Digital Divide across the European Union

por

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Abstract

Our research analyzes the digital divide within the European Union 27 (EU-27). To achieve this objective we use multivariate statistical methods, more specifically factor and cluster analysis, to address the disparities in the digital development levels between EU countries. Our results lead to an identification of two latent dimensions and five groups of countries when it comes to the digital development. We conclude that a digital gap does, in fact, exist within the EU. Moreover our results suggest that there is a relation with the entrance year to the Union with the digital development stage, considering that newer member presents lower digital developments.

Keywords: Digital Divide, Digital Development, ICT, Information Society, Electronic Services, European Union, Factor Analysis, and Cluster Analysis.

Resumo

A nossa pesquisa analisa a divisão digital dentro da União Europeia a 27 (UE-27). Para alcançar este objectivo fizemos uso de métodos estatísticos multivariados, mais especificamente de uma análise factorial e de análise de clusters, de forma a analisar as disparidades nos níveis de desenvolvimento digital entre os países-membros da UE-27.

Os nossos resultados levaram à identificação de duas dimensões latentes e cinco grupos de países no que toca ao desenvolvimento digital. Concluímos que, de facto, existe uma divisão digital dentro da EU-27. Adicionalmente os nossos resultados sugerem que existe uma relação entre o ano de adesão na UE com o nível de desenvolvimento digital, considerando que membros mais recentes apresentam um desenvolvimento digital mais baixo.

Palavras-Chave: Divisão Digital, Desenvolvimento Digital, TIC, Sociedade da Informação, Serviços Electrónicos, União Europeia, Análise Factorial e Análise de Clusters.

Publications

List of publications resulting from this dissertation

Papers

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Abbreviations

EU – European Union

EU-15 – 15 European Union countries

EU-27 – 27 European Union countries

ICT – Information and Communication Technologies

KMO – Kaiser-Mayer-Olkin

OECD – Organization for the Economic Co-operation and Development

WSIS - World Summit on the information society

1 INTRODUCTION

The attention given by leaders from all over the world to the concept of information society and the potential for a digital divide has risen significantly in recent years. At the World Summit on the information society (WSIS), it was declared that the global challenge for the new millennium is to build a society "where everyone can create, access, utilize and share information and knowledge, enabling individuals, communities and peoples to achieve their full potential in promoting their sustainable development and improving their quality of life" (WSIS, 2003, 2005).

Moreover, the European Union (EU) has just released the Europe 2020 Strategy, which seeks to lead to "a smart, sustainable and inclusive growth for European Economy" (European Commission, 2010b) and "to exit the crisis and prepare the EU economy for the challenges of the next decade" (European Commission, 2010a). This economic growth will be accomplished by (among other things) developing a (digital) economy based on knowledge and innovation (European Commission, 2010b). The Digital Agenda for Europe is included in the Europe 2020 Strategy as one of the seven strategy flagships. It aims to define the central role that the use of information and communication technologies (ICT) must play if Europe wishes to realize its ambitions for 2020 (European Commission, 2010a). Therefore, important digital inequalities that exist within the 27 European Union (EU-27) countries must be detected and corrected in order to avoid jeopardizing the objectives of Europe 2020.

There is a lack of studies that address the situation regarding the digital divide, particularly within the European context. Considering the importance that the European Commission gives to a homogeneous digital development in all of its members, the first step to take toward this development is to assess the current situation within the Union. This research helps to fill this gap and shed light on the issue in order that efficient policies may be deployed. Hence, we intended to provide a complete and updated analysis of digital asymmetries within the EU-27 with data pertaining to the year 2010.

2 DIGITAL DIVIDE AND DIGITAL DEVELOPMENT

The term digital divide was first used in the mid-1990s by the former Assistant Secretary for Communications and Information of the United States Department of Commerce, Larry Irving Junior (Dragulanescu, 2002). According to the Organization for Economic Co-operation and Development (OECD),

> ‘the term digital divide refers to the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access ICT and to their use of the Internet for a wide variety of activities’ (2001).

Initially the digital divide was understood in binary terms, meaning that the differences were in “has” or “has not” access to ICT. Today, however, this binary difference is considered narrow, since that other factors need to be considered (Brandtzæg, Heim, & Karahasanovic). Therefore, digital divide is today understood to be a complex, multidimensional phenomenon (Bertot, 2003; Hsieh, Rai, & Keil, 2008; Okazaki, 2006; Warschauer, 2002).

There are two types of digital divide. The first is located at an international level, that is, between different countries. The second is located at an intra-national level, or within a country. In these types of digital divide gaps can occur regarding access to ICT between regions, or groups of individuals, when characteristics of different nature exist (Ono & Zavodny, 2007; Unesco, 2003). Some authors have demonstrated that the domestic digital divide is characterized by a higher risk of digital exclusion of the elderly, women, population with lower income, education attainment, those with disabilities, those living in rural areas, and ethnic minorities (US Department of Commerce, 1995, 1998, 1999, 2000, 2002; Vicente & Lopez, 2008, 2010a, 2010b; Vicente & López, 2006). Hsieh and Rai (2008) showed that economically advantaged and disadvantaged people also have very different post-implementation behaviour regarding the use of ICT. These authors concluded that economically advantaged people have a “higher tendency to respond to network exposure”, using these technologies with much more confidence than the disadvantaged. They named these inequalities about access and use of ICT as “first order” and “second order” digital divides, respectively, adding greater complexity to the phenomena. Moreover, according to Dewan and Riggins (2005), digital disparities may also be found at an organizational level, in which “large organizations are more likely to adopt innovations and advanced ICT solutions than smaller organizations". Hence, the digital divide can represent a threat to all of the *e-strategies* around the world, including the Digital Agenda for Europe (Cuervo & Menéndez, 2006; OECD, 2009).

