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Understanding the Asymmetries in ICT Adoption across Countries:
The Global Digital Divide

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Abstract

Although Information and Communication Technologies (ICT) are today deeply embedded with almost every aspect of our lives, they are still far from achieving the tremendous potential in terms of innovation and development opportunities that they are recognised to have (European Commission, 2013; United Nations, 2014). This achievement is limited by the existence of disparities in the rates of adoption and use of these technologies – the so-called digital divide. Digital divides exist both between and within countries, among the different socio-economic groups of the population, and are known as international and domestic digital divides, respectively.

With this Dissertation we intend to contribute to a better awareness and understanding of ICT asymmetries across countries, i.e., the global digital divide. In order to do so, we develop five studies. The first of these (chapter two) is a literature review of the global digital divide and its main drivers. In this chapter we are able to clearly identify growing attention about this phenomenon, some of its most commonly identified drivers, as well as a gap in the literature, which has to do with the fact that research usually is conducted at cross-country or within countries – but not simultaneously.

In the European context, given the importance demonstrated by the European Commission toward this subject, with several initiatives implemented, we have developed two studies (chapters three and six). The first of these includes the 27 member states of the European Union with data from 2008 until 2010. With this research we found two latent dimensions on the digital development of the 27 countries – ICT infrastructure and adoption by population and e-business and Internet access costs – as well as five distinct country profiles in terms of digital development, ranging from the "digital laggards" to "digital leaders". We were also able to conclude that if in the first dimension (ICT infrastructure and adoption by population) there is some evidence of a narrowing digital divide, in the second (Internet access costs) the digital divide appears to be widening. Our second European study (chapter six) addresses the digital divide both across and within the 28 member states of the European Union, as Croatia had meanwhile joined. To some extent, our results continue to point to a European digital divide across countries, also with two latent dimensions. The most important contribution of this work is, however, the fact that we were able to find that even for those European

countries that are outperforming their counterparts in terms of digital development, some internal gaps still remain and need to be addressed. In other countries, the divides are a matter for concern. These insights would most likely be overlooked if we worked only with aggregate levels. Consequently, chapter six draws attention to the importance of complementing cross-country analysis of the digital divide with an assessment of internal gaps, which is also identified as a literature gap in chapter two.

Outside the European context, chapters four and five are dedicated to developing and testing a conceptual model for the global digital divide (chapter four) and analyse in detail the correlation between economic and digital developments of countries (chapter five). The first, based on data collected from 45 countries, including the ones belonging to the European Union, the OECD, with Brazil, Russia, India, and China, develops a measure of digital development which, used with additional variables hypothesised as drivers of the divide for a regression analysis, shows economic and educational imbalances between countries, along with its geography, as the main drivers of the digital divide. Other variables tested, such as individuals living in rural versus urban areas, and official language, are not. In chapter five our focus is to analyse to the greatest extent possible for 110 countries the relationship between the global digital divide and the economic development of countries, the most important driver identified in the previous chapter. Our findings are substantive in that the correlation between economic and digital development was not linear, being much stronger in poorer countries – something that is neither commonly hypothesized nor found in the literature. As a result, future studies that focus on the relationship between economic and digital developments may benefit from our findings, by postulating this type of relationship. In our model we were able to explain 83% of the variation in the digital development of countries, compared to just 72% if considering only a linear relationship.

Keywords: digital divide, digital development, ICT, information society, e-inclusion, diffusion, technology adoption

Resumo

Apesar das Tecnologias de Informação e Comunicação (TIC) estarem, hoje em dia, profundamente enraizadas no nosso quotidiano, estas estão ainda longe de atingir o enorme potencial que lhes é reconhecido em termos de oportunidades de inovação e desenvolvimento (European Commission, 2013; United Nations, 2014). Esta conquista está a ser impedida pela existência de disparidades na adoção e uso destas tecnologias – fenómeno conhecido como divisão digital. Divisões digitais são suscetíveis de existir entre ou dentro de países, entre diferentes grupos socioeconómicos da população, sendo conhecidas como divisão digital internacional/global ou doméstica, respetivamente.

Com a presente Dissertação pretendemos contribuir para uma melhor compreensão das assimetrias que existem no acesso às TIC entre diferentes países, ou seja, a divisão digital global. Com este objetivo, desenvolvemos cinco estudos. O primeiro (capítulo dois) consiste numa revisão da literatura sobre a divisão digital global e as suas principais causas. Neste capítulo, foi-nos permitido identificar claramente a crescente atenção que o fenómeno da divisão digital tem tido na academia, bem como algumas das suas principais causas, assim como uma lacuna na literatura, que tem que ver com o facto de estudos nesta área serem normalmente conduzidos entre países ou dentro de um dado país – mas muito raramente os dois em simultâneo.

Dada a importância demonstrada pela Comissão Europeia para com o tema da divisão digital, com várias iniciativas implementadas, desenvolvemos dois estudos dedicados ao contexto Europeu (capítulos três e seis). O primeiro inclui os 27 estados membros da União Europeia, com dados de 2008 a 2010. Neste estudo encontrámos duas dimensões latentes no desenvolvimento digital dos 27 países - infraestrutura de TIC e adoção pela população; e e-business e custo de acesso à Internet - assim como cinco perfis de países distintos em termos de desenvolvimento digital, que vão desde os "digitalmente atrasados" até aos "líderes digitais". Este estudo permitiu-nos igualmente concluir que, se na primeira dimensão do desenvolvimento digital (infraestrutura de TIC e adoção pela população), existe evidência que a diferença entre países está a diminuir, já na segunda (e-business e custos de acesso à Internet) a divisão digital parece estar a aumentar. O segundo estudo dentro do contexto Europeu

(capítulo seis), foca-se em simultâneo na divisão digital entre, e dentro, dos 28 Estados membros da União Europeia, contando já com a Croácia. Em certa medida, os resultados continuam a apontar para uma divisão digital europeia entre países, também em duas dimensões latentes. A contribuição mais significativa deste trabalho é, no entanto, a evidência de que, mesmo nos países europeus com maior desenvolvimento digital, existem divisões internas que ainda precisam de ser eliminadas. Estas conclusões passariam despercebidas se tivéssemos apenas disponíveis dados agregados a nível nacional. Consequentemente, o capítulo seis demonstra a importância de complementar análises da divisão digital entre países com dados respeitantes à realidade interna dos mesmos, algo, também, pouco comum na literatura identificada no capítulo dois.

Fora do contexto Europeu, os capítulos quatro e cinco dedicam-se, respetivamente, ao desenvolvimento e teste de um modelo conceptual para a divisão digital global (capítulo quatro) e à análise em detalhe da relação entre os desenvolvimentos económicos e digitais em grande escala dos países (capítulo cinco). O primeiro inclui dados de 45 países, incluindo os pertencentes à União Europeia, à OCDE, juntamente com o Brasil, Rússia, Índia e China. Neste capítulo é elaborada uma medida de desenvolvimento digital, usada como variável dependente numa regressão linear, em que as variáveis independentes são aquelas identificadas como potencialmente explicativas da divisão digital global na literatura. Nesta análise, o desenvolvimento económico dos países, juntamente com aspetos de natureza educacional e geográfica, são identificados como as causas mais relevantes da divisão digital. Outras variáveis incluídas, como a percentagem de indivíduos residentes em zonas rurais vs. zonas urbanas e a língua oficial do país, não são. O capítulo cinco dedica-se a analisar, de forma tão alargada quanto possível, a relação entre a divisão digital e o desenvolvimento económico de 110 países. Note-se que esta relação foi identificada como a mais relevante no capítulo anterior. Os resultados indicam que esta relação não é linear, visto ser muito mais intensa nos países mais pobres - algo que não é normalmente tido como pressuposto na literatura. Assim, estudos futuros que incidem sobre a relação entre o desenvolvimento económico e digital podem ter em conta este pressuposto no desenvolvimento das suas metodologias. Desenvolvendo um modelo de regressão com efeitos não lineares fomos capazes de explicar 83% da variação do desenvolvimento digital entre países, em comparação com os 72% obtidos numa regressão linear simples.

Palavras-Chave: divisão digital, desenvolvimento digital, TIC, sociedade da informação, inclusão digital, difusão e adoção de tecnologias.

Publications

List of publication resulting from this dissertation

Papers:

Cruz-Jesus, F., Oliveira, T., & Bacao, F. (2012). Digital divide across the European Union. Information & Management, 49(6), 278-291. doi:10.1016/j.im.2012.09.003

Cruz-Jesus, F., Oliveira, T., Bacao, F., & Irani, Z. (2016). Assessing the pattern between economic and digital development of countries. Information Systems Frontiers, 1-20. doi:10.1007/s10796-016-9634-1

Cruz-Jesus, F., Vicente, María R., Bacao, F., & Oliveira, T. (2016). The education-related digital divide: An analysis for the EU-28. Computers in Human Behavior, 56, 72-82. doi:http://dx.doi.org/10.1016/j.chb.2015.11.027

Cruz-Jesus, F., Oliveira, T., & Bacao, F. The global digital divide: Evidence and drivers. Submitted.

Cruz-Jesus, F., Oliveira, T., & Bacao, F. The global digital divide: A literature review. Submitted.

ISI Proceedings:

Cruz-Jesus, F., Oliveira, T., & Bacao, F. (2011). Exploratory Factor Analysis for the Digital Divide: Evidence for the European Union - 27. ENTERprise Information Systems. M. M. Cruz-Cunha, J. Varajão, P. Powell and R. Martinho, Springer Berlin Heidelberg. 219: 44-53.

Cruz-Jesus, F., Oliveira, T., & Bacao, F. (2014). Exploring the Pattern between Education Attendance and Digital Development of Countries. Procedia Technology, 16(0), 452-458. doi:http://dx.doi.org/10.1016/j.protcy.2014.10.112

Others proceedings:

Cruz-Jesus, F., Oliveira, T., & Bacao, F. (2011). Divisão Digital na União Europeia. Conferência da Associação Portuguesa de Sistemas de Informação (CAPSI 2011). Lisbon.

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Avós: Ana, Carlos, Jorge e Palmira;
Mãe;
Pai;
Mariana;
Tiago;
Babá.

