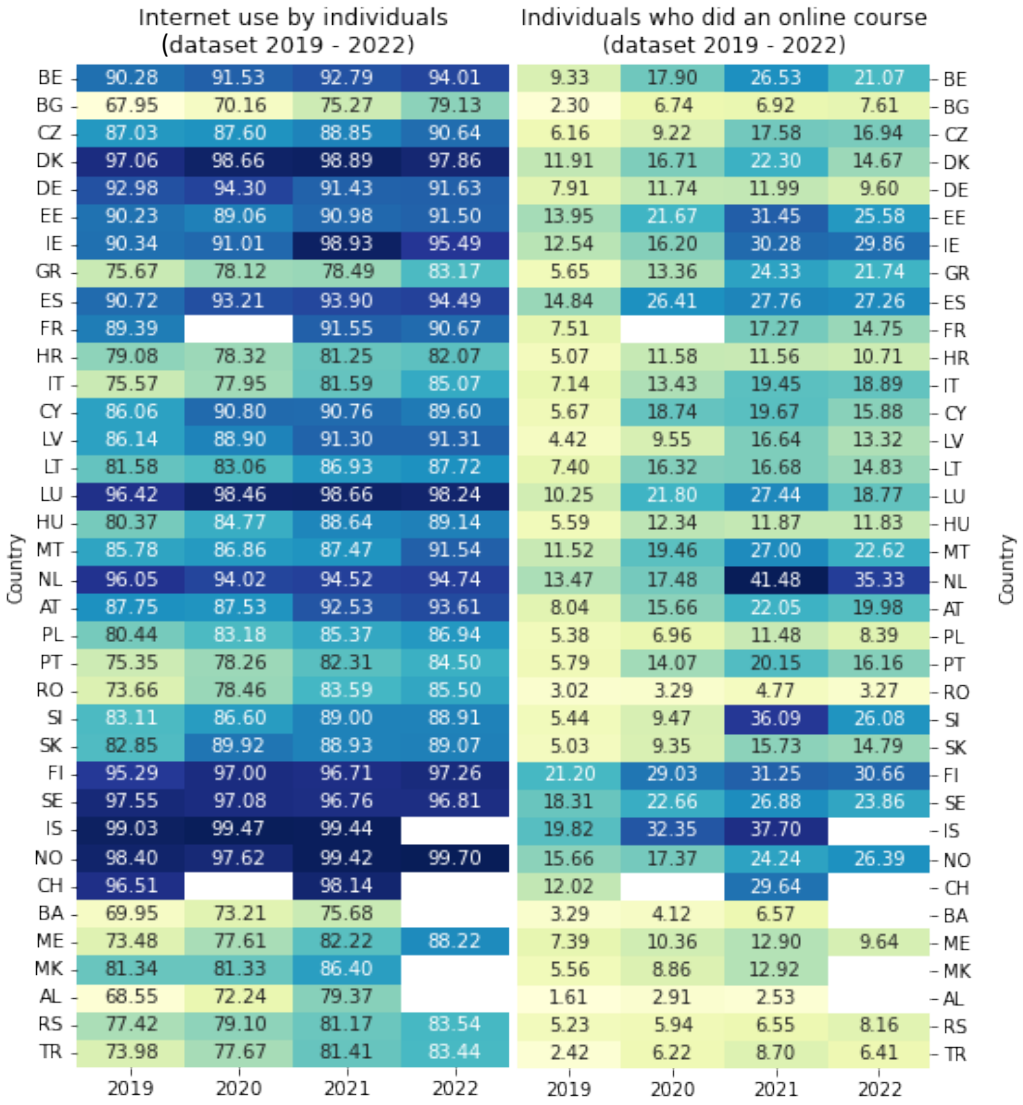
learning a reality (Pennisi, 2020). As a result, the future of online education can move from an organization that primarily serves higher education and adult learners to one that increasingly serves many young students, or those coming from primary and secondary education (Lockee, 2021). The pandemic itself has brought to the fore a number of benefits (Watermeyer et al., 2020; Pikoos et al., 2021) and disadvantages of online learning (Pikoos et al., 2021; Shin & Hickey, 2021). Therefore, during the pandemic and after the measures were removed, educational institutions switched from a purely online approach to a combination of remote delivery and in person education (Cunha et al., 2020; Bashir et al., 2021). In point of fact, the well-established good practices of hybrid or blended learning serve as a guide for new combinations of lessons delivery and offer better solutions for students in terms of getting hands-on experience and face-to-face communication to stay motivated and gain a sense of community, while at the same time enjoying the flexibility of online learning (Czerniewicz et al., 2019; Chatterjee & Correia, 2020). However, it should be noted that structural reforms and paradigm shift in education tend to be particularly challenging primarily due to distinct and often conflicting interests among various groups of stakeholders.