Development and use of ICT have undergone exponential growth in recent decades. These technologies are playing a decisive role in improving almost every aspect of our societies, including business transactions, communications, economics, and politics. Wattai and Schuff (2010) studied the impact of the Web 2.0, especially the influence of social networks on politics, in the 2008 U.S. Primary Presidential Campaign, and concluded that the Internet is changing the very nature of political competition. Carlsson (2004) studied the effects of the ICT in the economy, comparing the potential of these technologies to the so called "general-purpose technologies (GPTs) which in the past revolutionized the economy", such as the transportation and communications technologies in the 19^{th} century, the Corliss steam engine, or the electric motor. He concluded that ICT appears to have an even greater impact on the economy since "it affects the service industries (e.g., health care, government, and financial services) even more profoundly than the goods-producing industries, and these service sectors represent over 75% of GDP". Jalava and Pohjola (2008) showed that the ICT contribution to Finland's GDP between 1990 and 2004 was three times larger than the contribution of electricity from 1920 to 1938. Moreover, new types of interactions, or advanced services, are becoming more and more common. These include e-commerce, e-government, e-health, e-learning, e-banking, e-finance, and others (Çilan, Bolat, & Coskun, 2009; European Commission, 2006; *Facer*, 2007; Vicente & Gil-de-Bernabé, 2010; Vicente & Lopez, 2010a). Actions and technologies like Internet surfing, YouTube, email, wiki-sites, and access to online libraries are gaining room in our daily routines, improving the way people interact with each other. These factors are drawing strong distinctions between individuals who have access to privileged information and those who have not (Brooks, Donovan, & Rumble, 2005). The emergence of ICT is even changing the notion of literacy, considering that the inability to use these technologies is creating an entirely new group of disadvantaged people who were considered "literate" in the past (Unwin & de Bastion, 2009). Therefore, there is evidence that ICT positively affects the economy and welfare in several dimensions (Çilan, et al., 2009; The World Bank, 2006). ICT creates competitive advantages in enterprises, improves national health systems (Bakker, 2002) through e-health, improves educational systems (Cukusic, Alfirevic, Granic, & Garaca, 2010; Hsieh, et al., 2008) through e-learning, which creates new opportunities, all of which reduces distance constraints and creates new industries that generate new employment opportunities (Castells, 2007; Castells & Himanen, 2002). Thus, for these benefits to be realized, certain obstacles need to be overcome, particularly inequalities both between and within countries regarding the access to these technologies.

3 MEASURING DIGITAL DIVIDE

3.1 Framework

Due to ICT's importance in the improvement of the economy and social care, the problem of how to measure the digital divide has gained importance in terms of research (Cuervo & Menéndez, 2006; OECD, 2009; The World Bank, 2006; Vehovar, Sicherl, Husing, & Dolnicar, 2006). Wang, McLee, and Kuo (2011) identified 852 journal articles and books published between 2000 and 2009, with more than 26,000 citations using the term "digital divide" as keyword, in order to map the intellectual structure on this subject. However, despite the increasing attention that this phenomenon has received, measuring the access and diffusion of ICT is a complex task plagued by several constraints. Firstly, there is no single and standardized definition of digital development, information society, or digital divide. As a result, considerations about these subjects differ between countries, geographical areas, organizations, and models of information society (Castells & Himanen, 2002). In fact there are several models of information society, such as those from Finland, Singapore, and the United States (Silicon Valley). Each emphasizes specific characteristics and objectives which are in line with their own respective national realities (Castells & Himanen, 2002). The second constraint is related to a lack of harmonized data available when considering analysis for multiple countries. Hence, there is a "trade-off" between the depth and the width of the analysis. This means that the more indicators that researchers try to use, the fewer are the countries that can be included in the analysis (Cuervo & Menéndez, 2006).

In the case of the present study this problem was mitigated by the fact that our analysis is restricted to the EU-27 and Eurostat data from recent years, which are fairly well harmonized. We were able to obtain 14 of 15 variables used in our analysis from the Information Society Statistics Category in the Eurostat website – all pertaining to the year 2010. Data from the 15th variable were obtained from the World Bank database. The fact that all variables were obtained from official entities, and concerns for the year 2010, guarantee that the results of the analysis enjoy a high degree of reliability.

According to the recommendations of the OECD, the variables that should be used to measure the digital divide vary with the goals of the research. For instance, if we wish to measure the internal or domestic digital divide we should “drill down” the ICT level indicators by groups such as gender, age, income, education, geographical place, and so on. To measure the digital divide between countries, the indicators should refer to the aggregated national reality. Since our objective is to analyze the divide within the EU, we will follow the second recommendation.

Recent studies have suggested that the international digital divide is mainly a consequence of economic inequalities between countries. The terms “information rich” and “information poor” have appeared to classify countries in terms of their digital development. Besides economic development, countries with lower educational attainment also tend to present lower rates on the use and adoption of ICT (M. D. Chinn & Fairlie, 2007; Menzie D. Chinn & Fairlie, 2010; Dewan, Ganley, & Kraemer, 2009; Hargittai, 1999; Kiiski & Pohjola, 2002; Pohjola, 2003). Dewan and Ganley (2009) showed that developing countries are being slower to achieve digital development but with the focus on certain technologies, particularly the availability of PCs and Internet with a cost-reduction policy, the cross-technology diffuse effects of these combined technologies will contribute to appreciably narrow the divide.

3.2 Data

To measure the levels of digital development across EU-27 we used 15 variables that are compatible with recommendations from the OECD and EU, and were mentioned in our literature review. These indicators were selected by combining a mix of prior studies with some recommendations from the organizations mentioned above. Table 3.1 shows the variables.

Table 3.1 Acronyms and Descriptions of Variables

Code	Variable
HsInt	Percentage of households having access to the Internet at home
BroRt	Broadband penetration rate
IntPop	Percentage of population regularly using the Internet
IntSrc	Percentage of population using Internet for finding commercial information
Cost	Percentage of households without Internet connection because of the access costs
eBank	Percentage of population using e-banking services
eLearn	Percentage of population using e-learning services
email	Percentage of population using e-mail
eHealth	Percentage of population using Internet for seeking health information
eGovI	Percentage of individuals using Internet for interaction with public authorities
eGovE	Percentage of enterprises using Internet for interaction with public authorities
eGovS	Percentage of government services available online
ecom	Percentage of enterprises selling online
Serv	Number of secure servers per million inhabitants
eSafeE	Enterprises having a defined ICT security policy with a plan of regular review

Considering the limitations on data availability for the EU, we chose to include indicators already reported on in the literature along with new ones that we considered valuable for the study. The percentage of households having access to Internet and broadband connections (HsInt) and (BroRt), respectively, the number of secure servers per million inhabitants (Serv), and the percentage of e-government services available (egovS) were used by Cuervo and Menéndez (2006), among other indicators, to measure the digital divide within the EU-15. The percentage of households having access to the Internet (HsInt), percentage of population regularly using the Internet (IntPop), percentage of population regularly using the Internet for finding commercial information (IntSrc), percentage of population using the Internet to interact with public authorities (egovI), and the percentage of population regularly using e-learning services (elearn), were used by Çilan, Bolat and Coskun (2009) to analyze the digital divide between member and candidate countries of the EU before the 2004 enlargement. Internet access costs is also an important factor for predicting ICT adoption, since these are strongly and negatively correlated, and for this reason was also included (Dewan, et al., 2009; Unwin & de Bastion, 2009)**.** Moreover, via the Digital Agenda for Europe (2010a) the European Commission emphasizes the role of services such as e-health, e-learning, e-banking, and e-government. E-banking and e-health are considered to be *"some of the most innovative and advanced online services"* (European Commission, 2010a); e-government services are also highlighted in the Digital Agenda, since *"despite a high level of availability of e-government services in Europe, differences still* *exist amongst Member States"* (European Commission, 2010a). The inclusion of these indicators, related to how ICT is used among populations also allows us to analyze the so called "second order digital divide", expanding our focus from ICT infrastructure, to include the manner in which it is used by populations and individuals (Hsieh, et al., 2008). Moreover, there are few studies on this subject that include the measurement of these services. The 15 variables allow us to explore multiple key factors related to the digital development, particularly the ICT infrastructure and its costs, adoption, and diffusion by population and enterprises, e-commerce, e-safety, and e-government.

