International Journal of Management and Marketing Research
Vol. 11, No. 1, 2018, pp. 113-122
ISSN: 1931-0269 (print)
ISSN: 2157-0698 (online)

IBFR
www.theIBFR.com

EUROPEAN EVIDENCE ON THE DIGITAL ACHIEVEMENT INDEX

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ABSTRACT

The incorporation of technology in all aspects of our lives has transformed the way of doing things, in form and substance. In recent years, the number of internet users has increased considerably both in Europe and in the rest of the world. It is necessary to acquire perspective to understand the phenomenon of access to digital technologies. This research examines technology use in 28 European Union countries, using a principal components methodology. Eighteen variables were examined, one for each objective that the population between 16 and 74 years old has when using the internet. The results indicate that countries using the most digital technology were Holland, Switzerland, Luxembourg, Finland, Denmark and Estonia. Countries with low utilization were Romania and Bulgaria.

JEL: C38, D83, L86

KEYWORDS: Digital Access, Digital Technologies, Main Components, European Union

INTRODUCTION

The objective of this work is to identify the use of digital technologies in 28 European Union countries. Martinez (2013) indicates in his study "Digital Skills and Gender Gap in Europe", that men and women have differences in the way they use technology. These differences are identified in both simple, frequently used activities and those whose use require greater knowledge and specialization. In most European countries there are differences in the way men and women use information. Differences between European countries in the management of technology and use of information are marked. For example, the people of the Netherlands and the Nordics have greater knowledge and skills with regard to technology and information management.

According to Castells (1997), "The term informative indicates the attribute of a specific form of social organization in which the generation, processing and transmission of information become the fundamental sources of productivity and power, due to the new technological conditions that arise in this historical period." (p 56). The use of these new technological conditions is present in daily activities including sending and receiving emails, participating in social networks, searching for information about goods and services, playing or downloading games, images, movies or music, finding a job or sending a job application, participating in online surveys or voting, downloading software, consulting encyclopedias, uploading content, searching for information related to health, using online banking, taking an online course, finding information on education , training or course offerings, buying goods or services, selling goods or services, searching for information and statistics from public institutions, downloading various formats from government agencies, loading forms and documents in public institutions. It is important to determine how technology is used today, since its evolution has generated changes in all aspects of live and to the benefit of a large part of society.

We investigate articles related to the use of technology. One article of particular interest is "The digital gender gap in Spain and Europe: Measurement with composite indicators" (Castaño & Martinez 2011). The results of the study confirm the usefulness of composite indicators in the use and application of technology, in which technological inclusion is determined between men and women. The document also notes that women are disadvantaged in relation to men in the use of technology. He also mentions that difference between men and women in the use of the Internet occurs in: games, leisure, entertainment, economic situations for men, and social welfare for women. He affirms that Spain is far behind Scandinavian countries in the use of technology. The present document is organized as follows: The literature review analyzes the contributions of theorists and researchers regarding the current use of technology in European countries to establish a point of reference. We continue with the methodology that establishes the type and design of the research, population and sample. The data collection instrument and elements for its proper interpretation are discussed, as well as reliability measurements of the model used. Finally, the results achieved are presented using the application of main components, and finally the results are interpreted and concluded.

LITERATURE REVIEW

It is increasingly necessary to have access to technology, since the employment and personal environments revolve around it. Digital technology refers to a wide range of tools, devices, programs and resources that store and transmit information in digital format, known as Web 2.0 technologies (Abbott, 2007, Hague & Williamson, 2009). These technologies include Facebook, Twitter, podcasts, wikis, blogs and virtual worlds (Bicen & Cavus, 2011). The Internet allows different forms of communication including, mass communication, discussion groups, chats, communication between people through email, text messages, and video conferencing. Hilbert (2010, 2011b), divided Information and Communication Technologies (ICTs) into three major groups: technologies that transmit and communicate information, those that store information, and those that process information. It is necessary to train in the specific competences required by ICTs, to permit more appropriate use. The method by which this training is carried out is crucial for incorporation into the digital culture. Huelves (2009: 56-77) makes mention of some elements that should be taken into account when training such as memory, psychomotricity, ergonomics, and learning development.

In developed countries, digital technology is used intensively for social and academic activities (Kolikant, 2010). However, in many developing countries, access to digital technologies is more limited (Acilar 2011, Miah & Omar 2012). Digital cities are those where technology, communications and information are used for the development and improvement of the quality of life. An important component in digital cities is access to high-speed Internet or broadband, which allows users to navigate through the network. Small businesses, populations located in rural areas and households in general need broadband, so its adoption is an important policy issue to make an online society (Mossberger, Tolbert, & McNeal, 2008, p.1). "This facilitates social inclusion through greater access to resources for individuals for individual well-being, such as government services, online news, and information. In health care."(DiMaggio, Hargittai, celeste & Shafer, 2004).