3. Data and methods

3.1. Datasets

The analysis is based on Eurostat statistics and data for 37 European countries about Internet use by individuals doing online courses, including Internet use in general. The reference timeframe refers to the period from 2019 to 2022, that is one year prior to outbreak of the pandemic, two years during the coronavirus disease, and one year after the removal of pandemic measures.

Several countries with missing years (especially for 2022) were identified in the dataset, and these were filled out by forward filling. In other words, assuming that the next value is likely to be similar to the previous one (e.g., the preceding year of the same country), the missing values were filled out with the last known non-null value in the column. Data was missing for two consecutive years (2021 and 2022) for the UK, so this country was excluded from further analysis (Figure 1).



Country	Internet use by individuals (dataset 2019 - 2022)				Individuals who did an online course (dataset 2019 - 2022)			
	2019	2020	2021	2022	2019	2020	2021	2022
BE	90.28	91.53	92.79	94.01	9.33	17.90	26.53	21.07
BG	67.95	70.16	75.27	79.13	2.30	6.74	6.92	7.61
CZ	87.03	87.60	88.85	90.64	6.16	9.22	17.58	16.94
DK	97.06	98.66	98.89	97.86	11.91	16.71	22.30	14.67
DE	92.98	94.30	91.43	91.63	7.91	11.74	11.99	9.60
EE	90.23	89.06	90.98	91.50	13.95	21.67	31.45	25.58
IE	90.34	91.01	98.93	95.49	12.54	16.20	30.28	29.86
GR	75.67	78.12	78.49	83.17	5.65	13.36	24.33	21.74
ES	90.72	93.21	93.90	94.49	14.84	26.41	27.76	27.26
FR	89.39		91.55	90.67	7.51		17.27	14.75
HR	79.08	78.32	81.25	82.07	5.07	11.58	11.56	10.71
IT	75.57	77.95	81.59	85.07	7.14	13.43	19.45	18.89
CY	86.06	90.80	90.76	89.60	5.67	18.74	19.67	15.88
LV	86.14	88.90	91.30	91.31	4.42	9.55	16.64	13.32
LT	81.58	83.06	86.93	87.72	7.40	16.32	16.68	14.83
LU	96.42	98.46	98.66	98.24	10.25	21.80	27.44	18.77
HU	80.37	84.77	88.64	89.14	5.59	12.34	11.87	11.83
MT	85.78	86.86	87.47	91.54	11.52	19.46	27.00	22.62
NL	96.05	94.02	94.52	94.74	13.47	17.48	41.48	35.33
AT	87.75	87.53	92.53	93.61	8.04	15.66	22.05	19.98
PL	80.44	83.18	85.37	86.94	5.38	6.96	11.48	8.39
PT	75.35	78.26	82.31	84.50	5.79	14.07	20.15	16.16
RO	73.66	78.46	83.59	85.50	3.02	3.29	4.77	3.27
SI	83.11	86.60	89.00	88.91	5.44	9.47	36.09	26.08
SK	82.85	89.92	88.93	89.07	5.03	9.35	15.73	14.79
FI	95.29	97.00	96.71	97.26	21.20	29.03	31.25	30.66
SE	97.55	97.08	96.76	96.81	18.31	22.66	26.88	23.86
IS	99.03	99.47	99.44		19.82	32.35	37.70	
NO	98.40	97.62	99.42	99.70	15.66	17.37	24.24	26.39
CH	96.51		98.14		12.02		29.64	
BA	69.95	73.21	75.68		3.29	4.12	6.57	
ME	73.48	77.61	82.22	88.22	7.39	10.36	12.90	9.64
MK	81.34	81.33	86.40		5.56	8.86	12.92	
AL	68.55	72.24	79.37		1.61	2.91	2.53	
RS	77.42	79.10	81.17	83.54	5.23	5.94	6.55	8.16
TR	73.98	77.67	81.41	83.44	2.42	6.22	8.70	6.41