The data used (see Table 3.2) show high disparities within the EU-27 related to the ICT: in Bulgaria only 2% of the population uses e-banking services, while in the Netherlands 77% do so. In Romania only 7% of the population uses the Internet for interacting with public authorities (egovI), while in the Denmark this figure stands at around 72%, which is ten times higher. When analyzing the e-government supply availability (egovS), there are six countries with 100% services available online and nine countries with values less to 75%. Also, when analyzing the percentage of households without Internet because of the access costs (Cost), we have four countries with a value above 15% and nine under 5%. We also notice extreme asymmetries in the overall profile of the 27 countries. The Netherlands is the best-ranked country for eight of the 15 variables used, while Bulgaria and Romania are the poorest-ranked in eight of them. These uneven distributions in the variables will not affect our analysis, since factor analysis does not make any assumptions about variables´ distributions. Nevertheless, they can tell us a great deal about the asymmetries that exist between countries. Moreover, the dimensionality of the data used -15- makes it impossible to address the digital divide with simple univariate statistics.

Table 3.2 Data Used

Country	Ach	HsInt	BroRt	IntPop	IntSrc	Cost	ebank	elearn	email	ehealth	egovI	egovE	egovS	ecom	Serv	eSafeE
Austria	**Au**	73	24	70	58	4	38	35	66	37	39	75	100	14	857	24
Belgium	**Be**	73	30	75	62	6	51	39	72	37	32	77	79	26	490	29
Bulgaria	**Bu**	33	14	42	26	9	2	13	35	13	15	64	70	4	73	7
Cyprus	**Cy**	54	23	50	47	9	17	23	41	21	22	74	55	7	1051	37
Czech Rep.	**CR**	61	20	58	53	5	23	22	59	21	17	89	74	20	318	21
Denmark	**De**	86	38	86	78	1	71	64	83	52	72	92	95	25	1866	43
Estonia	**Es**	68	26	71	61	17	65	33	63	35	48	80	94	10	434	11
Finland	**Fi**	81	29	83	74	5	76	70	77	57	58	96	95	16	1246	37
France	**Fr**	74	31	75	65	10	53	53	72	36	37	78	85	12	306	22
Germany	**Ge**	82	31	74	72	5	43	38	72	48	37	67	95	22	874	27
Greece	**Gr**	46	19	41	36	5	6	28	32	22	13	77	48	9	124	39
Hungary	**Hu**	60	20	61	55	16	19	33	58	41	28	71	66	8	166	9
Ireland	**Ir**	72	23	63	57	3	34	44	58	27	27	87	100	21	1005	28
Italy	**It**	59	21	48	35	4	18	38	43	23	17	84	100	4	154	29
Latvia	**La**	60	19	62	57	22	47	42	55	32	31	72	93	6	173	15
Lithuania	**Li**	61	20	58	48	8	37	25	49	31	22	95	72	22	176	25
Luxembourg	**Lu**	90	33	86	78	0	56	72	83	58	55	90	72	14	1413	28
Malta	**Ma**	70	29	60	52	1	38	43	54	34	28	77	100	16	1365	30
Netherlands	**Ne**	91	39	88	82	0	77	38	87	50	59	95	95	22	2276	29
Poland	**Po**	63	15	55	39	8	25	35	48	25	21	89	79	8	211	11
Portugal	**Pt**	54	19	47	44	8	19	42	45	30	23	75	100	19	174	22
Romania	**Ro**	42	14	34	26	22	3	20	31	19	7	50	60	6	40	9
Slovakia	**Sk**	67	16	73	62	6	33	27	70	35	35	88	63	7	128	35
Slovenia	**Sn**	68	24	65	57	13	29	47	58	43	40	88	95	10	301	16
Spain	**Sp**	59	23	58	54	10	27	39	55	34	32	67	95	12	233	33
Sweden	**Sw**	88	32	88	82	3	75	50	84	40	62	90	100	24	1266	46
U. K.	**UK**	80	31	80	63	4	45	42	74	32	40	67	98	15	1396	29
Minimum		33	14	34	26	0	2	13	31	13	7	50	48	4	40	7
Maximum		91	39	88	82	22	77	72	87	58	72	96	100	26	2276	46
Std. Deviation		15	7	15	16	6	22	14	16	12	16	11	16	7	623	11
Average		67	24	65	56	8	38	39	60	35	34	80	84	14	671	26

4 METHODOLOGY

4.1 Factor Analysis

Factor analysis uses the correlation between variables in order to find latent factors within them (Spicer, 2005). In order to apply factor analysis successfully some assumptions need to be confirmed. Using this technique depends on the correlation structure within the input data (Hair, Anderson, Tatham, & Black, 1995). Hence, we need to confirm that this correlation exists, otherwise the factor analysis may provide weak results. Our analysis involved several steps. The first was to analyze the correlation structure of the data by using the correlation matrix. The second was to confirm the suitability of the data using the Kaiser-Mayer-Olkin (KMO). In the third step we chose the extraction method to be used. In the fourth step the number of factors to be extracted was defined and we proceeded to the interpretation of the factors based on its loadings.

The correlation matrix (see Table 4.1) shows that each variable has, at least, one absolute correlation coefficient of 0.53 with another variable. Although this correlation value is moderate, it ensures that all of the variables used for measuring the digital divide are measuring the same phenomena. We notice that some pairs of variables present extreme correlation levels. The percentage of population regularly using the Internet (IntPop) has a correlation level of 0.99 with the percentage of population regularly using e-mail (email) and a value of 0.97 with the percentage of population using the Internet for finding commercial information about products or services (IntSrc). At the other end of the spectrum we have the percentage of e-government services available online (egovS) with a correlation level of 0.13 with the percentage of enterprises that have adopted a regular ICT security plan (esafeE). We also notice that the same availability of e-government services online shows a low correlation (0.2) with the adoption of these services by the enterprises (egovE). Hence, it may be that factors other than the availability of these services influence the adoption decisions. Lee, Kim, and Ahn (Lee, Kim, & Ahn) showed that the willingness by business users to adopt public services online is significantly related to the perceived quality of those *services vis-à-vis* traditional (offline) channels. These authors showed that businesses tend to have other drivers that influence the decision of use e-government services than its mere availability, a belief that our correlation matrix appears to support.