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Abbreviations

Area	Surface area (million square-miles)
BRIC	Brazil, India, China and Russia
BroRt	Broadband penetration rate
Cost	Percentage of households without Internet because of the access costs
Dens	Population density (thousands / square-miles)
DigDev	Digital development
DOI	Diffusion of innovations theory
eBank	Percentage of population using e-banking services
EC	European Commission
eCivic	Individuals taking part in online consultations or voting to define civic or political issues
eCom	Individuals ordering goods or services online
eCom_CB	Individuals ordering goods or services online, from sellers from other EU countries
EdSp	Public spending on education (% of GDP)
eGov	Individuals interacting online with public authorities, last 12 months
eGovE	Percentage of enterprises using Internet for interaction with public authorities
eGovI	Percentage of population using Internet for interaction with public authorities
eGovS	Percentage of government services available online
eHealth	Percentage of population using Internet for seeking health information
eLearn	Percentage of population using e-learning services
email	Percentage of population using e-mail
Eng	Native English speaking country (Y=1/N=0)
eSafeE	Enterprises having a formally defined ICT security policy with a plan of regular review
EU	European Union
EU-27	27 member states of the European Union
EU-28	28 member states of the European Union
FixTel	Percentage of fixed telephone subscriptions
GDP	Gross domestic product
GPT	General purpose technologies
HR	Human resources
HsInt	Percentage of households having access to the Internet at home
HsPC	Percentage of households with computer
ICT	Information and communication technologies
IntPop	Percentage of population regularly using the Internet (every day or almost every day)

IntSrc	Percentage of population using Internet for finding commercial information
IS	Information systems
IT	Information technologies
ITU	International Telecommunications Union
KMO	Kaiser–Mayer–Olkin
Mob	Percentage of population using mobile devices to access the Internet
Mobile	Individuals using a mobile device to access the Internet, away from home or work
MobRt	Mobile (wireless)-broadband subscriptions per 100 inhabitants
MobTel	Percentage of mobile/cellular telephone subscriptions
NTIA	US Department of Commerce's National Telecommunications and Information Administration
OECD	Organisation for Economic Co-operation and Development
OLPC	One Laptop per Child
OLS	Ordinary least squares
PC	Personal computers
PCA	Principal components analysis
SAS	Statistical Analysis System
Serv	Number of secure servers per million inhabitants
Speed	International Internet bandwidth (bit/s) per Internet user
SupEd	Percentage of labour with tertiary education
UN	United Nations
Urban	Percentage of population living in urban areas
US	United States
USA	United States of America
VIF	Variance inflation factors
WSIS	World Summit on Information Society

Chapter I

1. Introduction

1.1 Motivation

Given the relevance of Information and Communication Technologies (ICT) for economic growth and development, along with its potential to improve social wellbeing, the global digital divide is a rich and timely research theme (European Commission, 2013; International Telecommunication Union, 2013; S. Y. T. Lee, Gholami, & Tong, 2005; United Nations, 2014; World Bank, 2016). ICT are general purpose technologies (GPT) that enable individuals, organizations, communities, and countries to achieve sustainable growth and development (Bresnahan & Trajtenberg, 1995; Doong & Ho, 2012). The positive impact of ICT on almost every aspect of our lives is well noticeable, particularly in the improvement that these technologies offer to communications and interactions between individuals and firms (OECD, 2004; Unesco, 2009; World Bank, 2009). However, access to and use of these technologies are not uniform, especially for those belonging to different countries (Frederico Cruz-Jesus, Oliveira, & Bacao, 2012). This fact is the main focus and motivation of this dissertation. We expect to be able to make a small contribution to a new world "*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). This contribution will be accomplished by providing an analysis and basis of understanding of the digital asymmetries across countries, the so-called global digital divide.

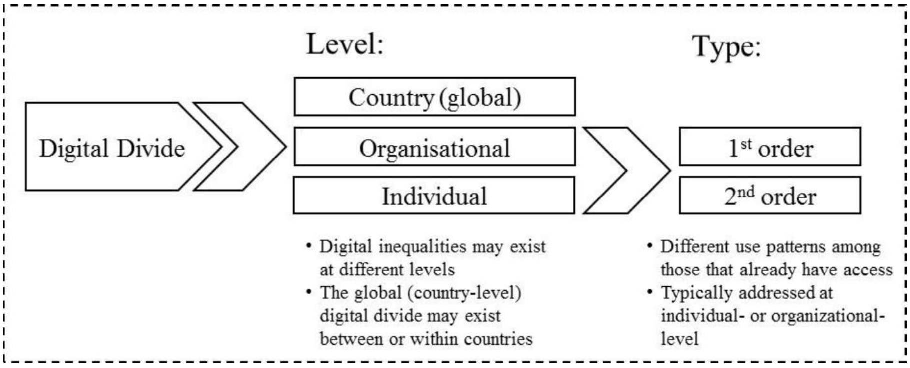
The international digital divide is a concern that is common to several international organizations. Entities such as the United Nations (UN) (e.g. (Unesco, 2009; United Nations, 2014)), the federal government of the United States of America (USA) (e.g. (National Information Infrastructure Advisory Council, 1996; US Department of Commerce, 2000)), the Organization for Economic Co-operation and Development (OECD) (e.g. (OECD, 2011)), and the European Union (EU) (e.g. (European Commission, 2010a, 2010b, 2013)), amongst several others, have manifested their concerns about the issue of the digital divide, suggesting several solutions to engender digital growth. A major problem with these strategies is that very commonly one can see that the actual situation in terms of digital development of countries is not completely understood (Frederico Cruz-Jesus et al., 2012). This is so mainly because data on ICT adoption in different countries are not available. This is the major issue we have sought to mitigate with this work.

1.2 Research Focus

The digital divide is a multifaceted phenomenon that can occur at different dimensions/levels. Thus, digital asymmetries may happen between different adoption units, namely individuals, households, organizations, and countries. At an individual level digital inequalities are more likely to exist between individuals economically and sociologically disadvantaged, i.e., individuals with lower incomes, education, those with disabilities, living in rural areas, belonging to ethnic minorities, women, and the elderly. In terms of organizations as adoption units, it is usually stated that larger firms, as they usually possess more resources, tend to be more prone to adopt technological innovations, although some authors do not agree with this notion because larger firms are also more likely to suffer from inertia. Finally, at a country (global) level – individuals and organizations in aggregate – inequalities in terms of ICT access and use may occur between and within countries, which are named, respectively, international and domestic digital divides. In respect to the international digital divide, research usually indicates that economic wealth and educational attainment are key-factors in explaining the digital development level of a country.

Besides the type of adoption unit, the digital divide may be related to access or use of ICT, which may appear to be the same but in truth are not (Dewan & Riggins, 2005). Thus, there are severe differences in ICT access and use patterns between those who are economically advantaged and disadvantaged. Besides the intrinsic motivations for access ICT, people also have very different post-implementation behaviour regarding the use of ICT. Economically advantaged persons have a “higher tendency to respond to network exposure”, using these technologies with much more confidence than the disadvantaged (Hsieh, Rai, & Keil, 2008, 2011). These two types of inequalities about access to and use of ICT are known as first- and second-order digital divides. In the first-order digital divide the inequalities have to do with access to ICT, while in the second-order the problem is postulated in terms of different use patterns and intensity amongst individuals/organizations that already have (very similar) access to ICT (e.g. using the Internet just for web-browsing or email vs. using it for e-learning, social-network, applying to jobs online, e-banking, e-health etc.). For a simplified scheme of the digital divide phenomenon see Figure 1.1.

Fig. 1.1 - Digital divide´s conceptual scheme (source: author)



Ultimately, countries (when considered as the as unit of analysis) are those that benefit the most from high ICT adoption from those within its boundaries - both individuals and organizations. ICT´s positive outcomes are various and can, therefore, pull countries toward a strong, sustainable, and inclusive growth development. For these reasons, in both developing and developed countries, policy makers have been dedicating their efforts to engender digital development and narrow digital gaps. In the EU, for example, the Europe 2020 Strategy was released, seeking "*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). European policy makers believe that European economic growth can only be accomplished if a digital economy based on knowledge and innovation is developed (European Commission, 2010b, 2013). The Digital Agenda for Europe, included in the Europe 2020 Strategy as one of the seven strategy flagships, aims to define the critical role that ICT must play if Europe wishes to realize its ambitions for 2020 (European Commission, 2010a). As the World Bank (2016) recommends, in order for ICT "*to benefit everyone everywhere requires closing the remaining digital divide, especially in Internet access*", although that may well not be enough.

The larger units (countries and their policy makers) are by definition those that exercise the greatest power and effectiveness in narrowing the digital divide. For this reason, this dissertation is especially focused on country-level (global) digital divide, and its main drivers, aiming to shed some light on this issue and, thereby, help policy makers to deploy more efficient measures to narrow the digital gaps.

1.3 Goals

The main goal of this dissertation is to analyse and understand the differences in terms of digital development across different countries, particularly ICT adoption amongst individuals and organizations. To do so we have separated our analysis by contexts, in which each one corresponds to a chapter, oriented to be published as a research paper in a reputable international information systems (IS) journal.

In chapter two we have conducted a global-level digital divide literature review. This chapter presents a comprehensive overview of the digital divide across countries, its evolution, and more importantly, its drivers. It is mainly a qualitative research.

In chapter three we analyse the digital divide across the 27 member states of the European Union. Based on data from the Eurostat and the World Bank we have as objective to find the latent dimensions of the European digital development. Moreover, based on the latent dimensions of European digital development, we classified each European country in terms of digital profile. In order to become aware of whether the European digital gap is narrowing or widening we have analysed the evolution of the digital development of countries between the years of 2008 and 2010.

In chapter four we extend the basis of our analysis to countries other than only the ones belonging to the European Union. For this purpose, we were able to collect data for 45 countries - belonging to the European Union or OECD, and Brazil, India, China, and Russia (BRIC) - from the International Telecommunications Union (ITU) and the World Bank, pertaining to the year of 2011. We measure the digital development level of each of the 45 countries mentioned, and based on what the literature usually indicates as digital development´s explanatory factors, addressed which ones actually impact and, to what level, the digital development.

In chapter five we focus the context of our study on the specific role of digital development, previously identified as one of the most important of the digital divide´s drivers. Given the significant disparities in economic development of countries worldwide, we included as many (and different) countries as possible, reaching a number of 110. Using 2011 data from the World Bank, we analysed the relationship between the digital development of countries with their economic performance - using the GDP per capita.

Chapter six is focused on another country-level digital divide driver – education. Using the European Union 28 as context, we collected 2013 data for 10 ICT-related variables, in which information was available at country level but also, within each, at three levels of education. This allowed us to analyse both international and domestic divides together, drawing a detailed picture regarding the European education-related digital divide.

1.4 Methodology

The nature of the objectives and conceptual background of this dissertation demand a combination of several methodological approaches. Theoretically we consider that this work presents characteristics fully consistent with the positivist approach, as we make use of multiple quantitative approaches, which assume a proposition of underlying and quasi-absolute rules, and regarding the quantitative methodologies, we make use of multivariate statistical methods. Details can be found within each chapter about how these were employed.