Source: Author's calculation based on Eurostat Database; Note: Countries are represented by the two-letter country codes defined in ISO 3166-1 alpha-2.

Figure 1. Datasets missing values

3.2. Research Design

The research methodology applied here was developed in accordance with the objectives of the article bearing in mind that the number of individuals doing online courses has significantly increased during the pandemic. Thus, the main research question reads as follows: what will be the trajectory of online course participation among European countries in post-Covid times, after significant increase that was observed during the years of the pandemic? Against this background, apart from descriptive statistical analysis and distribution of data and trends in both

datasets, a cluster analysis of countries was performed based on datasets measuring the proportion of individuals participating in online courses during different years. In this context, the cluster analysis is actually a technique that helps reorganizing countries in a way that minimizes the distance of the clustering variables between countries belonging to the same cluster, whilst maximizing the distance among various groups (Hristoski & Kostoska, 2018; Kostoska et al., forthcoming). The purpose of the analysis is actually to construct groups with homogeneous characteristics out of heterogenous large samples (Hair et al., 2014), so that variables identifying each cluster would have smaller standard deviation and a higher mean contrasted to those of other clusters (Cornia & Scognamillo, 2016). In this way, distinct shifts in how countries respond to pandemic-induced changes could be identified and potential recalibrations of country groups across the observed period can also be examined.

All statistical analyses were conducted in the Python programming language using libraries such as NumPy, Pandas, Seaborn, and Matplotlib, along with the scikit-learn Python library that provides a machine learning algorithm for performing a cluster analysis, which is represented by hierarchical clustering model. Basically, hierarchical clustering represents a method for grouping data points in such a way that items in a certain group are more similar to each other and different from items in other groups. What is also important when it comes to hierarchical clustering is to decide on the linkage method to be used. In view of what has been said, the Ward linkage method is used here, which requires that the subsequent clustering steps be chosen in a way that minimizes the increase in 'error sum of squares' at each step. The main benefit of hierarchical clustering is that it is not necessary to pre-specify the number of clusters. Instead, a dendrogram, which is a visual representation of clusters in a hierarchical tree, can be cut at a given level to obtain the desired number of clusters.

4. Results

Descriptive statistical analysis shows that the means, medians and minimum values for Internet use by individuals in European countries show a continuous and almost linear increasing trend from year to year. As expected, the minimum values exhibit a certain increase (67.95% in 2019 and 75.68% in 2022), but the maximum values remain almost unchanged (at a level close to 99% during all years). On the other hand, standard deviation, as a measure of

data dispersion or spread, shows a certain decrease in each successive year, indicating reduced data variability (Table 1).

Table 1.
Descriptive statistics - Internet use by individuals in European countries

	Mean	Median	Stan-dard Devia-tion	Min	Max	25% Quartile	50% Quartile	75% Quartile	IQR	Variance	Skew-ness
2019	84.82	85.92	9.24	67.95	99.03	76.98	85.92	91.28	14.30	85.45	-0.13
2020	86.64	87.56	8.32	70.16	99.47	78.42	87.56	93.41	14.99	69.14	-0.18
2021	89.91	88.96	7.10	75.27	99.44	82.29	88.96	94.06	11.77	50.46	-0.16
2022	89.85	90.12	6.16	75.68	99.70	85.39	90.12	94.55	9.16	37.95	-.028

(Source: Author's calculation based on Eurostat Database)

When it comes to individuals who have done an online course over the period 2019 - 2020, the data shows that there is an increasing trend for means, medians, and standard deviation, with some decreases in values in 2022. Namely, the minimum value increased from 1.63% in 2019 to 2.53% in 2022, or there is a growth of less than 1 percentage point. However, the maximum values show an increase of more than 20 percentage point in 2021 (from 21.20% to 41.48%) compared to the period prior to pandemic (2019), and a subsequent decrease to 37.73% in 2022 (Table 2).