Table 4.1 Correlation Matrix

	HsInt	BroRt	IntPop	IntSrc	Cost	eBank	eLearn	email	eHealth	eGovI	eGovE	eGovS	eCom	Serv	eSafeE
HsInt	1	0.87 **	0.95 **	0.94 **	-0.55 **	0.88 **	0.74 **	0.94 **	0.84 **	0.86 **	0.55 **	0.53 **	0.64 **	0.77 **	0.49 *
BroRt		1	0.83 **	0.85 **	-0.55 **	0.82 **	0.69 **	0.83 **	0.75 **	0.82 **	0.37	0.48 *	0.65 **	0.84 **	0.53 **
IntPop			1	0.97 **	-0.46 *	0.92 **	0.69 **	0.99 **	0.84 **	0.92 **	0.53 **	0.45 *	0.57 **	0.71 **	0.44 *
IntSrc				1	-0.43 *	0.90 **	0.70 **	0.97 **	0.87 **	0.91 **	0.51 **	0.43 *	0.62 **	0.72 **	0.50 **
Cost					1	-0.34	-0.37	-0.47 *	-0.33	-0.38 *	-0.54**	-0.25	-0.56**	-0.64 **	-0.67 **
ebank						1	0.7 **	0.89 **	0.78 **	0.91 **	0.55 **	0.53 **	0.58 **	0.70 **	0.42 *
elearn							1	0.68 **	0.80 **	0.75 **	0.45 *	0.50 **	0.37	0.54 **	0.42 *
email								1	0.83 **	0.90 **	0.50 **	0.46 *	0.60 **	0.70 **	0.42 *
ehealth									1	0.86 **	0.46 *	0.38 *	0.47 *	0.61 **	0.35
egovI										1	0.51 **	0.49 *	0.49 **	0.74 **	0.46 *
egovE											1	0.20	0.42 *	0.38 *	0.41 *
egovS												1	0.40 *	0.39 *	0.13
ecom													1	0.56 **	0.48 *
Serv														1	0.54 **
esafeE															1

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

To confirm the suitability of the data for factor analysis, KMO was performed. It returned the value of 0.82, which expresses a good suitability (Jolliffe, 2005).

As extraction method we applied the factor analysis, which is the method most widely used in Marketing and the Social Sciences (Peres-Neto, Jackson, & Somers, 2005). Since our aim is to reduce the complexity of the problem, we had to decide how many factors we would extract from the factor analysis. There are no definitive criteria to define the number of factors to retain, but it is important to note that the decision should depend on the context of the analysis. There are three main criteria for defining the number of factors to retain; Pearson´s, Kaiser´s, and the Scree Plots. All of these methods were taken into consideration (Peres-Neto, et al., 2005), and all yielded the same solution: the optimal number of factors to be extracted is two. As shown in Table 4.2, the percent of variance retained in these two factors is 76%.

Since our objective is to reduce the complexity of the data about the digital divide, in our factor analysis we used the rotation of the factors in order to achieve a better split of the original indicators in only one factor. Although there are several types of rotation, including orthogonal and oblique methods, the orthogonal ones seem to be the most widely used (S. Sharma, 1996). In particular, we applied the Varimax rotation.

Varimax and Quartimax rotations led to similar results, in fact, which support the belief that our solution is based on a well explained factor structure.

To measure the scale reliability of each factor, Cronbach´s Alpha was also calculated. It measures the internal consistency of each factor within itself. Nunnally (J. C. Nunnaly, 1978) suggests that a value over 0.7 is considered good. The values returned were 0.97 for factor 1 and 0.85 for factor 2, which confirm the high reliability of the two factors extracted.

Table 4.2 Results of Factor Analysis and Cronbach´s Alpha

	Rotated Factor Model: Varimax	
	Factor 1	**Factor 2**
eGovI	**0.90**	0.31
IntPop	**0.89**	0.36
eBank	**0.89**	0.30
IntSrc	**0.89**	0.38
email	**0.88**	0.36
eHealth	**0.88**	0.22
HsInt	**0.85**	0.46
BroRt	**0.76**	0.49
eLearn	**0.76**	0.25
eGovS	**0.58**	0.08
eSafeE	0.17	**0.83**
eCom	0.42	**0.63**
Serv	0.54	**0.62**
eGovE	0.35	**0.56**
Cost	-0.13	**-0.91**
Variance (%)	**51%**	**25%**
Variance Total	**51%**	**76%**
Cronbach´s Alpha	**0.97**	**0.85**

Note: variables are marked according to factor loading

As mentioned above, the final step of our factor analysis is to interpret the factors extracted based on their loadings, i.e., based on the variables that contribute the most to each dimension.

Apparently the digital development can be explained by two latent dimensions, in which asymmetries between countries may, or may not, exist. The first is the *ICT Infrastructure and adoption by Population,* which is related to the availability of ICT infrastructures and their use by the population. This dimension includes the Internet and broadband penetration rates, the availability of e-government services by the supply (public) side, the adoption of e-government services by the users' (population) side, as well as the nature and intensity of Internet use. The second dimension is related to the commercial use of the ICT and its access costs and is therefore named *e-business and Internet access costs.* This dimension is related to the diffusion of e-business, including the diffusion of e-commerce, e-safety concerns, and e-government, as well as the internet access costs. The fact that all variables except this last one have high positive loadings, and this one has a high negative loading, means that there is an inverse proportionality between the e-commerce, e-government, and safety, with the Internet costs. We note that the Internet access cost (Cost) has a highly negative influence (loading) on this factor, meaning that higher costs are associated with low levels on this dimension, as observed in earlier studies (Cuervo & Menéndez, 2006; Dewan, et al., 2009; Unwin & de Bastion, 2009). We computed the factor scores for each country, and plotted it for a comparison analysis (see Figure 4.1).

In this way, public authorities must ensure that the prices to access the Internet are low in order to deter the digital divide within the EU-27 (Dewan, et al., 2009). Thus, Denmark, the Netherlands, and Sweden are the best-ranked countries for the two dimensions extracted together. These North European Countries present high levels of both *ICT Infrastructure and adoption by Population* and *e-business and Internet access costs.* Moreover, when we consider these three countries plus Luxembourg and Finland, we conclude that this group is clearly more advanced when it comes to the digital development. This situation is not surprising, considering that North European Countries are pioneers in promoting digital development (Castells & Himanen, 2002). On the other hand we have Bulgaria and Romania as the least digitally developed countries in the EU, showing extremely low levels for both dimensions. Another insight from our results is related to the fact that some countries present high levels for one dimension and low levels for the other. Greece, for instance, has the lowest level for *ICT Infrastructure and adoption by Population* while at the same time, a high level for the *e-business and Internet access costs.* Estonia shows the inverse situation. These unbalanced digital developments threaten the national *e-strategies* across the each European country since, like economic development, digital development must be harmonized and affect sectors within each country. Hence, besides the need for high levels in each of the two dimensions, it is also imperative that countries strive to achieve a balanced and homogeneous digital development for each of the two dimensions as well, i.e., achieve a position near to the diagonal line in Figure 1. The closer a country is to the diagonal line, the more balanced is its digital development.