Mathematical models are methods that have been automated thanks to the development of computer science. As such they are of great practical use to solve problems in society. The Principal Component method (ACP) provides a statistical tool used in various areas of knowledge. Most commonly it is used where there exists considerable data volume which increases the need to understand the data structure and data interrelations. In some cases, assumptions of the method are not met, especially those related to the level of variable measurement and the linear relationship between variables. The ACP establishes the study objective. However, if the method's assumptions are not met for the observed data, the results are not trustworthy. In this situation, the non-linear or categorical ACP with optimal quantifications is a useful alternative.

Various statistical data catalogs exist regarding countries. Examples include the index of citizen network preparation, in the World Economic Forum (Dutta & Mia, 2008), The eReadiness index of the Economist Intelligence Union (Economist Intelligence Unit, 2009), the index of information in the society of IDC World Times (IDC, 2009), the digital opportunity index, the new opportunity index of UNCTAD ITU (ITU UNCTAD, 2007), and the digital index in Spain of the Orange Foundation (France Telecom Spain Foundation, 2006). These catalogs contain ordered indicators which show the dimensions and categories of the countries with information on technology to generate a comparable value. These indicators include aspects such as technological infrastructure, regulations and policies in technology, technological scope in market capacities, scope in business, the level of use of technology in companies and their use by citizens.

METHODOLOGY

The current study is mixed, documentary, non-experimental, descriptive and transactional. Data were downloaded from the "Eurostat" page (http://ec.europa.eu/eurostat), a site that contains statistical information from the European Union. Specifically, the section "Society and Digital Economy" was used. With the data obtained, a data matrix of 28 x 18 was generated (the 28 countries of the European Union and 18 independent variables). This matrix was used obtain the dependent variable digital achievement. Table 1 shows an analysis of the 18 exploratory variables in percentage of the population between 16 and 74 years old that used the Internet to perform some specific activity. The second column shows the number of observations for each item, followed by the mean, standard deviation, coefficient of variation, minimum observed value, the median and the maximum.

Table 1: Descriptive Statistics

Variable	N	Media	Standard Deviation	Coefficient of Variation	Min	Median	Max
A1	28	0.7057	0.1516	21.48	0.45	0.695	0.94
A2	28	0.5775	0.0972	16.83	0.43	0.58	0.75
A3	28	0.6132	0.1449	23.64	0.26	0.61	0.84
A4	28	0.4011	0.1101	27.45	0.23	0.385	0.65
A5	28	0.1618	0.0587	36.28	0.05	0.15	0.29
A6	28	0.0829	0.0626	75.54	0.02	0.07	0.32
A7	28	0.2425	0.1082	44.63	0.08	0.25	0.48
A8	28	0.4432	0.1552	35.02	0.17	0.435	0.79
A9	28	0.3557	0.1041	29.26	0.22	0.335	0.54
A10	28	0.5279	0.1046	19.81	0.33	0.54	0.71
A11	28	0.525	0.2333	44.44	0.05	0.56	0.9
A12	28	0.1636	0.0928	56.72	0.02	0.165	0.37
A13	28	0.0675	0.0412	61.1	0.02	0.05	0.18
A14	28	0.3307	0.109	32.97	0.18	0.315	0.6
A15	28	0.5246	0.1974	37.63	0.16	0.525	0.82
A16	28	0.465	0.1901	40.88	0.07	0.45	0.87
A17	28	0.3221	0.1501	46.59	0.05	0.305	0.69
A18	28	0.3379	0.1984	58.71	0.04	0.31	0.72

Table 1 shows a general analysis of the exploratory variables in percentages of the population between 16 and 74 years old that used the Internet to perform a specific activity. The second column shows the number of observations, followed by the mean, standard deviation, coefficient of variation, minimum observed value, the median and maximum. A1 = Send and/or receive emails, A2 = Participate in social networks, A3 = Search for information about goods and services, A4 = Play or download games, images, movies or music, A5 = Find a job or send a job application, A6 = Participate in online surveys or to vote, A7 = Download software, A8 = Consult wiki (encyclopedias), A9 = Upload content created by themselves, A10 = Search for health-related information, A11 = Use online banking, A12 = Take an online course, A13 = Search for information on education, training or course offerings, A14 = Buy goods or services, A15 = Sell goods or services, A16 = Search for Information and statistics of public institutions, A17 = Download several formats of governmental instances, A18 = Upload forms and documents in public institutions.