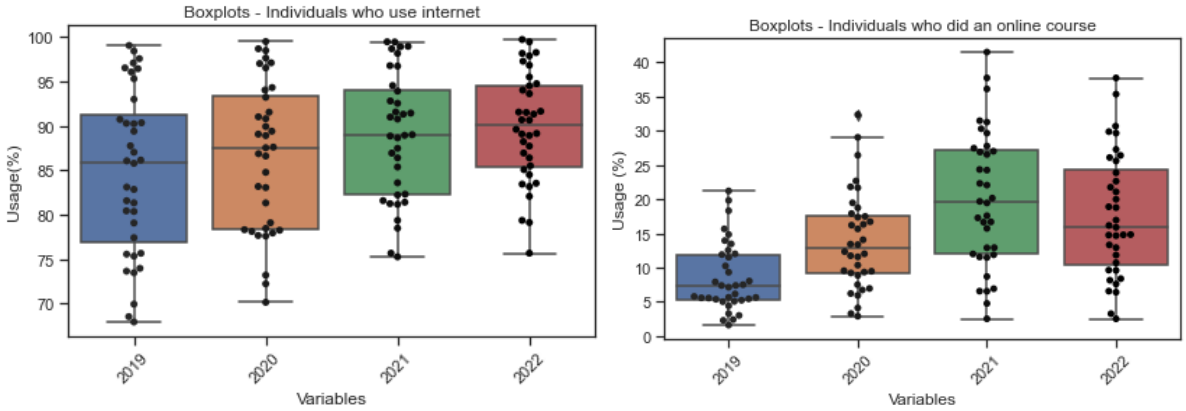
Table 2.
Descriptive statistics - individuals who have done an online course

	Mea n	Medi an	Standa rd Deviati on	Min	Max	25% Quart ile	50% Quart ile	75% Quart ile	IQR	Varian ce	Skew ness
2019	8.55	7.26	5.03	1.61	21.20	5.34	7.26	11.94	6.60	25.34	0.93
2020	13.86	12.85	7.11	2.91	32.35	9.13	12.85	17.58	8.46	50.57	0.68
2021	19.95	19.56	9.88	2.53	41.48	11.96	19.56	27.11	15.15	97.62	0.20
2022	17.62	16.02	8.99	2.53	37.70	10.44	16.02	24.29	13.85	80.91	0.37

Source: Author's calculation based on Eurostat Database

The boxplots show that median internet usage increased from 2019 to 2022. The interquartile range (IQR) increased slightly in 2020, indicating a greater data spread during that year, but decreased in 2021 and especially in 2022. The relatively shorter upper whiskers indicate the presence of certain very high values in the data. For individuals who did an online course, the boxplots by year indicate that the median number of participants increased from 2019 to 2021, with a slight dip in 2022. Thereupon, only one