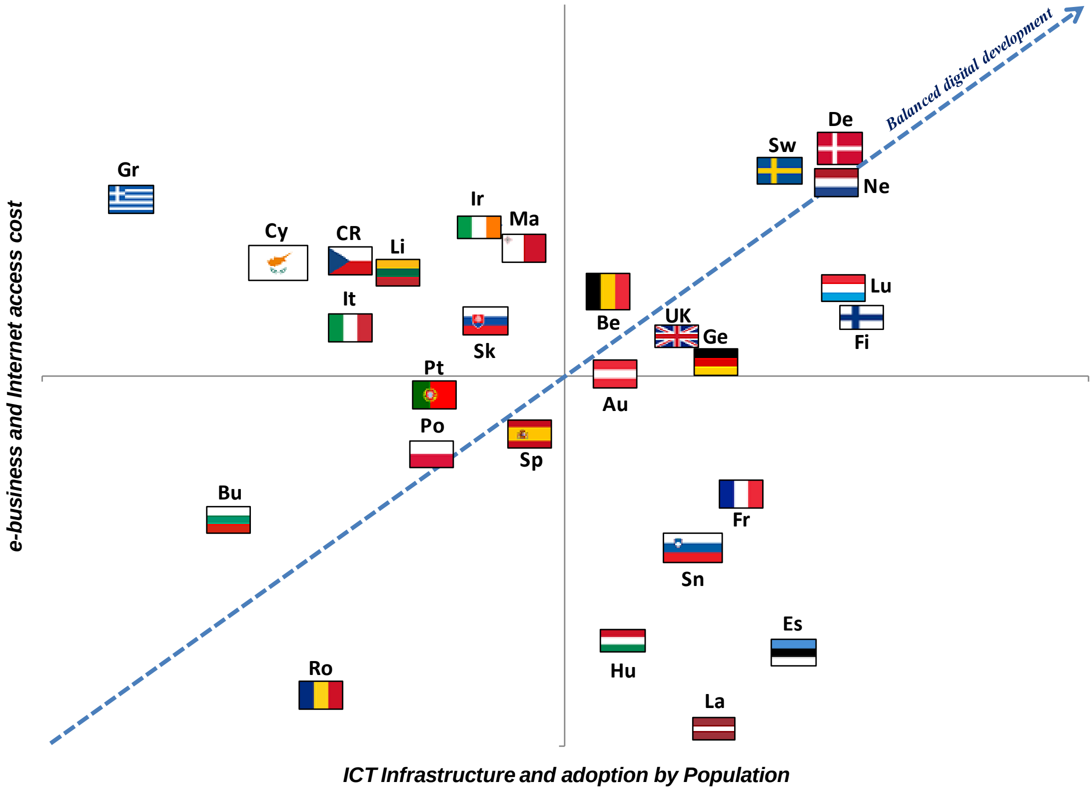

Figure 4.1 Countries´ coordinates on extracted factors.

4.2 Cluster Analysis

After the use of factor analysis - in which we found two latent dimensions on the digital divide - we used a cluster analysis to group the countries by similarity criteria, both for factors and the original 15 variables. The use of cluster analysis involves two main methods, either hierarchical or non-hierarchical. The methodology used for clustering based on factors and the original 15 variables were similar. We first ran a hierarchical procedure to define the number of clusters to extract, since in these procedures the number of clusters depends on the data, which means that we do not need to define *a priori* how many clusters we wish to generate. The solution based on hierarchical procedures depends on the distance measurement and the algorithm used (Leisch, 2006). In particular, we used Single, Centroide, Complet, and Ward´s methods. Moreover, different distances were used. Euclidean distance, squared Euclidean distance, the city-block approach, and the Minkowsky distance were taken into consideration. All of these approaches returned similar results, and the solution was made based on its performance, that is, based on the analysis of the R-Square and dendogram. Then, the best combination of hierarchical procedures was used to generate the seeds of the non-hierarchical algorithm – k-means. According to Sharma (1996), this approach tend, to yield better results. Following the generation of the clusters, we classified them, and their countries, based on a "profiling analysis", in other words, on the average of each cluster for each factor/variable. Finally, we performed a Kruskal-Wallis test to verify if each variable presented statistically different values in each cluster.

4.2.1 Cluster analysis using factor scores.

The solution of the hierarchical methods of the cluster analysis based on factor scores is given by the dendogram (see Figure 4.2). The vertical axis measures the distance and the horizontal axis represents the countries. From bottom to top, the dendogram maps the clusters´ formation. Thus, Ireland and Malta is the first pair of countries to form a group, which means that considering the two dimensions on the digital divide, these countries are those having digital profiles that are most similar, followed by Finland and Luxembourg, the Czech Republic and Lithuania, Denmark and the Netherlands, and finally, Germany and the United Kingdom. As the algorithm continues, all countries are grouped into clusters. As mentioned, the number of clusters to extract from k-means, as well as the initial seeds, is obtained by hierarchical methods. We opted for a five-cluster solution with the initial seeds determined by Ward´s method, since this combination is, by analysis of the dendogram and the R-Square (respectively, Figure 4.2 and Figure 7.1 in Appendix), the best solution. Thus, Bulgaria and Romania form Cluster one. Cluster two comprises Estonia, France, Hungary, Latvia, and Slovenia. Cluster three includes Cyprus, the Czech Republic, Greece, Ireland, Italy, Lithuania, and Malta. Austria, Belgium, Germany, Poland, Portugal, Slovakia, Spain, and the United Kingdom form cluster four. Finally we have Denmark, Finland, Luxembourg, the Netherlands, and Sweden as cluster five.

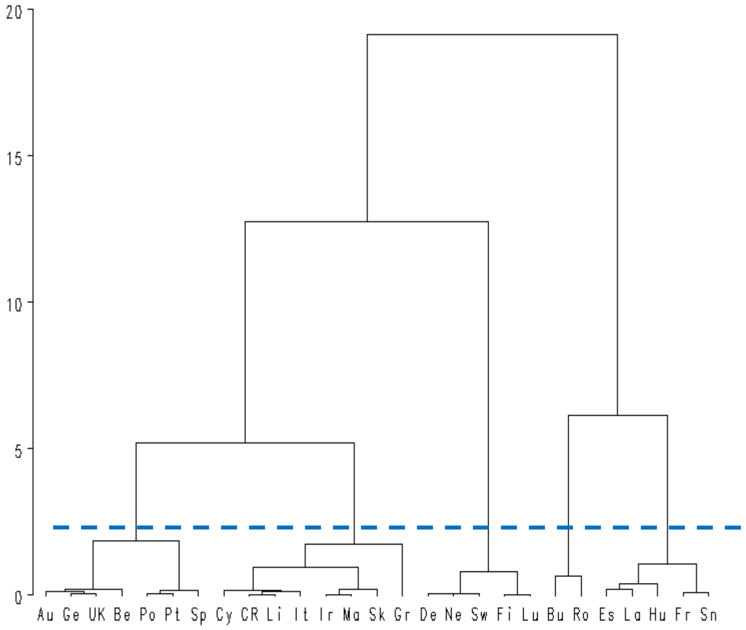

Figure 4.2 Ward´s dendogram for the digital divide across the EU-27 (factors).