1.5 Path of Research

The work was initialized in an attempt to measure the digital divide across the European Union-27 (chapter three). The path toward publication of the first research paper consisted in submission, and subsequent acceptance, to two double blind review conferences. The first one – CENTERIS 2011 – is an international one and is indexed to ISI. The submitted work was published as a book chapter (Frederico Cruz-Jesus, Oliveira, & Bacao, 2011b). The second conference – CAPSI 2011 – is not indexed to ISI. Therefore the work appeared in the conference´s proceedings (Frederico Cruz-Jesus, Oliveira, & Bacao, 2011a). These steps allowed us to gain maturity in our work, giving us the opportunity to constantly improve it until the final submission to the *Information & Management.* In this journal the submission process lasted for approximately one year, and two revisions were requested in which our paper improved greatly (Frederico Cruz-Jesus et al., 2012). With respect to the content and findings of the work, as the results indicated a severe digital gap between European countries, that should be somehow homogeneous (they all belong to the EU, thus having access to specific policies to engender ICT such as structural funds), we felt tempted to extend the research to other countries beyond Europe. Moreover, besides measuring ICT adoption, we also found it interesting to understand/measure what drives its disparities.

The above mentioned objective is accomplished in chapter four, thus making the dissertation follow a natural and intuitive structure. The intention was for this chapter to develop a new model of country-level ICT adoption / digital development of countries. Using a set of 45 developed and developing countries, we collected data for seven ICT-related variables, transforming them into a unified measure (index) of digital development (DigDev). Then, this measure was used as dependent variable in an ordinary least squares (OLS) model in which economic, educational, geo-demographic, and linguistic characteristics of countries were used as explanatory variables. This research was the first approach toward achieving a better understanding of what drives a problematic phenomenon (the global digital divide) identified in the previous chapter. The paper is currently under review (since March 2014), with a positive feedback so far from the reviewers.

With the findings of chapter four – in which economic and educational aspects of countries were identified as the most important digital divide drivers – we expanded our research to address these two dimensions in detail. This path is addressed in chapters five and six, respectively. Chapter five consists of a broad analysis of the specific relationship that economic development, measured by Gross Domestic Product (GDP) per capita, has with the digital development. Hence, for 110 countries of the World, the digital development was measured using a set of ICT-related variables and, together with the GDP per capita, the relationship between these two developments was addressed in detail. Our main finding of this research project was concluding that there is no linear relationship between them, something that has been routinely assumed by earlier investigators to be true. This research was published in *Information Systems Frontiers* (Frederico Cruz-Jesus, Oliveira, Bacao, & Irani, 2016).

Chapter six is dedicated to the specific role of education in the digital divide across countries. The first research document, which is not included in this dissertation, analysed the digital development of 105 countries, using seven ICT-related variables, comparing it with the educational attainment of those same countries. The work was published in Procedia Technology as a proceeding of CENTERIS 2015, an international conference indexed to ISI (Frederico Cruz-Jesus, Oliveira, & Bacao, 2014). The results showed an extremely high linear correlation between education attendance and digital development. Given these results, we intended to go further in terms of education´s aspects influencing ICT adoption, which was not possible for such a high number of countries under study. Hence, we eventually returned to the context where this dissertation began – the EU. The reason is because EU has a unified statistical entity – the EUROSTAT – which provides comprehensive data about the subject under study for all of the 28 member states. Our last work consisted of analysing several dimensions of the Information Society across the EU-28, with *drill-downs* available for three education levels. in this way, we were able to bridge a previously identified gap in the academia – the fact that studies usually tend to address disparities across or within countries, i.e., country-level or domestic digital divides. This work allowed us to assess both at the same time. The results showed two dimensions in the European digital divide, in which even the most digitally developed countries present internal education-related divides. The results of this chapter were published in *Computers in Human Behavior* (F. Cruz-Jesus, Vicente, Bacao, & Oliveira, 2016).

Finally, the last work to be completed - but also the first one that was undertaken - gathered the knowledge assimilated over the years, resulting in a comprehensive country-level digital divide literature review. The increasing attention that the digital divide has been receiving demanded a document gathering the main drivers of digital asymmetries across countries. Our findings confirm that there is clear growing attention dedicated to this subject, in terms of both publications and citations. Our most important conclusions are twofold: First, economic, educational, and demographic characteristics are consistently identified as the most important digital divide drivers and; secondly, there is a gap in the literature in the sense that most of these studies tend to address digital asymmetries only across, or within countries, but as countries might perform well overall and at the same time, hide significant internal divides. The view in the literature so far is thus incomplete. This paper has been under review since May 2016.

Chapter II

2. The global digital divide: A literature review

Abstract The increasing attention that the digital divide has been receiving in the literature demands a literature review on the main drivers of digital asymmetries across countries. This paper does so, providing a review of studies addressing the digital divide across countries. Our findings confirm that there is a clear growing attention dedicated to this subject, in terms of both publications and citations. Our substantive findings are twofold: First, economic development of countries, followed by education and demographic characteristics are consistently identified as the most important digital divide drivers and; second, there is a gap in the literature in the sense that most of these studies tend to address digital asymmetries only across, or within countries, but as countries might perform well overall and at the same time, hide significant internal divides, the view in the literature so far is incomplete.

Keywords: digital divide, digital development, ICT, literature review

2.1 Introduction

The increasingly widespread diffusion of Information and Communication Technologies (ICT) into almost every aspect of our lives is already a characteristic of the global society. For both scholars and policy-makers this represents a profound social and economic transformation leading toward a "*knowledge economy*" or "*information society*", which demands from individuals and organizations - and thus countries in the aggregate – that they acquire the necessary conditions, skills, and access to take full advantage of ICT´s benefits (Castells, 2007a; Castells & Himanen, 2002). Such advantages are, however, not uniformly spread across countries, leading to a "global digital divide". As a result, in recent years generic ICT adoption has become one of the main topics of research in academia (C.-H. Wang, McLee, & Kuo, 2011). Simultaneously, policy-makers from all over the World have been dedicating their efforts to bridge the digital divide. Some examples are the United States (US) (e.g., National Information Infrastructure Advisory Council, 1996; US Department of Commerce, 2000), the European Union (EU) (e.g., European Commission, 2010a, 2010b, 2013), the United Nations (UN) (e.g., Unesco, 2003, 2009), and the Organization for Economic Co-operation and Development (OECD) (e.g., OECD, 2011), among many others. All of these have developed some type of strategy for promoting digital development and intensifying the use of ICT to engender growth and development. At the World Summit on the Information Society (WSIS), sponsored by the UN, 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).

The aim of this paper is to provide an overview of the literature regarding the digital divide phenomenon. Given the importance of this research topic and the considerable amount of research in the last years focused on it, it is worth addressing what the main conclusions have been. Hence, this literature review is expected to provide researchers and policy makers with an accessible and comprehensive examination of research seeking to understand what drives the global digital divide. In order to do so, the remainder of this paper is organized as follows: Section 2 presents some measures regarding the digital divide subject in academia, namely the number of papers published, citations, and respective trends; Sections 3 and 4 introduce the digital divide as subject, its main theoretical foundations, history, and evolution across the recent years; Section 5 presents a literature review of some of the most important papers published in this field; and Section 6 presents the conclusions and future work.

2.2 Digital divide as a research topic

In order to assess the importance given by researchers to the digital divide phenomenon, we used the Thomson Reuters Web of Science^{tm} search engine to conduct a literature analysis. We searched for all the papers in the database having the digital divide as subject. All of the available scientific databases were included in our search, resulting in 5,016 documents, of which 2,189 are journal articles. The timeframe considered was between 1997 and 2015, inclusively. Some key metrics are in Table 2.1:

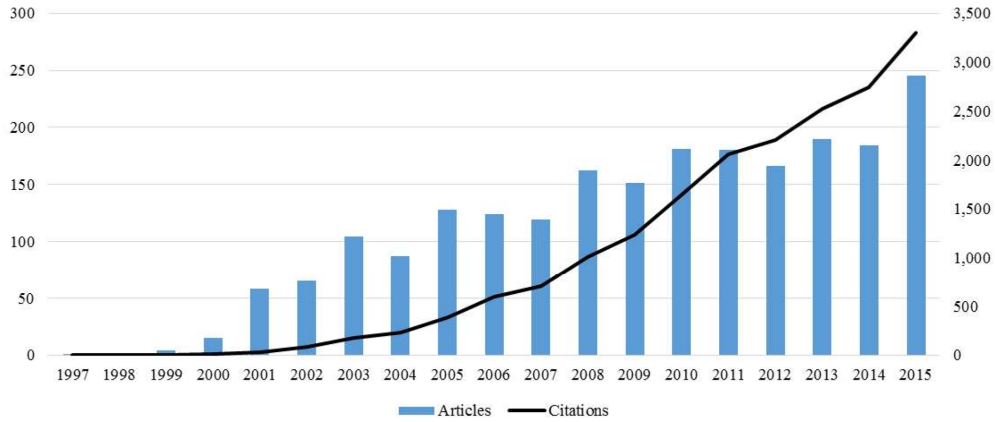
Table 2.1 - Main digital divide research metrics

Digital Divide Journal Articles	n	Avg
Journal Articles	2,189	
Times Cited	19,236	8.79
Times Cited without self-citations	14,486	6.62
Citing Articles	11,656	5.32
Citing Articles without self-citations	10,516	4.80

Our search found 19,263 citations among the 2,189 journal articles with subject about the digital divide. Hence, we have an average of 8.79 citations per journal published in this subject. If we exclude those citations that refer to any of the 2,189 journal articles found in our search, then the number of citations narrows to 14,486. This corresponds to an average of 6.62 citations per article published. The 2,189 digital divide articles were cited in 11,656 other journal articles (average of 5.32), which decreases to 15,516 (average of 4.8) if we consider only the articles that are not included in the 2,189 found, that is to say, if we only consider articles that are not in the group of the 2,189.

When we look at the number of articles and citations from 1997 to 2015 (see Figure 2.1), we easily notice that this subject is gaining attention, both in the number of articles and the number of citations. The year of 2015, the last one within our time period, was the one with most articles published (245) and also the one with most citations (3,297). As a matter of comparison, 2015 had approximately the same number of articles published from 1997 to 2003, and the same number of citations between the years of 1997 and 2008. From another perspective, in 2015, the number of articles and citations grew, respectively, 35 and 100% in comparison to 2010; and 91% and 754% if we look at 2005, ten years earlier. Hence, it is expected that the digital divide as a research topic will continue to increase in the near future.