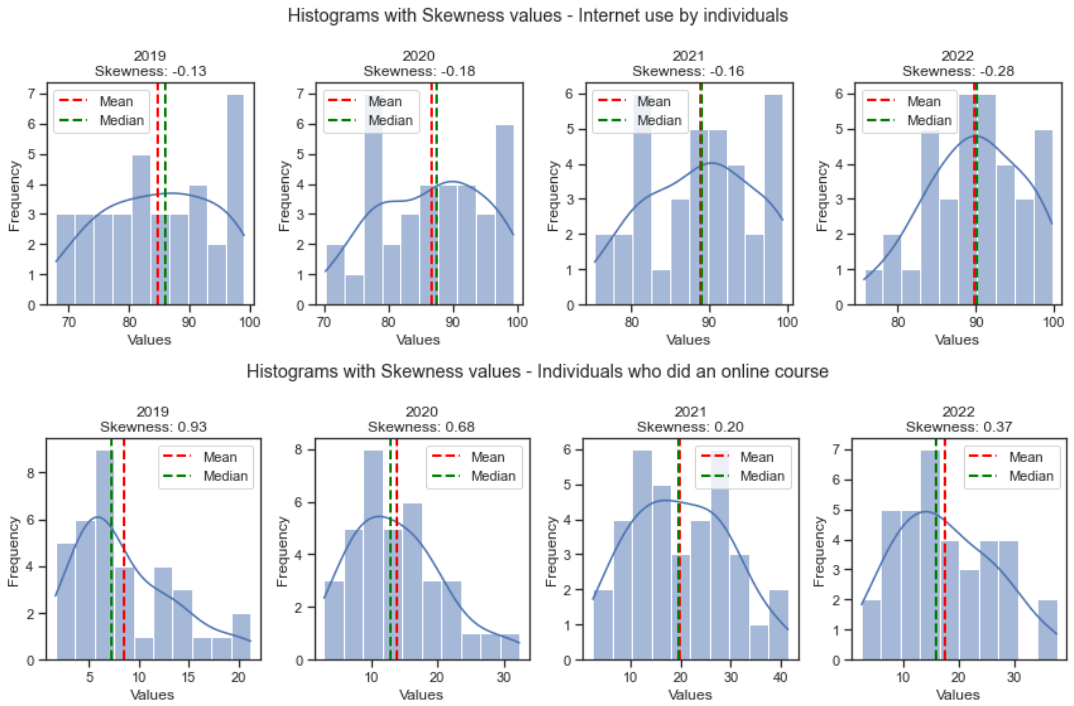
outlier relating to Iceland has been identified in 2020. The interquartile range (IQR) had the lowest value in 2019, indicating low data spread in the year prior to pandemic, then increased from 2019 to 2021, and subsequently decreased in 2022. The relatively short lower whiskers suggest that there are not too many small values in the data, while the longer upper whisker indicates the presence of some very high values (Figure 2).



Source: Author's calculation based on Eurostat Database

Figure 2. Boxplots – Individuals who use Internet and Individuals who did an online course

Furthermore, an analysis was performed on data distribution for both datasets. In the first dataset, which refers to individual internet users, the skewness values, as a measure of data distribution asymmetry, are negative but close to zero, pointing towards almost symmetry in the data with a slightly left-skewed distribution throughout all observed years (Figure 3). On the other hand, the skewness values for the dataset related to individuals who did an online course are positive all the time, with the highest value of 0.93 in 2019, suggesting that the data tends to be more concentrated towards lower values, and there are relatively few extremely high values. This means that the tail on the right side of the distribution is longer. The skewness values for this dataset started to decrease in the following years, reaching a value of 0.20 in 2021, which means that it is slightly skewed to the right. However, the value recorded an increase in 2022 (0.37), suggesting that, once again, there is a tendency for a slight increase in data asymmetry (Figure 3).