From the analysis of the average levels of the factors, for each cluster (see Table 4.3 and Figure 4.2) we noticed that: cluster one includes the group of the least digitally developed countries in the EU-27, having extremely low levels on the average of both dimensions. Besides the level of *ICT Infrastructure and adoption by Population* which is by far the lowest within the EU, the *e-business and Internet access cost* is also, along with cluster two, extremely low. These differences are strong enough to form a specific cluster with only these two countries, meaning that the difference between these and the rest of the EU is very significant. Efforts to achieve a digital development must be made toward the direction of cluster one´s dashed arrow, focusing on both dimensions. Cluster two includes five countries having high levels of *ICT Infrastructure and adoption by Population* and low levels of *e-business and Internet access costs*. This cluster has a highly unbalanced digital development. Cluster three has an unbalanced digital development as well, but with opposite values for each dimension. Hence, *ICT Infrastructure and adoption by Population* is low in these countries, but on the other hand, the levels of *e-business and Internet access costs* are high. In order to achieve the objectives expressed in the Digital Agenda, countries within clusters two and three must strive for homogenous digital development following their respective dashed arrows, i.e., cluster two needs to move toward cluster five in a bottom to top vertical direction, emphasizing the development of *e-business and Internet access*, and cluster three needs to move in a left to right horizontal direction focusing on the *ICT Infrastructure and adoption by Population*. In cluster four we have eight countries, making this cluster the largest. It comes as no surprise that this cluster represents the average of the EU on the two dimensions of the digital divide. Despite the absence of high levels in either of the two dimensions, the fact is that neither of the two has significant negative values either. Therefore, these countries are relatively digitally developed, with balanced levels on both dimensions. The effort toward a more noticeable digital development should be made via a diagonal path, focusing on both *ICT Infrastructure and adoption by Population* and the *e-business and Internet access costs*, in order to maintain the balance already achieved for these dimensions. Finally, we have cluster five, with the most digitally developed countries in the EU. These countries present the highest levels for both dimensions of digital development.

If Europe wishes to see the objectives expressed in the Europe 2020 Strategy and the Digital Agenda succeed, then all other European Countries need to move toward the direction of these countries. The results of the Kruskal-Wallis test also show that there are significant statistical differences in the levels of *ICT Infrastructure and adoption by Population* and *e-business and Internet access cost* for each cluster at a significance level of 1%. Another interesting conclusion that can be drawn from our results is related to the correlation that appears to exist between the entrance year to the EU and the countries' digital development. We notice that the last two countries to enter the EU are those in cluster one. Moreover, cluster five, which includes the most digitally developed countries, includes only countries that entered the Union before the 2004 enlargement. All of the countries (10) that entered in 2004, with the exception of Poland and Slovakia, are found in clusters with uneven digital developments. The only two exceptions are in cluster four, which is representative of the average in both dimensions, having balanced levels for both of them. It therefore seems that the process of integration in the EU, in terms of digital development, is not yet completed, especially for the newest members.

Table 4.3 Descriptive Statistics for the identified clusters (factors)

	Cluster One		Cluster Two		Cluster Three		Cluster Four		Cluster Five		Kruskal-Wallis
	Average	St Dev	Average	St Dev	Average	St Dev	Average	St Dev	Average	St Dev	p-value
Factor 1	-1.38	0.31	0.69	0.32	-0.99	0.62	-0.02	0.51	1.28	0.14	0.0002
Factor 2	-1.4	0.8	-1.4	0.6	0.7	0.3	0.0	0.3	0.9	0.5	0.0002

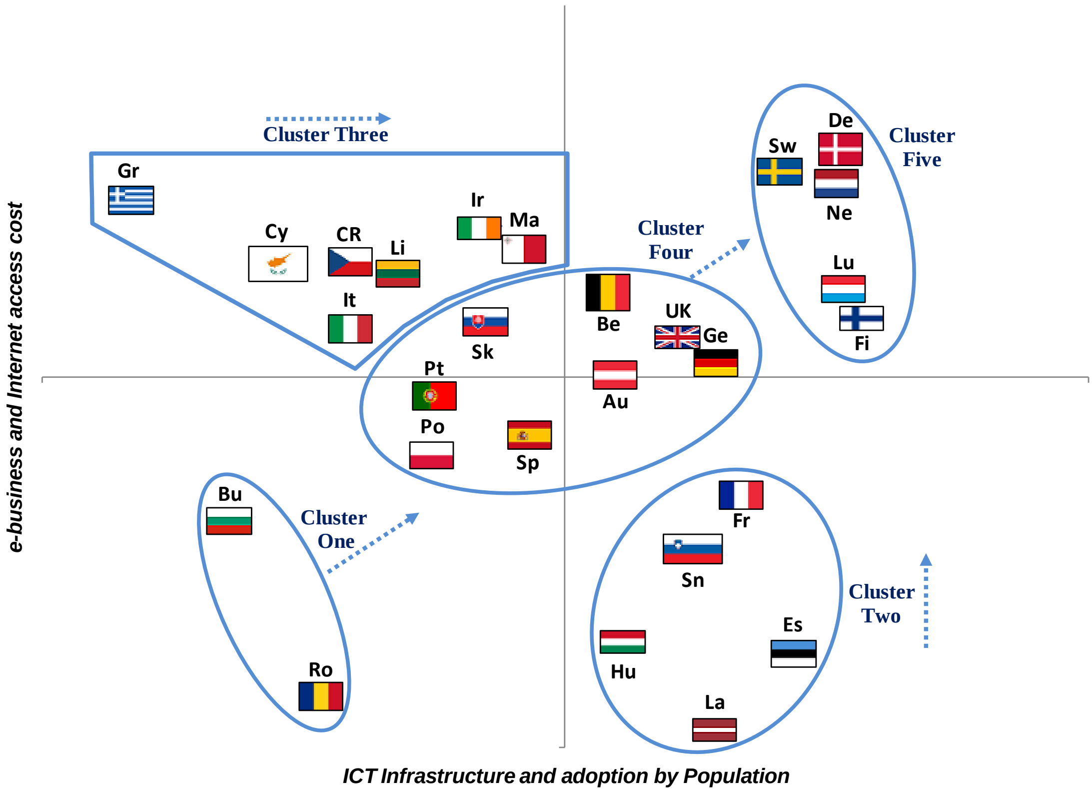

Figure 4.2 Cluster analysis on factor scores.