Fig. 2.1 - Digital divide as subject of research: Papers vs citations



When looking at the top-10 (number of publications) journals in which the articles are published (see Table 2.2), *Telecommunications Policy*, *Information Society* and *Information Communication Society*, appear in the first three positions. Although *Telecommunications Policy* is the one with the highest number of articles, they only account for, approximately, 3% of the total publications, whereas in the other two journals, although the overall number of articles is smaller (around 50) their proportion is quite larger (7%). Even so, this value means that there is no journal specialized in the field of the digital divide. The overall number of articles published in the top-10 journals is 396, which corresponds to 18% of the 2,189 articles. This suggests that there is not an overwhelming concentration of articles in a very narrow number of journals, making the digital divide a field of general interest in academia.

Table 2.2 - Top-10 journals in terms of digital divide research

Top-10 highest number of articles	n	t	%
Telecommunications Policy	63	2,437	3%
Information Society	53	801	7%
Information Communication Society	51	681	7%
New Media Society	46	1,165	4%
Government Information Quarterly	43	1,946	2%
Journal of Medical Internet Research	42	1,815	2%
Computers Education	32	6,489	<1%
Social Science Computer Review	27	1,135	2%
Computers in Human Behavior	21	7,445	<1%
Journal of Health Communication	18	1,624	1%

In the field of information systems (IS), the digital divide still has a modest presence (see Table 2.3). Considering just the IS basket of eight journals, both the number and the percentage of articles dedicated to the digital divide is quite small. The total number of articles published in these journals is 33, and in none exceeds 1% of the 2,189 articles found.

Table 2.3 - Number of digital divide papers in IS basket of eight

IS Journals Basket of eight	n	t	%
European Journal of Information Systems	4	706	1%
Information Systems Journal	2	396	1%
Information Systems Research	8	594	1%
Journal of Information Technology	6	463	1%
Journal of Management Information Systems	3	691	<1%
Journal of Strategic Information Systems	0	347	<1%
Journal of the Association for Information Systems	6	332	2%
MIS Quarterly	4	649	1%

2.3. The Digital Revolution

In the last decades our reality has been completely (re)shaped by ICT. It is only some 40 years ago that electronic calculators and digital watches began to be widely available in developed countries, whereas nowadays most of us have access to digital devices that can store entire libraries of documents, videos, images, music, and books and that have thousands of times more processing power and memory capability than those same calculators. Likewise, around 50 years ago long-distance communications were mainly via postal services or telephone, whereas presently much of the world is connected via digital networks that allow incredible volumes of data to be exchanged instantly. The rhythm of ICT innovation and adoption has been astounding and it is plausible to assume that it will continue growing at this or even greater speed. ICT´s impact ranges from science, services, agriculture, and manufacturing. ICT development goes hand in hand with innovation, creating a snowball effect that individuals, firms, communities, and countries can benefit from. This is one of the reasons why ICT are, very likely, the key general purpose technology (technological innovations that have the potential to improve most industries and society sectors) of the present time (Bresnahan & Trajtenberg, 1995; Doong & Ho, 2012; European Commission, 2013). ICT impact began with the automation and computerization of manufacturing, followed by the spread of personal computers (PC) and the Internet, which led to the fact that broad sectors of the economy, previously untouched by these technologies, benefited from these, through investment and productivity improvements. The service sector of the economy, which accounts for the major portion of Gross Domestic Product (GDP) in developed economies, has also experienced considerable benefits from these technologies. However, not only the tertiary sector, but also the primary and secondary ones, have been touched by ICT. Thereafter, also non-market sectors such as finance, health, education, and even government services, have become exposed to the positive growth effects of ICT (European Commission, 2013).

For the above mentioned reasons, ICT are playing a decisive role in improving almost every aspect of society (World Bank, 2009), including business transactions, communications, economics, and politics (OECD, 2004). ICT applications such as Internet browsing, blogs, social networks, YouTube, on-line job seeking, email, wiki-sites, and access to online libraries are gaining room in our daily routines, improving the way people interact with each other. Additionally, new types of interactions, or advanced services, are becoming more and more common. These include e- and m-commerce, e-government, e-health, e-learning, e- and m-banking, social networks, cloud computing, among many others (Çilan, Bolat, & Coskun, 2009; European Commission, 2006; Facer, 2007; Krishnan & Lymm, 2016; Vicente & Gil-de-Bernabé, 2010; Vicente & Lopez, 2010b; Fang Zhao, Scavarda, & Waxin, 2012). Moreover, ICT positively affects the economy and welfare in several important dimensions (Çilan et al., 2009; World Bank, 2006), as it creates competitive advantages in enterprises, improves national health systems (Bakker, 2002) through e-health, and improves educational systems (Cukusic, Alfirevic, Granic, & Garaca, 2010; Hsieh et al., 2008) through e-learning, which in turn creates new opportunities, all of which reduces distance constraints and creates new industries that generate new employment opportunities (Castells, 2007b; Castells & Himanen, 2002). Hence, several academic studies have sought to assess how ICT can improve national economies and productivity. As Gurstein (2003) explains, "*ICT provides the basic infrastructure for production, and dissemination in any area of activity which has a significant information, knowledge or learning component*". Following that stream of thought, Carlsson (2004) studied the effects of ICT in the economy, comparing the potential of these technologies to the so called "*general-purpose technologies (GPT) which in the past revolutionized the economy*", such as the transportation and communications technologies in the 19th century, the Corliss steam engine, and the electric motor. His conclusions indicate 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*".

Using Solow´s Residual and time series analysis, S. Y. T. Lee et al. (2005) concluded that for a set of 20 developed and developing countries, ICT positively contributes to the productivity of developed and newly industrialized economies, although similar conclusion could not be ascertained for developing countries. Accordingly, Jalava and Pohjola (2008), analyzed ICT´s contribution to Finland's GDP between 1990 and 2004, concluding that the impact of these technologies was three times greater than the contribution of electricity from 1920 to 1938. Through a literature review, Holt and Jamison (2009), analyzed the relationship between ICT and broadband connections with economic growth, finding what appears to be a positive correlation between them.

Despite the above-mentioned examples, ICT´s impact goes far beyond the economic/productivity effects. Individuals´ well-being, living standards, and even sociological attributes, have also been touched by ICT since its appearance. Mo et al. (2013), for example, report empirical evidence that ICT use in education, specifically in the context of the One Laptop per Child (OLPC) program, benefits children by developing their computer skills and math scores. Additionally, there is also evidence that students' self-esteem is higher in the cases in which a PC is available at their homes, a finding in line with Hatakka, Andersson, and Gronlund (2013), although these authors also turned their attention to the hypothetically negative effects of ICT, such as distraction from school, isolation, or social media addiction.

As far as civic matters are concerned, ICT has also been playing an important role. In the awareness of individuals toward political ideologies, for example, E. Kim, Lee, and Menon (2009) concluded that these technologies are improving the way that democracy works. Shirazi et al. (2009) studied the relationship between ICT and economic freedom, and found that ICT expansion in the Middle East countries has been effective in supporting that freedom, as ICT has facilitated the "Arab Spring" revolution (Sandoval-Almazan & Ramon Gil-Garcia, 2014). On the other hand, even for countries in the EU, civic participation on the Internet depends upon the individual's income and education levels, as socioeconomically advantaged individuals are more likely to participate in civic matters online (Vicente & Novo, 2014). Wattal, Schuff, Mandviwalla, and Williams (2010) addressed the impact of the Web 2.0, especially the influence of social networks on politics in the 2008 US Presidential Primary Campaign, and concluded that the Internet is changing the very nature of political competition.

More recently, Andrade and Doolin (2015) addressed the benefits that ICT could bring to a specific group of disadvantaged people – refugees. By interviewing 53 refugees in New Zealand, they concluded that ICT helped in five dimensions: "*(1) participating in an information society; (2) communicating effectively; (3) understanding a new society; (4) being socially connected; and (5) expressing a cultural identity*".

Ultimately, countries (when considered as the as unit of analysis) are those that benefit the most from high ICT adoption from those within its boundaries - both individuals and organizations. As shown above, ICT´s positive outcomes are various and can, therefore, pull countries toward a strong, sustainable, and inclusive growth development. For these reasons, in both developing and developed countries, policy makers have been dedicating their efforts to engender digital development and narrowing digital gaps. In the EU, for example, the Europe 2020 Strategy was released, seeking "*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). European policy makers believe that European economic growth can only be accomplished if a digital economy based on knowledge and innovation is developed (European Commission, 2010b). The Digital Agenda for Europe, included in the Europe 2020 Strategy as one of the seven strategy flagships, aims to define the critical role that ICT must play if Europe wishes to realize its ambitions for 2020 (European Commission, 2010a). As the World Bank (2016) recommends, in order for ICT "*to benefit everyone everywhere requires closing the remaining digital divide, especially in Internet access*", although that may well not be enough.

2.4 The rising of a digital divide

Even today the mystery remains regarding who the first person was to employ the term "digital divide", and when and in what circumstances it was used (Gunkel, 2003). Nevertheless, in the literature and forums about this subject it is widely stated that the term was coined in the mid-1990s by the former Assistant Secretary for Communications and Information of the United States (US) Department of Commerce, Larry Irving Junior (Dragulanescu, 2002). According to his own report, he used the term to simply describe the social division between those who were very involved in technology and those who were not. Later he stated that the term digital divide was "*appropriated from an unknown source and redefined by the US Department of Commerce in the process of preparing the third 'Falling Through the Net' report*" (Gunkel, 2003).