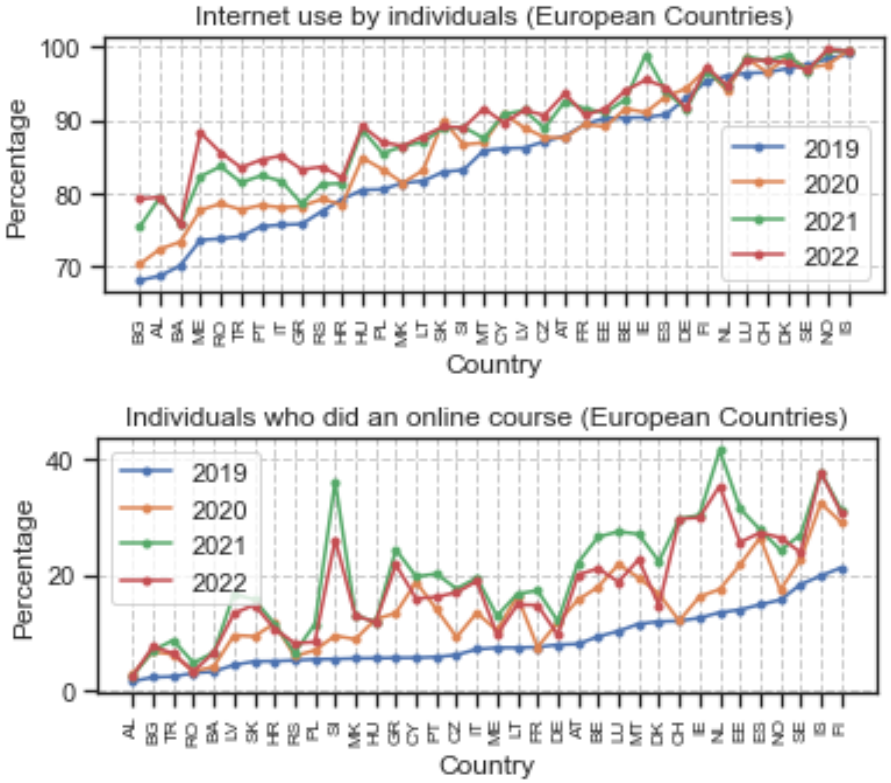


Source: Author's calculation based on Eurostat Database

Figure 3. Histograms with skewness

The analysis by country shows that, from year to year, every country experienced an increase in the percentage of individual internet users (countries in the graphs are sorted by 2019). Despite the proportional increase in the number of internet users in each country, the chart depicting individuals who have taken an online course exhibits certain fluctuations. There was a significant increase in 2020, with a peak reached in 2021, followed by a slight decrease in 2022. (See Figure 4).

Given that the range of data for individual internet users is relatively small and varies between 67.95% and 99.03% in 2019, and between 75.68% to 99.70% in 2022, the cluster analysis is performed only on countries using datasets that measure the percentage of individuals who did an online course in different years. The goal is to identify specific changes in how countries have adapted to the new situation caused by the pandemic and to examine potential re-grouping of countries during the observed years. Against this background, four distinct clusters have been identified to investigate the changes in countries across different groups from 2019 to 2022 and determine the impact of the pandemic on the progress of specific countries in terms of individuals who did an online course.



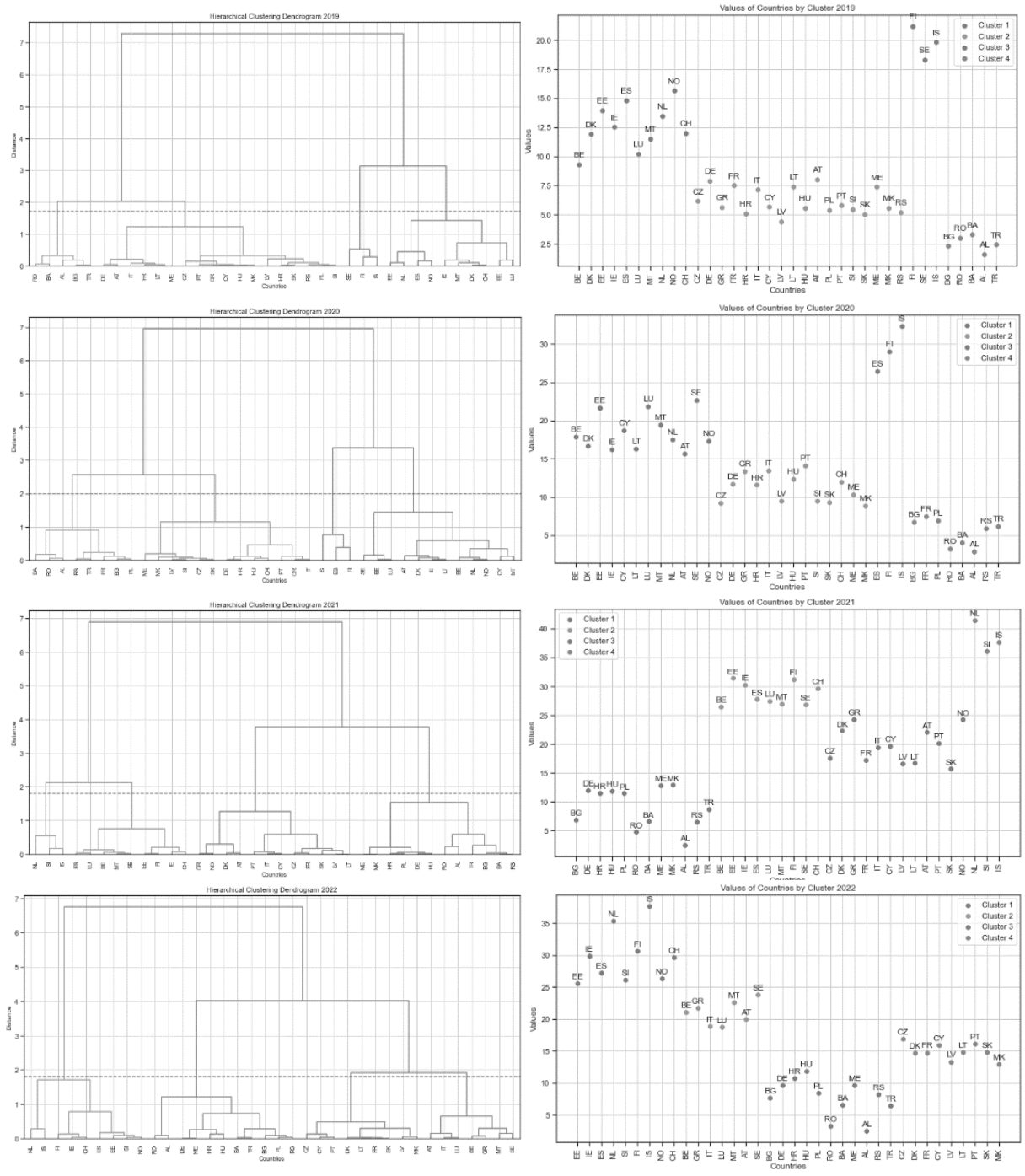
Source: Author's calculation based on Eurostat Database