4.2.2 Cluster analysis using original 15 variables

As mentioned above, the cluster analysis involved two perspectives. In the first, we used the factor scores obtained from the factor analysis to generate five groups of countries based on their digital profile similarity. In the second, the whole set of the 15 original variables was used, instead of the factor scores. Again the methodology was the same, hierarchical methods were used to define the number of non-hierarchical clusters and to obtain the final solution. Thus, the Czech Republic and Lithuania is the first pair of countries to form a group, followed by Ireland and Malta, Austria and the United Kingdom, Belgium and Germany, and finally Denmark and Sweden. Once again, the hierarchical solution is given by the dendogram and R-Square (See Figures 4.3 and 7.2 in Appendix, respectively). The result is a five-cluster solution obtained by using the Ward´s method. The results of the k-means algorithm, with the initial seeds from the Ward´s method, were the following: Bulgaria and Romania formed cluster one; cluster two was formed of Estonia, France, Hungary, Latvia, and Slovenia; Cyprus, the Czech Republic, Greece, Italy, Lithuania, Poland, Portugal, Slovakia, and Spain grouped into cluster three; Austria, Belgium, Germany, Ireland, Malta, and the United Kingdom made up cluster four; cluster five comprises Denmark, Finland, Luxembourg, the Netherlands, and Sweden.

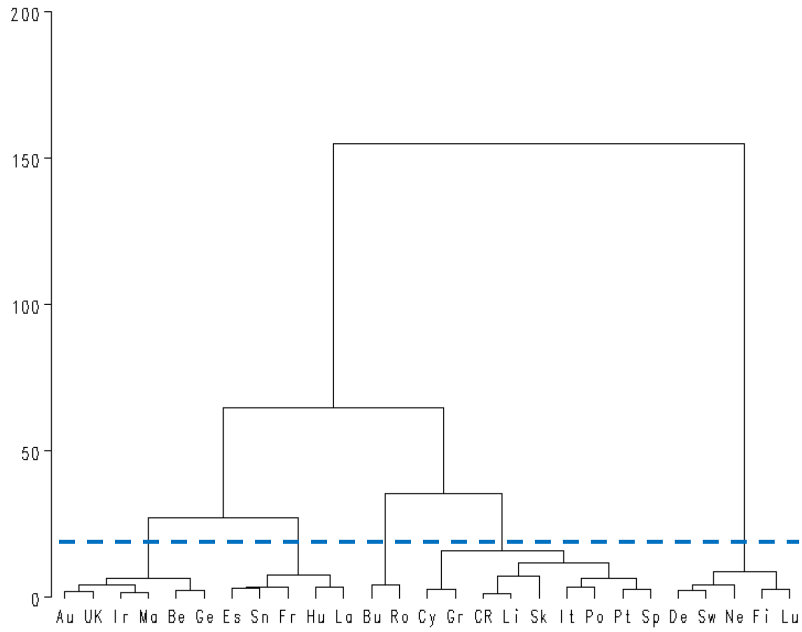

Figure 4.3 Ward´s dendogram for the digital divide across the EU-27 (variables).

From the analysis of the averages of each cluster on the original 15 variables (see Table 4.4), some conclusions can be drawn. Cluster one is the group of countries with the lowest level in 14 of the 15 variables used, showing the high asymmetry between these countries and the rest of the EU; cluster two is in the mid-position in 7 of the 15 variables. It is noticeable for being the group with the second highest levels of penetration of “advanced services” like e-banking, e-learning, e-health, and e-government amongst the individuals. On the other hand, it stands out as the group with the highest Internet access costs, although the difference between it and cluster one is negligible. Cluster three has the second-poorest levels for 10 of the 15 variables, more specifically in the adoption of “advanced services” by individuals and ICT infrastructure. On the other hand, these countries are relatively well positioned in some features of digital development, particularly in the business dimension. Hence, the percentages of enterprises using the Internet for interacting with public authorities (egovE) and having an ICT security plan (eSafeE) are the second-best ranked in the entire EU. Cluster four is, with no surprise, the second-best ranked cluster in 8 indicators, and is even in first place regarding the availability of public services online.

However, these countries need to improve the penetration of the "advanced services" amongst the population in order to take advantage of their already significant infrastructure. Finally, cluster five is the high point of digital development in the EU-27. It presents the highest levels in 14 of the 15 variables. The Kruskal-Wallis test shows that all variables except the eGovS present statistically significant differences at the 1% level for each cluster. The differences in eGovS are statistically significant only at 10%. This can be explained by the fact that the percentage of public services online can, but it should not, be independent of the diffusion of ICT within a country, since government policies can implement an e-government service only from the supply side. The relationship between the entrance year to the EU and the cluster membership appears to be correlated as well. The newest members continue in a cluster apart, and are less digitally developed. The cluster comprising the most digitally developed countries continues to include only those that entered the EU before the 2004 enlargement. Moreover, the majority of countries that entered in 2004 are spread out amongst clusters two and three, with Malta in cluster four. Despite some positive aspects of each cluster, they all continue to show imbalance in digital development.

Table 4.4 Descriptive Statistics for the identified clusters (variables)

	Cluster One		Cluster Two		Cluster Three		Cluster Four		Cluster Five		Kruskal-Wallis
	Average	St Dev	Average	St Dev	Average	St Dev	Average	St Dev	Average	St Dev	p-value
egovI	11.0	5.7	36.8	7.9	22.4	7.1	33.8	5.6	61.2	6.5	0.0004
IntPop	38.0	5.7	66.8	6.0	54.2	9.2	70.3	7.6	86.2	2.0	0.0003
ebank	2.5	0.7	42.6	18.5	22.8	9.2	41.5	6.1	71.0	8.7	0.0004
IntSrc	26.0	0.0	59.0	4.0	46.4	9.0	60.7	6.8	78.8	3.3	0.0004
email	33.0	2.8	61.2	6.7	49.1	11.1	66.0	8.3	82.8	3.6	0.0006
ehealth	16.0	4.2	37.4	4.5	26.9	5.6	35.8	7.0	51.4	7.2	0.0006
HsInt	37.5	6.4	66.0	6.0	58.2	6.1	75.0	4.8	87.2	4.0	0.0002
BroRt	13.8	0.1	23.8	5.0	19.5	2.8	27.8	3.7	34.2	4.1	0.0006
elearn	16.5	4.9	41.6	8.8	31.0	7.5	40.2	3.4	58.8	14.5	0.0038
egovS	65.0	7.1	86.6	12.3	76.0	19.3	95.3	8.4	91.4	10.9	0.0782
eSafeE	8.0	1.4	14.6	5.0	28.0	9.1	27.8	2.1	36.6	8.1	0.0038
ecom	5.0	1.4	9.2	2.3	12.0	6.6	19.0	4.7	20.2	4.9	0.0057
Serv	56.5	23.7	276.2	111.0	285.4	293.4	997.6	342.3	1613.4	446.8	0.0005
egovE	57.0	9.9	77.8	6.9	82.0	9.2	75.0	7.5	92.6	2.8	0.0036
Cost	15.5	9.2	15.6	4.5	7.0	2.1	3.8	1.7	1.8	2.2	0.0004