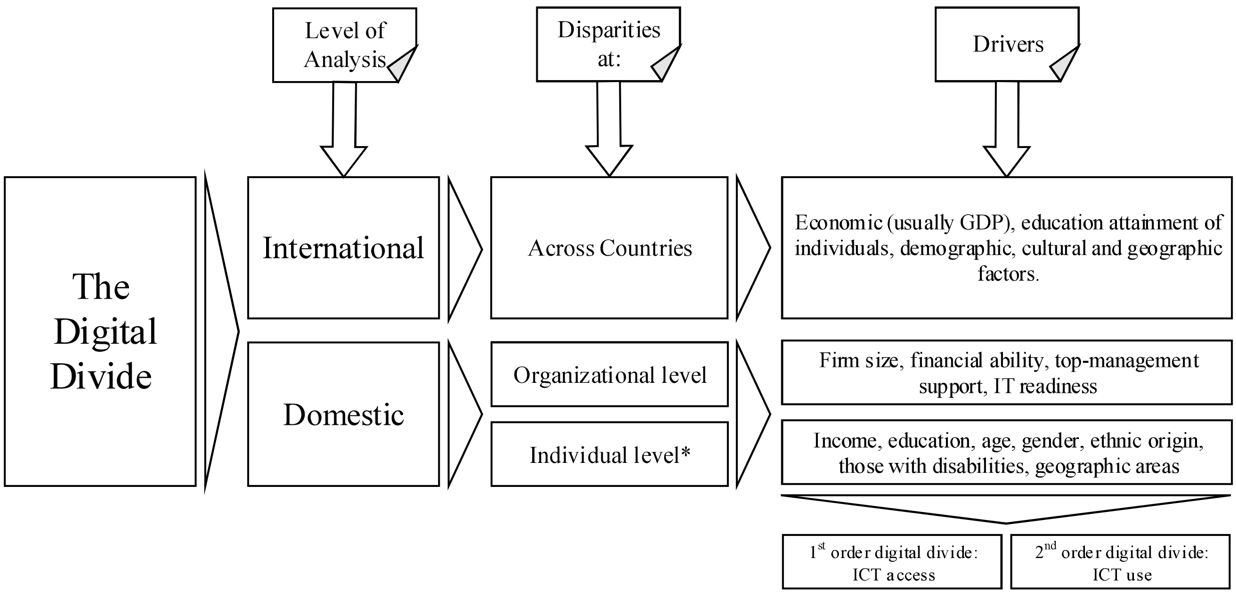
The digital divide was therefore initially understood in a binary way, meaning that there was a choice between "*has*" and "*has not*" access to ICT. While useful for describing the limits of various social and technological inequalities, this binary classification was very shallow. Consequently, this definition evolved from the binary understanding between "*has"* versus "*has not"* to focus on the reasons why disparities in access and use really existed. Perhaps one of the most important contributors to raise awareness about this subject was the popular "Falling through the Net" Reports (US Department of Commerce, 1995, 1998, 1999, 2000, 2002). In this series of reports the definition of digital divide evolved from simple PC ownership to the inclusion of Internet access, and later to the availability of broadband connections and also the types of online usages. As digital divide´s drivers, it was discovered that geographic area was an important factor in drawing a line between information haves and have-nots. Individuals belonging to ethnic minorities, or with lower incomes, were also more vulnerable to asymmetries in the access to digital technologies (Gunkel, 2003). In other words, the very same term digital divide underwent considerable change as the subject started to be understood as a multidimensional and complex issue. Hence, it is widely recognized today that the initial binary definition was narrow, since other factors need to be considered (Brandtzæg, Heim, & Karahasanovic, 2011). A widely accepted and repeated definition of digital divide is the one provided by 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*" (OECD, 2001). Therefore, digital divide is today understood to be a complex, multidimensional phenomenon (Bertot, 2003; Hsieh et al., 2008; Okazaki, 2006; Warschauer, 2002).

Generally speaking, there are two types of digital divide; the first is located at an international level, that is, between different countries; whereas the second is at an intra-national level, or within a country. In both 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 (Crenshaw & Robison, 2006; US Department of Commerce, 1995, 1998, 1999, 2000, 2002; Vicente & Lopez, 2006; Vicente & Lopez, 2008, 2010b, 2010c). 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).

In addition to the extensive nature of the digital divide´s drivers and whether these are across or within countries, there is also the issue of where the divide is actually located, that is to say, if in ICT access or ICT use (or both, if the case may be). These two types of inequality about access to and use of ICT are known as "first-" and "second-order" digital divides (Dewan & Riggins, 2005). In the first-order digital divide, inequalities have to do with ICT access, while in the second-order, the problem is postulated in terms of different use patterns among individuals/organizations that already have (very similar) access to ICT (e.g., using the Internet just for web-browsing or email vs. using it for e-learning, social-network, applying to jobs online, e-banking, e-health, etc.). As noted by Epstein et al. (2011), different types of inequalities (first- or second-orders) require different actions from different entities. Hence, inequalities in ICT access may be bridged through the subsidization of these technologies, which governments and organizations may well provide; whereas for inequalities in ICT usage patterns, possible solutions are in the hands of educational institutions and individuals themselves. Hsieh and Rai (2008), for example, demonstrated that economically advantaged and disadvantaged people, besides having different ICT access levels, also present very different post-implementation behavior, regarding the use of these technologies. That is to say, even when individuals belonging to different socioeconomic groups were equivalent in terms of ICT access, it is likely that across these groups, very different use habits may exist. 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.

The larger units (countries and their policy makers) are by definition those that exercise the greatest power and effectiveness in narrowing the global digital divide. For this reason, this paper is especially focused on country-level (global) digital divide, and its main drivers. A conceptualization of the digital divide phenomenon is presented in Figure 2.2.

Fig. 2.2 - Digital divide conceptualization (source: author)



2.5 Literature review on the drivers of the global digital divide

One of the first papers addressing the cross-country digital divide was the one from Hargittai (1999). In her work, aspects related with economic, education, language, legal environment, and technology infrastructure of countries were tested as digital (Internet) divide´s drivers. Of these, economic wealth and telecommunications policy were the ones identified as the most important. Three years later, Corrocher and Ordanini (2002) developed a measurement framework for a synthetic index of digitalization of countries and geographic areas. They were among the first authors who, perceiving the digital divide as a multidimensional phenomenon, employed multivariate techniques to investigate it, making use of principal components analysis (PCA). Their model resulted in a composite index, since it took into account the existence of multiple “layers” in the digital development of countries. The index included six factors: markets, diffusion, infrastructure, human resources (HR), competitiveness, and competition. The standard deviation of the composite index is the digital divide, whereas its actual value is the level of digitalization, i.e., the digital development of the country. In their study (2001 data), the United States of America emerged as the most digitally developed country, followed by Finland, Sweden, United Kingdom, Norway, Japan, Germany, Italy, France, and Spain. As the economic development of countries started to be increasingly important, Beilock and Dimitrova (2003) were, to the best of our knowledge, the first authors to hypothesize a non-linear relationship between Internet penetration and per capita income, the most important predictor of the digital divide found in their study. it was possible to test this hypothesis because the paper included 105 developed and developing countries, contrary to what was normal at the time, when mainly developed countries were included. However, perhaps due to the fact that this was not the main focus of their paper and the unclear nature of their results (especially the fact that the overall explanatory value was not enhanced by including the non-linear relationship), their study did not receive the attention that it probably deserves. In a later work, following a similar path, Frederico Cruz-Jesus et al. (2016), found evidence that a non-linear relationship between GDP and the global digital divide actually exists. In their study they made use of OLS with the ability to measure non-linear relationships for 110 countries that provided very robust support for this to be true. Nevertheless, with these exceptions, virtually every empirical study focusing on the digital divide assumes that theoretically and empirically, due to the statistical techniques used, economic effects on the global digital divide are linear, while there is nothing that suggests, or assures, that this is indeed so.

Dewan, Ganley, and Kraemer (2005) studied the global digital divide using OLS and quantile regressions for three distinct generations of ICT – Mainframes, PCs, and the Internet. As explanatory variables their framework included economic indicators (GDP and ICT Costs), socio-demographic characteristics (urban population and years of schooling), as well as environmental factors (telephone lines per capita and trade in goods). Their findings suggested that "*IT penetration is positively associated with national income for all three technology generations, and the association between penetration and income is stronger for countries with higher levels of IT penetration*". Additionally, demographic and non-economic factors proved to be significant in explaining the digital divide across countries, although not to the same extent. However, only the GDP per capita and the years of schooling achieved statistical significance for the penetration per capita of the three generations of ICT included in their study.

As for developing countries, Oyelaran-Oyeyinka and Lal (2005) addressed the Internet diffusion in 40 sub-Saharan countries. Their paper confirmed the vital importance of telecommunications´ infrastructure, represented by the high correlation of telephone density with Internet regardless of the per capita income level of the country. They made use of macroeconomic indicators such as the GDP per capita and investment in telecommunications´ infrastructure, education of individuals, along with technological indicators to understand Internet use. Using a simultaneous equation framework, their substantive findings indicate that economic wealth plays a critical role in promoting Internet diffusion. Along with the GDP, this study concluded that education is also a key aspect in Internet diffusion. M. Chinn and Fairlie (2007) examined data from 161 countries to assess the determinants of PC and Internet adoption. As would-be drivers of the global digital divide, they included the income per capita, years of schooling and illiteracy, trade openness, as well as other demographic, infrastructure and market indicadors. Using regression models, per capita income was found to be generally the most important digital divide antecedent, although, in some cases, other factors rival that of income. Regulatory aspects and education were also found to be positively correlated with PC and Internet adoption.

Billon, Marco, and Lera-Lopez (2009), developed a cross-country study of ICT diffusion using a set of ICT-related variables that covered several aspects of the digital revolution, along with multiple characteristics of countries, including economic, demographic, and educational ones. Their study indicated that for those countries with higher levels of ICT adoption, the GDP, the education of its inhabitants, and the service sector and government effectiveness were the most important drivers of digitalization. As for developing countries, the age of its inhabitants, the percentage of people living in urban areas, and the Internet cost were identified as the main determinants of digitalization. This study shed some light on the role that factors such as population age, geography, and education could play in the digital development of countries. In the same direction but for organizational level, i.e., asymmetries in ICT adoption of firms per country, Billon, Ezcurra, and Lera-López (2009) found evidence that, the GDP, population density, and education of countries are positively associated with the Internet adoption of firms in EU, in addition to the presence of a spatial correlation.

In the mid-2000s, a new stream of papers started to make use of multivariate exploratory analysis, to better understand the digital divide across countries. One of the first to employ this approach was that of Cuervo and Menéndez (2006), in which a multivariate framework was employed to assess digital divide across the European Union 15. Using factor and cluster analysis, their substantive findings pointed to the existence of two latent dimensions by which European countries fall into four distinct profiles (clusters), thus unveiling the presence of a European digital divide in which northern European countries perfomed much better in terms of digital development than their southern counterparts. Still within the European context, Çilan et al. (2009) addressed the digital divide between the original 15 member states, those who entered in 2004 and the candidate members that entered in 2007. Their findings pointed to a severe digital divide between these three groups of countries, although digital disparities were also found within them, namely across the original 15 member states. More recently, in 2012, (Frederico Cruz-Jesus et al.) analyzed the European digital divide, using 15 ICT-related indicators to understand how the 27 member states (at the time) performed in digital development. They found two latent dimensions on the European digital divide, one for ICT infrastructure and use by individuals and the other related with e-business and Internet access costs. They classified countries into five categories that to some extent are associated with the European entrance year, the GDP and the education attainment of individuals. Using data from 2008 to 2010, they posit that the most digitally developed European countries – those from northern Europe – were much more digitally developed in 2008 than any of their European counterparts in 2010. Also using a multivariate analysis, complemented by a probit model, Doong and Ho (2012), found that Gross National Income had a significant positive effect the ICT profile of 136 countries from 2000 to 2008, obtained from a cluster analysis, and using a probit model. Countries with higher national income tended to present higher levels of digital development.