Coding of variables used in the study indicate the percentage of European population between 16 and 74 years old that used the internet to carry out some specific activity in 2017. We categorized these activities as: A1 = Send and/or receive emails, A2 = Participate in social networks, A3 = Search for information about goods and services, A4 = Play or download games, images, movies or music, A5 = Find a job or send a job application, A6 = Participate in online surveys or to vote, A7 = Download software, A8 = Consult wiki (encyclopedias), A9 = Upload content created by themselves, A10 = Search for health-related information, A11 = Use online banking, A12 = Take an online course, A13 = Search for information on education, training or course offerings, A14 = Buy goods or services, A15 = Sell goods or services, A16 = Search for Information and statistics of public institutions, A17 = Download several formats of governmental instances, A18 = Upload forms and documents in public institutions.

Table 2 shows correlation matrix eigenvalues listed in descending order for each main component. The first column shows the variable number. The second column shows the eigenvalue obtained after running the PRINCOMP procedure included with the SAS statistical package. The third column shows the difference between each eigenvalue of each main component. By subtracting the eigenvalue of the main component 2 from the eigenvalue of the main component 1, the first difference is obtained with a value of 10,325. The fourth column indicates the most important information in relation to this study. It shows the total variability among the 18 variables explained by each main component obtained. The first value has a high value of 0.661. When multiplied by 100, we see that main component 1 itself explains 66.1% of the total variability. Finally, the fifth column shows the cumulative result of adding each proportion obtained from the various main components. The eigenvalue of main component 2, with a value of 1.57, explains 8.8% of the total variability. When added to the first component, these variables explain 74.9% of the total variability. Finally, the third principal component obtains an eigenvalue of 1.071, explaining 5.9% of the total variability. The first three components have cumulative explanatory power equaling 80.8% of total variability. Component 1 has a high value explaining 66.1% of total variability. For this reason, it is possible to consider it an index, which reduces the dimensions necessary to make a comparison between the 28 countries of the European Union.

Table 2: Eigenvalues

No.	Eigenvalue	Difference	Proportion	Accumulated
1	11.901	10.325	0.661	0.661
2	1.576	0.506	0.088	0.749
3	1.071	0.377	0.059	0.808
4	0.693	0.118	0.039	0.847
5	0.576	0.055	0.032	0.879
6	0.521	0.047	0.029	0.908
7	0.473	0.190	0.026	0.934
8	0.283	0.037	0.016	0.950
9	0.246	0.059	0.014	0.963
10	0.187	0.042	0.010	0.974
11	0.145	0.044	0.008	0.982
12	0.101	0.014	0.006	0.987
13	0.087	0.027	0.005	0.992
14	0.060	0.028	0.003	0.996
15	0.033	0.013	0.002	0.997
16	0.019	0.004	0.001	0.999
17	0.015	0.003	0.001	0.999
18	0.012	0.000	0.001	1.000

Table 2 shows eigenvalues of the correlation matrix in descending order. Rows correspond to variables noted in Table 1.

Figure 1 shows a visual corroboration of the weight that each main component has on total variability. The figure shows high values of principal component 1 and the difference between the other 17 components can be visually appreciated. The eigenvalue obtained for the main component 1 was 11,901, placing it in the highest part of the graph. It has a difference of 10,325, with respect to the second eigenvalue which obtained a value of 1,576. From this information we summarize that 74.9% of the variability is explained taking into account only the first two main components.

Figure 1: Sedimentation Graph

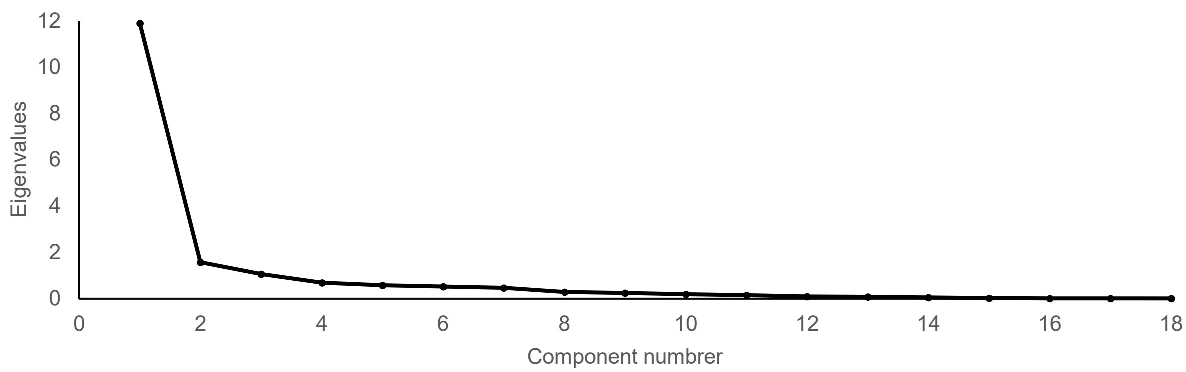

Figure 1 shows a visual depiction of the weight that each main component has on the total variability.