Figure 4. Growth by years - Individuals who use Internet and Individuals who did an online course

The four groups of countries, or the four different clusters were categorized according to their levels of internet usage for doing an online course, that is low, above-low, below-high, and high level (See Figure 5).

The data presented in a tabular format shows the countries belonging to each cluster for a given year (Table 3). There are some countries (e.g. Bulgaria, Romania, Albania, Bosnia and Herzegovina and Turkey) that already did not have a culture of engagement in online courses, so they continuously belong to the cluster with a low level of internet usage for doing an online course. On the contrary, Finland consistently shows the highest share of people attending online courses, and thus almost continuously maintains its position in the cluster with high level of internet usage for doing online courses. At the same time, the findings point to some movements between clusters over the years, which means that there are changes among countries regarding the interest in doing online courses. For example, Spain and the Netherlands are moving from below-high to the cluster with a high level of internet usage for doing an online course, while

the example of Slovenia (moving from above-low to the high-level cluster) is even more striking.



Source: Author's calculation based on Eurostat Database

Figure 5. Cluster analysis on countries for individuals who did an online course in different years

Table 3.
Country groupings into clusters for each observed year

	low	above-low	below-high	high
2019	BG, RO, BA, AL, TR	CZ, DE, GR, FR, HR, IT, CY, LV, LT, HU, AT, PL, PT, SI, SK, ME, MK, RS	BE, DK, EE, IE, ES, LU, MT, NL, NO, CH	FI, SE, IS
2020	BG, FR, PL, RO, BA, AL, RS, TR	CZ, DE, GR, HR, IT, LV, HU, PT, SI, SK, CH, ME, MK	BE, DK, EE, IE, CY, LT, LU, MT, NL, AT, SE, NO	ES, FI, IS
2021	BG, DE, HR, HU, PL, RO, BA, ME, MK, AL, RS, TR	CZ, DK, GR, FR, IT, CY, LV, LT, AT, PT, SK, NO	BE, EE, IE, ES, LU, MT, FI, SE, CH	NL, SI, IS
2022	BG, DE, HR, HU, PL, RO, BA, ME, AL, RS, TR	CZ, DK, FR, CY, LV, LT, PT, SK, MK	BE, GR, IT, LU, MT, AT, SE	EE, IE, ES, NL, SI, FI, IS, NO, CH

Source: Author's calculation based on Eurostat Database; Note: Countries are represented by the two-letter country codes defined in ISO 3166-1 alpha-2.