Based on the Internet Consumption Model, Xiaoqun Zhang (2013), studied the Internet diffusion for four time intervals between 1991 and 2010, for a set of develop and developing countries. His findings suggest that developed countries have a sharper Internet diffusion curve and faster adoption rates than developing ones. As hypothesized, the GDP per capita and the Gini Index proved to be significantly positive and negative, respectively, as predictors of the Internet adoption across countries. Education, rural population, and economic openness were found to be significant drivers in only some time intervals. Another important conclusion drawn from this study is that, as developed countries presented much shorter lag periods in Internet adoption, the idea that the digital divide would eventually be bridged was contradicted.

One of the relatively few studies that do not point to economic wealth as a significant driver of ICT adoption, was the one from F. Zhao, Collier, and Deng (2014). These authors used a multidimensional framework to analyze the digital divide and its effects on e-government adoption. Their findings suggest that ICT infrastructure and socio-demographic characteristics of countries are significant predictors of the global digital divide, but surprisingly, the GDP per capita was not. Park, Choi, and Hong (2015) studied the global digital divide in 108 countries, classifying them into three groups according to digital convergence. As the main drivers of digital development, the GDP, tertiary education, and the share of service trade in GDP were found to be significant, whereas the urban population was not.

Perhaps one of the major gaps found in the digital divide literature is that studies usually focus on either digital divides across countries (global-level), or within them (domestic-level). However, either one of these two analysis alone can provide only a partial picture of the digital divide phenomenon. In other words, cross-country analysis allows us to assess the extent to which asymmetries in ICT adoption across countries exist, but can also hide important insights about domestic gaps, i.e., while a country might perform well on average, there might be digitally excluded groups of individuals. As F. Cruz-Jesus et al. (2016) say in their study – one of the first to consider international and domestic analyses together, only by running them both "*is it possible to expose the partial nature (if such is the case) of the picture provided by an analysis performed only at the country-level, which is the standard practice in the literature*". In their study they focused on the European age-related digital divide. The authors found that at the international level, north European countries continue to be the most digitally developed member-states, whereas south and east European ones are the digital laggards. When they analyzed ICT adoption at different education groups – keeping the analysis per country – their found evidence that even the more digitally developed, on the aggregate, countries suffer from domestic divides. Without much surprise, there is indeed a European education-related digital divide, as 27 of the 28 member states systematically present higher levels of ICT adoption among its most educated inhabitants.

The above literature review is summarized in Table 2.4. From the studies, consistent with the World Bank´s (2016) World Development Report, "*there also are persistent digital divides across gender, geography, age, and income dimensions within each country*". The next sub-sections extend the theory regarding the global digital divide drivers identified above.

Table 2.4 - Studies addressing the global digital divide

Reference	Journal	Context	Drivers found
(Hargittai, 1999)	Telecommunications Policy	18 OECD countries	Economic development and telecommunications infrastructure
(Corrocher & Ordanini, 2002)	Journal of Information Technology	10 developed countries	N/A
(Beilock & Dimitrova, 2003)	Telecommunications Policy	105 countries	Economic development (per capita income) with a non-linear relationship along with society openness and ICT infrastructure
(Dewan et al., 2005)	Journal of the Association for Information Systems	40 countries	Economic development and education
(Oyelaran-Oyeyinka & Lal, 2005)	Telecommunications Policy	40 sub-Saharan countries	Telecommunications infrastructure and economic development and education
(Cuervo & Menéndez, 2006)	Information & Management	European Union 15	N/A
(M. Chinn & Fairlie, 2007)	Oxford Economic Papers	161 countries	Economic development, regulatory aspects, and education
(Çilan et al., 2009)	Government Information Quarterly	European Union 27	Entrance year to the EU
(Billon, Marco, et al., 2009)	Telecommunications Policy	142 countries	Economic development, education, share of service sector, and government effectiveness in developed countries; Age, urban population, and Internet costs in developing countries
(Billon, Ezcurra, et al., 2009)	Growth and Change	European Union	Economic wealth, population density, and education
(Frederico Cruz-Jesus et al., 2012)	Information & Management	European Union 27	Economic development and education
(Doong & Ho, 2012)	Electronic Commerce Research and Applications	136 countries	Economic development
(Xiaoqun Zhang, 2013)	Telecommunications Policy	65 – 87 countries	Economic development and education; rural population and economic openness in some years
(F. Zhao et al., 2014)	Information Technology and People	76 – 171 countries	Telecommunications infrastructure and socio-demographic characteristics as drivers

(Park et al., 2015)	Technological Forecasting and Social Changes	108 countries	Economic development, education, and share of services
(F. Cruz-Jesus et al., 2016)	Information Systems Frontiers	110 countries	Economic wealth (GDP per capita) with a non-linear relationship
(Frederico Cruz-Jesus et al., 2016)	Computers in Human Behavior	European Union 28	Education (although it was the only driver tested)

2.5.1 Income/GDP

The link between economic development and the digital divide, usually assessed through the gross domestic product per capita (GDP), is well supported in the literature (Kauffman & Techatassanasoontorn, 2005). Considering that newer technologies tend to be more expensive, naturally presenting higher risks for those who decide to adopt them, the diffusion of innovations theory (DOI) theory (Rogers, 2005) states that wealthier individuals and firms - and thus wealthier countries in the aggregate - are more likely to adopt technological innovations, as is the case of ICT. Moreover, the digital revolution began within the western developed world, i.e., almost all new products and technologies came from developed countries (James, 2011). These effects combined to lead the developed countries to rapidly adopt and increase their use of ICT for a wide variety of activities (e.g., individuals started using PCs for personal purposes and firms for business). The developing countries, on the other hand, did not possess the same resources to effectively acquire ICT, and did not benefit from its use at the same scale as did the richer countries. During the early years of ICT the adoption rate was unquestionably several times higher in richer countries (Xiaoqun Zhang, 2013), although the question whether this fact is still occurring today remains, as there are contradicting conclusions in academia. Nevertheless, countries with stronger economies are more likely to have the possibility of using ICT. Additionally, as these countries tend to have more developed economies in terms of information-, financial-, and innovation-based economic activities, the likelihood of presenting higher levels of ICT adoption is also greater.

Moreover, it seems reasonable to hypothesize that greater ICT adoption and use is likely to lead to higher levels of economic growth, generating a snowball two-way effect that may lead to an increasing or, at least, stable digital divide between developing and developed countries. On the other hand, it also seems plausible that continued economic growth results in ever smaller increases in ICT adoption, as there is a finite limit to its level, and its financial constraints lose importance, thereby reducing digital gaps across countries. As this takes place, factors other than economic ones gain importance, such as education, demography, and geography.

2.5.2 Education

Education, along with economics, is one of most mentioned reasons for the digital divide (see, for example, Frederico Cruz-Jesus et al., 2012; Kiiski & Pohjola, 2002; Shirazi, Ngwenyama, & Morawczynski, 2010). Theoretical foundations for this relationship abound and can be found in several different theories. The DOI claims that education attainment can help to reduce ICT´s perceived complexity, which is a major obstacle for adoption and use (Rogers, 2005). Hence, the easier a technology seems to be, the faster is its adoption rate (Katz & Aspden, 1997). This gives an important role to individuals´ educational features, as when technically challenged, more educated individuals are likely to be more prone to flexibly and effectively overcome complexity´s constraints (H. Zhao, Kim, Suh, & Du, 2007). Thus, as in the case of ICT, when one is interacting with it, the relatively higher educational attainment should make it easier to cope with the complexity of the technology, minimizing the impact of the difficulties (Hsieh et al., 2008). In this sense education facilitates the absorption and comprehension of information, leading to an increasing information divide between higher- and lower-educated individuals. This is, in fact, the main argument lying behind the knowledge gap theory (Tichenor, Donohue, & Olien, 1970), developed within the context of mass media´s (TV, radios, etc.) wide dispersion. Tichenor et al. (1970) state that, "*as the infusion of mass media information into a social system increases, higher socioeconomic status segments tend to acquire this information faster than lower socioeconomic status population segments so that the gap in knowledge between the two tends to increase rather than decrease*". If this happens in mass media technologies, which are far less complex and challenging than the Internet-related ones, then in the case of these last, that fact should be even more noticeable.

Mass media technologies are not as demanding as are ICT, since they do not require a set of actions by its users. ICT and Internet related activities, however, require that the users navigate throughout a great amount of information instead of being (almost) mere passive receptors of information (Bonfadelli, 2002). Moreover, in case of ICT, although access is a prerequisite, it is not enough, *per se*, for taking all of the advantages these technologies can bring, as important differences may remain in the nature of Internet use (van Dijk, 2005). As Vicente and Lopez (2006) point out "*not only does the user need access to infrastructure but also he needs the ability to access to information, to look for it and to use it*". Moreover, it is also reasonable to hypothesize that higher educated individuals are more likely to work in information-intensive industries, thus using ICT more often and intensively whether at work or at home. Accordingly, Howard et al. (2001) found that more educated individuals will tend to employ the Internet more productively and to greater economic gain than those with lower educational attainments, consistent with the findings of Hargittai and Hinnant (2008). More recently Peng et al. (2011) found that individuals who use a PC at work or school are more likely to adopt ICT. A consistent finding has been demonstrated by Tengtrakul and Peha (2013), in which the authors conclude that "*the higher the educational level of students, the stronger the increase in likelihood of a household adopting ICT*".

2.5.3 Age

Age is generally acknowledged as a critical digital divide driver between individuals considering that, in general, older people are less likely to use ICT in comparison to youth. The main argument lies, perhaps, in the fact that individuals who were born and grew up in a world surrounded by ICT are more likely to assimilate these technologies better than those who needed, at some point in their lives, to adapt to it. In other words, the foundation for the age-related digital divide is the so-called "digital natives" and "digital immigrants" (Günther, 2007; Prensky, 2001). Naturally, there is no fixed threshold for defining those who can be characterized into one group or the other. In fact, this classification is not even really binary, as there are those who certainly fit both to different degrees.

Digital natives, also widely referred as "millennials", are basically native speakers of the digital language, as they grew up with these technologies without having to adapt to them (e.g., children who today learn how to use a tablet before they can actually talk, read, or write). This aspect stems from the fact of youth growing up around ICT, having a natural tendency to use these technologies. As Prensky (2001) argues, "*they have spent their entire lives surrounded by and using computers, videogames, digital music players, video cams, cell phones, and all the other toys and tools of the digital age*". This fact is especially valid in developed countries, where ICT are more widely available in households, schools, public libraries, etc. At the other end of the spectrum, “digital immigrants”, were not born into a world surrounded by ICT, having, at some point in their lives, to adapt to it, often in a lengthy and complex process. Another important aspect in the duality between “digital natives” and “digital immigrants” arises from the fact that as these last are, in the same context, older than the first, they are prone to present more constraints in adopting and adapting themselves to a digital world. As a natural consequence of ageing, it seems natural to hypothesize that “digital immigrants” require more practice to successfully assimilate ICT use. Additionally, it is often argued in literature that the elderly are more likely to suffer from “inertia”, i.e., are more likely to resist changing a known way of doing something, even if for a more efficient one (Hawthorn, 2000).