When comparing the results from the cluster analysis based on factor scores and those based on the original 15 variables, some conclusions may be drawn from the results. The number of clusters present within the EU when it comes to the digital divide was the same – five. Moreover, the composition of these clusters is very similar (see Figure 4.5). Clusters one, two, and five maintained the same composition. Only clusters three and four showed slight differences – Ireland and Malta, the two best ranked countries of cluster three, changed to cluster four, while Poland, Portugal, Slovakia, and Spain moved in the opposite direction. If in the cluster analysis based on factor scores, cluster three presented higher levels on *e-business and Internet access cost* than cluster four using the original 15 variables for cluster analysis, this holds true only for some contributing variables of that dimension. Hence cluster four presents higher levels of enterprises selling online (ecom) and lower internet access costs (Cost), which can be explained by refinement of our analysis involving all variables that led to the disaggregation of the second dimension, providing a more detailed analysis. In this way, the cluster analysis using the original 15 variables was worth doing since it complemented the one based on factor scores. Nevertheless, the factor analysis revealed the latent dimensions of the European digital divide, *ICT Infrastructure and adoption by Population* and *e-business and Internet access costs,* since the overall results of the cluster analysis do not differ greatly.

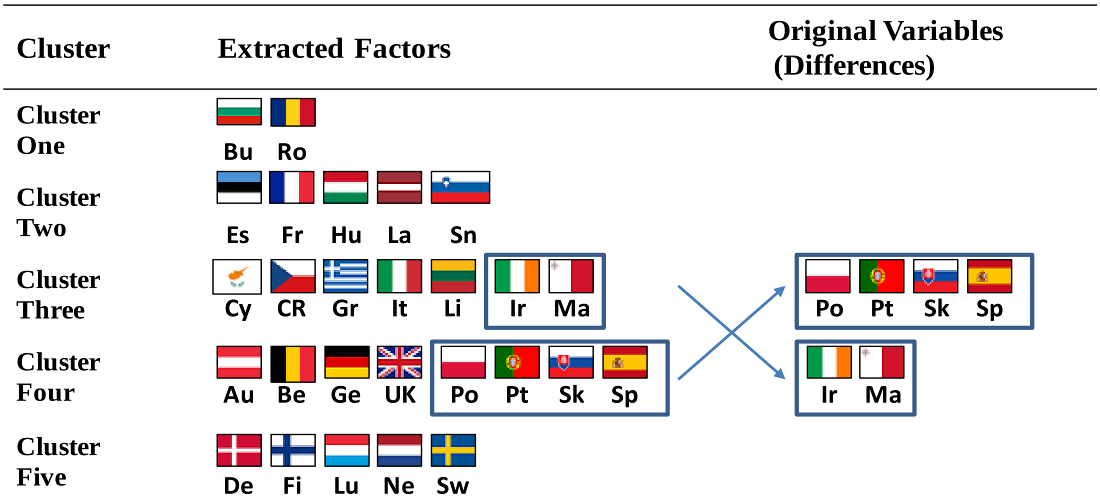

Figure 4.4 Changes in cluster analysis (factors vs. variables)

5 SUMMARY OF FINDINGS AND LIMITATIONS OF THE STUDY

The digital divide appears to have two latent dimensions, which are the *ICT Infrastructure and adoption by Population* and the *e-business and Internet access costs.* These two dimensions are independent, considering that countries may have a top position in one dimension, and at the same time, a bottom position in the other. Moreover, these two underlying dimensions expose the imbalance digital development amongst the EU-27 countries. The cluster analysis for both the latent dimensions and the original 15 variables showed that, in fact, this digital gap exists. The fact that the composition of the clusters was similar in both analyses confirmed the accuracy of the two dimensions extracted. There are five stages of digital development within EU-27, each one with its own strengths and weaknesses.

Some policy actions might be proposed based upon our findings: the high performance of some countries in only a single dimension of digital divide, and low levels in the other constitutes a challenge. As with economic development, digital development needs to be harmonized and affect all dimensions; the poorest ranked countries, especially Bulgaria and Romania, need to emphasize their policies that promote digital development in order for them to converge with the Northern European Countries. Improvement in this regard may only be accomplished with a multifaceted strategy, stimulating both ICT Infrastructure, including the reduction of access costs, and adoption by the population of developmental policies that boost e-commerce and e-government. As pointed by DiMaggio et al (2004), initiatives to minor digital inequalities have emphasized mainly the access to technologies, which may not be sufficient. Above all it is necessary to combine the efforts of public authorities, private organizations, and the population itself to bridge this divide (Dewan & Riggins, 2005), since a single community or sector cannot do it alone (Unwin & de Bastion, 2009). It seems also that in terms of digital development the integration process within the EU is not yet completed, especially for the two countries that entered in 2007, which remain the least digitally developed countries of the Union.

In spite of our effort to offer a complete and multidimensional analysis, some limitations must be recognized. First, our analysis refers to the digital divide at a specific point of time, the year of 2010. Changes in this context are likely to occur rapidly, and our findings may soon become outdated. Second, our empirical application consists of just 15 variables, and, some features of the information society may not be covered. Third, we analysed the digital divide within the EU, which means that all indicators used were concerned with aggregated national realities, meaning that internal, domestic digital divides gaps may not be covered.

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7 APPENDIX

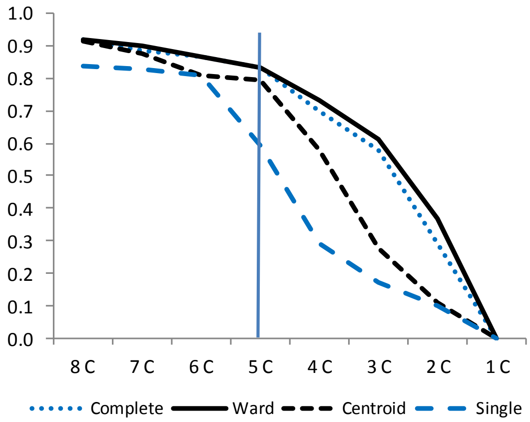

Figure 7.1 R-square plot for cluster analysis based on factor scores.

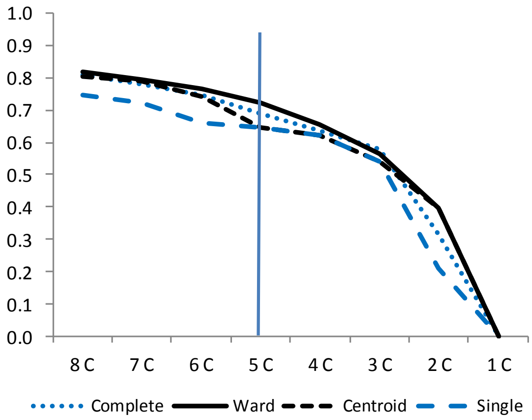

Figure 7.2 R-square plot for cluster analysis based on original 15 variables.