Table 3 shows values ordered in ascending sequence of the main component 1, corresponding to each country. When executing the SAS PRINCOMP procedure these values are calculated and stored in the program. However, when using the SORT procedure together with the PRINT procedure, it is possible to order the 18 countries by the value obtained for each main component. The component that summarizes the greatest total variability was main component 1. Main component 1 explained 66.1%, making it possible to create an index that allows for classifying the digital use by European Union countries. We conclude that Romania uses the least digital, while Denmark is located at the highest level.

Table 3: Ordered Values for the Main Component 1

Country	Prin1	Country	Prin1
Romania	-6.490	Hungary	-0.871
Bulgaria	-5.834	France	-0.272
Italy	-4.129	Austria	-0.182
Poland	-3.602	Belgium	0.774
Greece	-2.726	Spain	0.847
Croatia	-2.380	Malta	1.486
Czech Republic	-1.929	Germany	2.036
Portugal	-1.817	United Kingdom	2.919
Slovakia	-1.715	Estonia	2.954
Cyprus	-1.714	Netherlands	5.215
Lithuania	-1.430	Sweden	5.401
Slovenia	-1.391	Luxembourg	5.512
Latvia	-1.377	Finland	5.791
Ireland	-1.080	Denmark	6.005

Table 3 shows the values ordered in ascending order of the main component 1, corresponding to each country.

Table 4 contains the Pearson correlation coefficients between the 18 study variables and main component 1. A strong positive correlation is observed. On average the correlations exceed a value of 0.7, and reach values close to 0.9, except for variables A9 and A14. P-values indicate that these correlations are significant, with values lower than 0.05 (marked with **). This high level of association, increases the reliability for the use of the main component 1 as an index.

Table 4: Pearson Correlation of the Main Component 1 with the 18 Explanatory Variables

VARIABLE	PRIN 1	VARIABLE	PRIN 1
A1	0.893**	**A10**	0.863**
A2	0.717**	**A11**	0.906**
A3	0.897**	**A12**	0.706**
A4	0.868**	**A13**	0.805**
A5	0.88**	**A14**	0.681**
A6	0.705**	**A15**	0.886**
A7	0.83**	**A16**	0.834**
A8	0.849**	**A17**	0.891**
A9	0.546**	**A18**	0.777**

*Table 4 contains the Pearson correlation coefficients between the 18 study variables and the main component 1. ** indicates significance at the 5 percent level.*

RESULTS

Table 5 shows the digital achievement index, based on the main component analysis. The value obtained in main component 1 was used to position the countries on some of the 5 scales. The eigenvalue obtained for this variable was 11,901, indicating explanatory power for 66.1% of total variability. Countries of the European Union that present the lowest level of digital achievement are Romania and Bulgaria. Those at the highest level are the Netherlands, followed by Sweden, Luxembourg, Finland and Denmark. In total the index consists of 5 scales depending on the value obtained in the main component 1. The scales are as follows: Very low (values less than or equal to -5), Low (values greater than -5 to values less than or equal to -2), Medium (values greater than -2 to values less than or equal to 1), High (values greater than 1 to values less than or equal to 4) and Very high (values greater than 4).

Table 5: Digital Achievement for the European Union

Country	Digital Achievement	Country	Digital Achievement
Romania	Very Low	Malta	High
Bulgaria		Germany	
Italy	Low	United Kingdom	
Poland		Estonia	
Greece		Netherlands	Very High
Croatia		Sweden	
Czech Republic	Moderate	Luxembourg	
Portugal		Finland	
Slovakia		Denmark	
Cyprus			
Lithuania			
Slovenia			
Latvia			
Ireland			
Hungary			
France			
Austria			
Belgium			
Spain			

Table 5 shows the digital achievement index, based on the main component analysis, where the value obtained in the main component 1 was used to position the countries in the 5 scales.