Additionally, besides the fact of growing up or not in a world dominated by ICT, there is another fact that influences age-related ICT asymmetries that arises from the natural ageing process and its implications in human beings. Ageing is a natural process that, almost inevitably, will lead to some physical and cognitive decreases (Czaja & Lee, 2006; Grady & Craik, 2000). Likewise, what probably happens in the other-aspects-driven digital divides, one of the most concerning matters related to age is the fact that the elderly, individuals who more likely to be info-excluded, are those who could benefit the most from ICT – as these technologies could help them to reduce the isolation that they often experience.

2.5.4 Other drivers

Besides income, education, and age, there are other would-be digital divide drivers. Although they are not as recognized as the above-mentioned ones, they may still have some influence (Billon, Marco, et al., 2009). Among these we have individuals living with disabilities (see, e.g., Annable, Goggin, & Stienstra, 2007; Oxley, 2012; Rosalia Vicente & Jesus Lopez, 2010), living in rural areas (see, e.g., Billon, Marco, et al., 2009), belonging to ethnic minorities (see, e.g., US Department of Commerce, 1998), and women (Brannstrom, 2012).

2.6 Conclusions and future work

Based on the literature review on the digital divide, we are led to conclude that the attention given in academia to the digital divide phenomenon, has increased steadily over the past few years. This attention reaches many scientific fields, as it is not concentrated in a small or specific number of outlets or in a specific field.

The most important drivers are apparently the economic performance of countries, the education attainment of its population, ICT infrastructure, and demographic factors (age of individuals). Additionally, there is some evidence that geography, gender, and ethnicity may lead to digital disparities across or within countries. Finally, research is usually conducted at the country level or within a country, providing, in either case, only a partial view of the digital divide. Future research should therefore focus on both national (aggregated) reality and, simultaneously, domestic divides, thereby providing a complete picture about digital inequalities.

Chapter III

3. Digital divide across the European Union

Abstract. Our research analyses the digital divide within the European Union 27 between the years of 2008 and 2010. To accomplish this, we use multivariate statistical methods, more specifically factor and cluster analysis, to address the European digital disparities. Our results lead to an identification of two latent dimensions and five groups of countries. We conclude that a digital gap does, in fact, exist within the European Union. The process of European integration and the economic wealth emerge as explanatory factors for this divide. On the other hand, the educational attendance is not proven to be significant, as one would expect.

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

3.1 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, 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).

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). The European Commission has, recently, also earmarked 1 billion Euros extra to “*help rural areas get online, bring new jobs and help businesses grow*” (European Commission, 2009). It is predicted that the ICTs “*will help create around 1 million jobs in Europe and a broadband-related growth of economic activity of 850 billion Euros between 2006 and 2015*” (European Commission, 2009). Also during the period between the year 2000 and 2006, it is estimated that the European structural funds spent 5.5 billion Euros on information society boosting programmes (Vicente & Gil-de-Bernabé, 2010). Therefore, considering the importance of the digital development to the EU, expressed by these measures, digital inequalities must be detected and corrected in order to avoid jeopardizing the objectives of the Europe 2020. Thus it has become fundamental to know what the current situation is regarding the digital divide within the whole EU. The best way to assess this is by studying the national realities regarding the multiple dimensions of the digital development, for a posterior comparison of each country with the rest of the European ones.

Keeping this goal in mind, although several authors have focused on understanding and measuring the digital divide, there is a lack of studies capable of taking a wide snapshot of the EU reality with a wide set of relevant and updated indicators. Considering the importance that the European Commission gives to a homogeneous digital development amongst all of its members, the first step to take toward this development is to assess the current situation within the Union. The current research helps to do this and sheds light on the issue in order that efficient policies may be deployed. We therefore intend to provide a complete and updated analysis of digital asymmetries within the 27 Member States of the European Union (EU-27), with data pertaining to the year 2010, and answer the following questions: (1) What are the most significant latent dimensions of the European digital divide, so that countries may act on them?; (2) Is the digital divide a consequence of economic wealth and educational attendance, as suggested by some authors (Billon, Ezcurra, & Lera-López, 2008; Billon, Ezcurra, et al., 2009; Vicente & Gil-de-Bernabé, 2010)?; (3) Is the European digital divide widening or narrowing?; In answering these questions, the paper is organized as follows: Section 2 presents a literature review of digital divide and digital development; in Section 3 we develop a theoretical framework for measuring the digital divide; Section 4 includes the analyses undertaken on the data collected, using factor and cluster analysis, and comparison with the previous two years (2008 and 2010); Section 5 presents the discussion of findings, while Section 6 presents the conclusions.

3.2 Digital Divide and Digital Development

Even today the mystery remains about who the first person was to use the term digital divide, and when this happened (Gunkel, 2003). However, in the literature and forums about the subject, it is widely stated that the term was coined in the mid-1990s by the former Assistant Secretary for Communications and Information of the United States (US) Department of Commerce, Larry Irving Junior (Dragulanescu, 2002). According to his own report, he used the term to describe the social division between those who were very involved in technology and those who were not. Later on he stated that the term digital divide was "*appropriated from an unknown source and redefined by the US Department of Commerce in the process of preparing the third 'Falling Through the Net' report*" (Gunkel, 2003).

The digital divide was initially understood in a binary way, meaning that there was a choice between "*has*" and "*has not*" access to ICT. While useful for describing the limits of various social and technological inequalities, this binary classification was very reductive, imprecise, and inaccurate. Consequently, the subject evolved from the binary understanding between "*has*" versus "*has not*" to focus on the reasons why disparities in access and use really existed. As a consequence, it was discovered that geographic area was an important factor in defining the divide between information haves and have-nots. Individuals belonging to ethnic minorities, or with lower incomes, were also more vulnerable to asymmetries in the access to digital technologies (Gunkel, 2003). In other words, the very same term digital divide underwent considerable evolution as the subject started to be understood as a multifaceted issue. Hence, it is widely recognized today that the initial binary definition was narrow, since other factors need to be considered (Brandtzæg et al., 2011). A widely accepted and repeated definition of digital divide is the one provided by 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*" (OECD, 2001). Therefore, digital divide is today understood to be a complex, multidimensional phenomenon (Bertot, 2003; Hsieh et al., 2008; Okazaki, 2006; Warschauer, 2002).

There are two types of digital divides. 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 both 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 (Crenshaw & Robison, 2006; US Department of Commerce, 1995, 1998, 1999, 2000, 2002; Vicente & Lopez, 2006; Vicente & Lopez, 2008, 2010b, 2010c). Hsieh et al. (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 (World Bank, 2009), including business transactions, communications, economics, and politics (OECD, 2004). Wattal et al. (2010) studied the impact of the Web 2.0, especially the influence of social networks on politics, in the 2008 US 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 (GPT) which in the past revolutionized the economy*", such as the transportation and communications technologies in the 19th 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 greater 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 et al., 2009; European Commission, 2006; Facer, 2007; Vicente & Gil-de-Bernabé, 2010; Vicente & Lopez, 2010b). Actions and technologies like Internet surfing, YouTube, social networking, on-line job seeking, 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; World Bank, 2006). ICT creates competitive advantages in enterprises, improves national health systems (Bakker, 2002) through e-health, improves educational systems (Cukusic et al., 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, 2007b; Castells & Himanen, 2002). Thus, for these benefits to be realized, certain obstacles need to be overcome, especially inequalities both between and within countries regarding the access to these technologies.

3.3 Measuring the European Digital Divide

3.3.1 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; S. Y. T. Lee et al., 2005; OECD, 2009; Vehovar, Sicherl, Husing, & Dolnicar, 2006; World Bank, 2006). Wang, McLee, and Kuo (C.-H. Wang et al., 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 (Vehovar et al., 2006). 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 US (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 the analysis for multiple countries. Hence, there is usually 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). This constraint affects accurate attempts to measure digital inequalities particularly, in a very significant way: if the data collected are scarce in terms of number of individuals (countries) the conclusions will be limited. On the other hand, if the data are scarce in terms of number of variables, the conclusions may be misleading, considering that “*sometimes digital divide indicators take different or even contradictory values*” (Vehovar et al., 2006), i.e., a country may have higher levels of broadband penetration rates but, at the same time, lower levels in Internet adoption by individuals and firms than another country. Therefore, if it is assumed that the broadband penetration rate is synonymous with Internet adoption (which seems at a first sight fair enough), the conclusions of the analysis will be misleading. Because of this, a consistent theoretical framework should be developed prior to the use of data, especially if this is scarce in terms of variety of indicators.

For these reasons, the use of indices to measure the digital divide has emerged as relatively popular alternatives to the use of ICT-related indicators. Various compound ICT-related indicator measures have appeared, such as, for example, the Digital Access Index (ITU, 2003), the Digital Opportunity Index (ITU, 2005), the Technology Achievement Index (UNDP, 2001), the Information Society Index (IDC, 2001), and the Infostate, which is an overall set of indicators comprising two components, info-density and info-use (Sciadas, Guiguère, & Adarn, 2005). There are even authors who have proposed new indices based on others, in a attempt to achieve a standardized solution for measuring ICT adoption and use (see for example, (Emrouznejad, Cabanda, & Gholami, 2010)). The use of indices can summarize complex and multidimensional phenomena such as the economic or digital development. They are also easy to interpret, and allow for easier tracks of changes across time periods (OECD, 2008).

However, they also entail several constraints (Bruno, Esposito, Genovese, & Gwebu, 2010). One of the main arguments against their use rests on the oversimplification of complex interrelations, i.e., the indices reduce the digital divide to a single value, which may be misleading in some instances (Vehovar et al., 2006). Another limitation is related to the variables that are included in each index (OECD, 2008; Unesco, 2003). For instance, besides technologies that have already reached some level of widespread use (e.g., TV, fixed telephone lines, PCs, and the Internet), it is fundamental to measure new emerging types of ICT (e.g., broadband, Internet access via mobile devices, e-banking services, among many others). New technologies should be continuously incorporated into the indices. Note that several of the ones mentioned above are almost ten years old, and some are even older. The advent of new types of ICT is very dynamic. Ten years ago the use of Internet via mobile devices, the use of e-banking, and e-government services were, at the very best, almost negligible. Finally, another limitation of these compound measures is related to the weight that each indicator (variable) has in calculating the index "*which could be the subject of political dispute*" and therefore not reliable for a specific subset of countries or ICT dimensions (Bruno et al., 2010; OECD, 2008).