5. Discussion and conclusion

The findings suggest that the highest positive correlation between individual internet users and individuals who did an online course was recorded in 2019 (correlation coefficient of 0.82). This strong positive correlation indicates that there is a significant relationship between these two variables, that is, higher internet usage is associated with a higher likelihood of taking online courses. In the years when pandemic measures were introduced (2020 and 2021), the correlation remained relatively high (0.71), with a slight increase observed in 2022, when the correlation coefficient was 0.74. Additionally, the analysis points to a consistent, almost linear increase in internet usage by individuals in European countries over the observed years. The maximum values remain relatively stable, hovering around 99%, which would mean that there is a saturation point in internet usage that reaches near-universal internet access. The annual downward trend of the standard deviation indicates a reduction in data variability, which in turn implies a more uniform and consistent pattern of internet usage across the countries. Means, medians, and standard deviation demonstrate an initial increase from 2019 to 2020, which would mean that there is a growth in online course participation during the pandemic, when traditional learning avenues were nearly limited. However, these values exhibit a certain decline in 2022, indicating a possible decrease in online course engagement compared to the peak of 2020. This might be due to the

gradual return to in-person learning or other factors affecting online course preferences. The difference of the minimum values from 2019 to 2022, although relatively small, signifies a slight increase in the proportion of individuals doing online courses. On the other hand, the significant upsurge of the maximum values in 2021 compared to 2019 and subsequent decrease in 2022 highlights fluctuations in the extent of online course participation.

Overall, the observed trends in online course engagement clearly reflect the transformative impact of the Covid-19 pandemic. Since individuals adapted to remote work and education, the pandemic has actually accelerated the adoption of digital technologies, including internet usage and online learning. In other words, during the coronavirus disease, when people were stimulated to limit the social contacts, online courses were increasingly popular as an alternative way of education and training. The continuous growth of internet usage indicates its increasing importance in various aspects of life, while the fluctuations in online course engagement suggest a dynamic and evolving landscape of online learning preferences. In view of this, a question that certainly arises is whether this downward trend will continue in the years to come, returning to some pre-pandemic levels, or whether some level of stability will be maintained. The analysis reveals that every country experiences a year-on-year increase in the percentage of individual internet users. This points to a positive and continuous trend of internet adoption and usage across all countries in the dataset. Moreover, there is a significant percentage growth in doing online courses in 2020, which likely corresponds to the initial impact of the pandemic. The pandemic-induced disruptions to traditional learning methods have led to a surge in online learning adoption during that year. On the other hand, the clustering analysis shows that the composition of clusters changes over time, indicating certain shifts in patterns of online course participation among different groups of countries. Some clusters remain relatively stable across the years, meaning that there is a consistent similarity in online course participation. Generally, the analysis provides insights into how the pandemic influenced the online course participation in different countries and how they adapted to the new circumstances over the observed years. In point of fact, this type of analysis is particularly useful as it provides guidance on how different groups of countries have responded to the challenges of the pandemic and how they might continue to evolve in terms of online learning practices. Overall, the results obtained and the analysis made here represent a valuable source for policymakers,

educators, and stakeholders in understanding the changing dynamics of internet usage and online learning across various countries at different timeframes. They may also serve as a basis for formulating strategies and interventions to further promote and support digital inclusion and online education initiatives.

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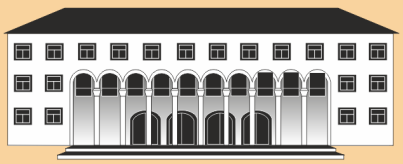

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6. Contacts:

Editor in chief: tel.: (++359) 631-66-201
Co-editor in chief: tel.: (++359) 631-66-395
Proofreader: tel.: (++359) 631-66-404
E-mail: bm@uni-svishtov.bg; zh.tananeeva@uni-svishtov.bg;
Web: bm.uni-svishtov.bg
Address: "D. A. Tsenov" Academy of Economics, 2, Em. Chakarov Str., Svishtov, Bulgaria