In Figure 3, the values of main component 1 against main component 2 are compared for each country. Visually, there is a considerable distance between countries with high digital achievement (Netherlands, Sweden, Luxembourg, Finland and Denmark) versus the other countries. This graph allows us to analyze the data from another perspective as well. Finland and Luxembourg are almost at the same height on the graph, however they are located in different quadrants from left to right. This is because they have similar values in main component 1 (5.79 and 5.51 respectively), but different values in main component 2 (-1.50 and 3.04). The latter is because Finland generally has a better digital use, but Luxembourg exceeds it in some specific variables. Specifically, A1, A2, A6, A7, A8, A9, A14, A15, variables are more related to the aspect of executing a particular action..

Figure 3: Main Component 1 vs Main Component 2

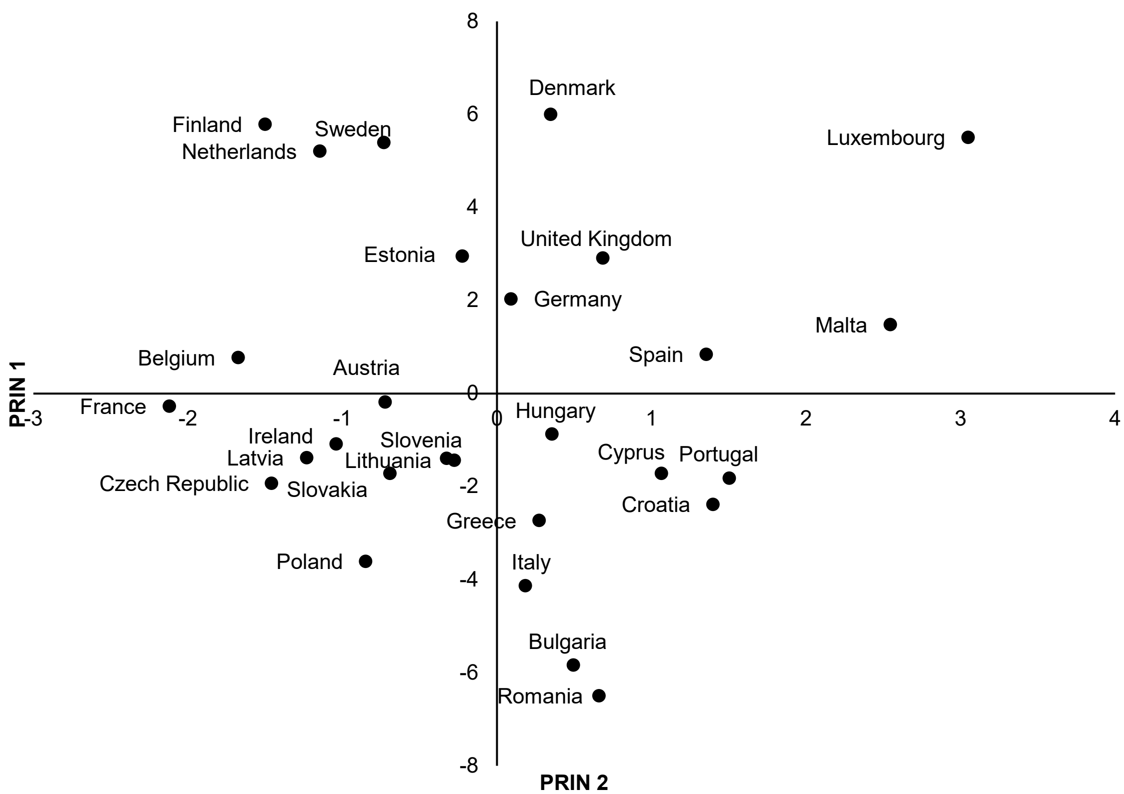

Figure 3, shows the values of main component 1 against main component 2 compared for each country.

CONCLUSIONS

This paper examines technology use in the European Union. The use of a principal components methodology allows us to summarize the variability of a phenomenon to be explained, through the eigenvectors calculated from the correlation matrix. We are further able to construct statistically validated indexes. By using 18 variables that described the use of information technologies in different areas of the sample countries, it was feasible to build an index through main component 1. This component managed to concentrate 66.1% of the total variability. We examine Pearson correlation analysis between the 18 study variables and the main component 1. Some 13 of the 18 variables presented a correlation coefficient greater than 0.8, at a level of significance of 5%. The digital achievement index proposed in the present study, allows us to classify the countries based on 5 different scales. It is then possible to evaluate areas of opportunity regarding the use of technology in each of the nations. Policymakers can further make decisions regarding ICT use policies of the government. Similarly, individuals can make investment decisions. Countries that presented the lowest level of digital exploitation were Romania and Bulgaria. Countries at the highest levels were the Netherlands, followed by Sweden, Luxembourg, Finland and Denmark. Analysis through time by means of this type of index allows us to show the progress or regression in terms of digital use. We recommend replicating this type of study in other phenomena.

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