Due to these limitations and the fact that we wish to assess the European digital divide, explaining the specific latent dimensions within the Union, and group the countries into similar digital profiles (clusters), we find the use of multivariate methods more suitable and reliable. Several authors in the past have also opted to follow this methodology (see, e.g. (Çilan et al., 2009; Cuervo & Menéndez, 2006; Vicente & Lopez, 2010a)). Moreover, considering that the EU has a unified statistics system, the Eurostat, the problem of data availability described above is mitigated by the fact that Eurostat has the data needed, and those data are fairly well harmonized.

In order to collect the ICT-indicators to measure the digital development of countries within EU, we conceptualize the ICTs as general purpose technologies (GPTs). GPTs are characterized by technological innovations that have the potential to positively affect multiple industries and society sectors (Doong & Ho, 2012), as is the case of ICT (Carlsson, 2004). We must therefore face the digital divide as a multidimensional issue. To do this we use multiple indicators to represent the ICT development of a country. According to the recommendations of the OECD (2009), 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, which are more likely to present disparities between categories. To measure the digital divide between countries, the indicators should refer to the aggregated national reality. Because our goal is to investigate the divide within the EU, we will follow the second recommendation. A limitation for this option must be recognized, however. The variables will not reflect any type of internal disparities (domestic digital divides) in each country within itself. It should be kept in mind that these potential domestic digital divides are more likely to occur in bigger (thus more heterogeneous) countries, as well as in countries of lower economic development. Countries with these characteristics are potentially more likely to reveal domestic digital disparities because smaller and richer societies are easier to connect than those which are bigger and poorer (Dewan et al., 2005; Emrouznejad et al., 2010).

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 in the use and adoption of ICT (M. Chinn & Fairlie, 2007; Menzie Chinn & Fairlie, 2010; Dewan, Ganley, & Kraemer, 2009; Hargittai, 1999; Kiiski & Pohjola, 2002; Pohjola, 2003). Dewan et al. (2009) showed that developing countries are slower to achieve digital development, but by focusing on certain technologies, particularly the availability of PCs and Internet with a cost-reduction policy, the cross-technology diffusion effects of these combined technologies will help to appreciably narrow the divide.

3.3.2 Data

Consistent with our theoretical framework, which comprises ICT into the category of GPT, for measuring the levels of digital development across the EU-27, we used 16 variables that are compatible with recommendations from the OECD and European Commission. These indicators were selected by combining a mix of earlier studies with some recommendations from the organizations mentioned. We were thereby able to obtain 15 of 16 variables used in our analysis from the Information Society Statistics Category in the Eurostat website – all pertaining to the year 2010. Data for the 16th variable were obtained from the World Bank database. The fact that all variables were obtained from official entities, and pertain to the year 2010, guarantees that the results of the analysis enjoy a high degree of reliability. Table 3.1 shows the variables collected.

Table 3.1 - Acronyms, descriptions and literature support of variables

Code	Variable	Support
HsInt	Percentage of households having access to the Internet at home	(Brandtzæg et al., 2011; M. Chinn & Fairlie, 2007; Çilan et al., 2009; Cuervo & Menéndez, 2006; Vicente & Lopez, 2010a)
BroRt	Broadband penetration rate	(Billon, Marco, et al., 2009; Brandtzæg et al., 2011; Çilan et al., 2009; Cuervo & Menéndez, 2006; Vicente & Lopez, 2010a)
IntPop	Percentage of population regularly using the Internet	(Billon, Marco, et al., 2009; Çilan et al., 2009; Vicente & Lopez, 2010a)
Mob	Percentage of population using mobile devices to access the Internet	(Kauffman & Techatassanasoontorn, 2005; Okazaki, 2006; Vicente & Lopez, 2006; Vicente & Lopez, 2008)
IntSrc	Percentage of population using Internet for finding commercial information	(Çilan et al., 2009; Ferro, Helbig, & Gil-Garcia, 2011; Vicente & Lopez, 2010a)
Cost	Percentage of households without Internet because of the access costs	(Cuervo & Menéndez, 2006; Kiiski & Pohjola, 2002)
eBank	Percentage of population using e-banking services	(European Commission, 2010a)
eLearn	Percentage of population using e-learning services	(Çilan et al., 2009; European Commission, 2010a)
email	Percentage of population using e-mail	(Billon et al., 2008; Bunz, Curry, & Voon, 2007; Ferro et al., 2011)
eHealth	Percentage of population using Internet for seeking health information	(European Commission, 2010a)
eGovI	Percentage of population using Internet for interaction with public authorities	(Çilan et al., 2009; European Commission, 2010a)
eGovE	Percentage of enterprises using Internet for interaction with public authorities	(European Commission, 2010a)
eGovS	Percentage of government services available online	(Cuervo & Menéndez, 2006; European Commission, 2010a)
eCom	Percentage of enterprises selling online	(Cuervo & Menéndez, 2006)
Serv	Number of secure servers per million inhabitants	(Billon, Marco, et al., 2009; Brandtzæg et al., 2011; Cuervo & Menéndez, 2006)
eSafeE	Enterprises having a formally defined ICT security policy with a plan of regular review	(Guan & Yang, 2002)

As in other studies focusing on the digital divide, we sought to include indicators that measure the ICT infrastructure of each country along with their pervasiveness at multiple units of adoption (individuals, and enterprises). Consistent with the literature (Dewan et al., 2009; Unwin & de Bastion, 2009), the Internet access cost (Cost) was also included in our analysis, since this is strongly negatively correlated with the digital development.

The percentage of households connected to the Internet (HsInt), and the broadband penetration rate (BroRt) are often used in the literature to measure the digital development/divide (Brandtzæg et al., 2011; M. Chinn & Fairlie, 2007; Çilan et al., 2009; Cuervo & Menéndez, 2006; Vicente & Lopez, 2010a). These variables express the connectivity level in terms of ICT infrastructure. The Internet secure servers (Serv) are also a specific ICT infrastructure of e-commerce, allowing secure electronic business transactions (Cuervo & Menéndez, 2006). Web browsing and using e-mail are probably some of the most general and popular actions that individuals can practice through the use of ICT (Ferro et al., 2011). Hence, the percentage of population regularly using the Internet (IntPop), and the percentage of population using e-mail (email), is an effective way for assessing the use of ICT of individuals for general purposes. The recent emergence of the mobile phones that allow Internet access is also an important aspect of the information society (Okazaki, 2006). However, as Kauffman and Techatassanasoontorn posit, "*little attention has been devoted to evaluate the extent of the divide and empirically examine determinants of the diffusion of digital wireless phones across countries*" (Kauffman & Techatassanasoontorn, 2005). For this reason, we find it particularly interesting to measure the percentage of population using mobile devices to access the Internet (Mob). The percentage of population using Internet for finding commercial information (IntSrc) allows us to assess the role that the Internet has in commerce (on the individual side). Considering that we are attempting to analyse the digital divide at a European level, we also find it particularly relevant to consider the position of the European entities concerning the digital divide. The European Commission, via the Digital Agenda for Europe (European Commission, 2010a), emphasizes the role of specific electronic services, more specifically 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 the use of these advanced services also allows us to analyse the so called "second order digital divide", expands our focus from mere ICT adoption, to include the manner in which it is used by individuals (Hsieh et al., 2008). For these reasons the percentage of population using e-health, e-learning, e-banking, and e-government services (eHealth, eLearn, eBank, eGovI, and eGovS, respectively) were also included in our analysis. As mentioned we also took into account the pervasiveness of ICT in adoption units other than the individuals. Hence, the percentage of enterprises selling online (eCom) is an important indicator of electronic commerce. Likewise, at the individual level e-government is also present in the relationship between firms and public authorities. We thus include the percentage of enterprises using Internet for interaction with public authorities (eGovE). Finally, consistent with the literature, security is recognized as a major issue in the e-commerce adoption both by firms and individuals (Guan & Yang, 2002; C. Kim, Tao, Shin, & Kim, 2010). For this reason, we also include the percentage of enterprises having a formally defined ICT security policy (eSafeE). The last column of Table 3.1 presents the literature support (either theoretical or empirical) of the suitability of our variables to measure the digital development.

It is important to keep in mind that we do not claim that our set of variables are exhaustive in terms of expressing the digital development, but we do believe that considering the limitations of data availability, they can efficiently measure each of the EU-27 member state's digital development to a significant and wide extent.

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 analysing the e-government supply availability (eGovS), there are six countries with 100% services available online and nine countries with values less to 75%. Also, in 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 16 variables used, while Bulgaria and Romania are the poorest-ranked in eight of them. These uneven distributions can tell us a great deal about the asymmetries that exist between countries. Nevertheless, the dimensionality of the data used -16- makes it impossible to address the digital divide with simple univariate statistics. This is why the use of multivariate statistical methods is much more appropriate in analysing all of these digital asymmetries.

Table 3.2 - Data used

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

3.4 Methodology

3.4.1 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 exist, otherwise the factor analysis may provide weak results. Our analysis involved several steps. The first was to analyse 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 3.3) shows that each variable has, at least, one absolute correlation coefficient of 0.55 with another variable. Although this correlation value is moderate, it ensures that all of the variables 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 (J. Lee, Kim, & Ahn, 2011) 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 3.3 - Correlation matrix

	HsInt	BroRt	IntPop	Mob	IntSrc	Cost	eBank	eLearn	email	eHealth	eGovI	eGovE	eGovS	eCom	Serv	eSafeE
HsInt	1	0.87 **	0.95 **	0.85 **	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 **	0.71 **	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	0.83 **	0.97 **	-0.46 **	0.92 **	0.69 **	0.99 **	0.84 **	0.92 **	0.53 **	0.45 **	0.57 **	0.71 **	0.44 *
Mob				1	0.79 **	-0.49 **	0.73 **	0.71 **	0.82 **	0.70 **	0.82 **	0.40 *	0.56 **	0.43 *	0.63 **	0.41 *
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	0.70 **	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 **	0.47 **
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 0.77, 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 3.4, 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 (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 (Ferro et al., 2011) 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 3.4 - Results of factor analysis and Cronbach's alpha

Rotated Factor Model: Varimax		
	Factor 1	Factor 2
EGovI	0.90	0.32
IntPop	0.89	0.37
Email	0.88	0.37
eBank	0.88	0.31
IntSrc	0.89	0.39
eHealth	0.88	0.23
HsInt	0.86	0.46
Mob	0.80	0.32
eLearn	0.77	0.25
BroRt	0.76	0.49
eGovS	0.59	0.07
eSafeE	0.17	0.83
eCom	0.40	0.68
Serv	0.55	0.61
eGovE	0.34	0.57
Cost	-0.14	-0.91
Variance (%)	51%	25%
Variance Total	51%	76%
Cronbach's Alpha	0.97	0.85

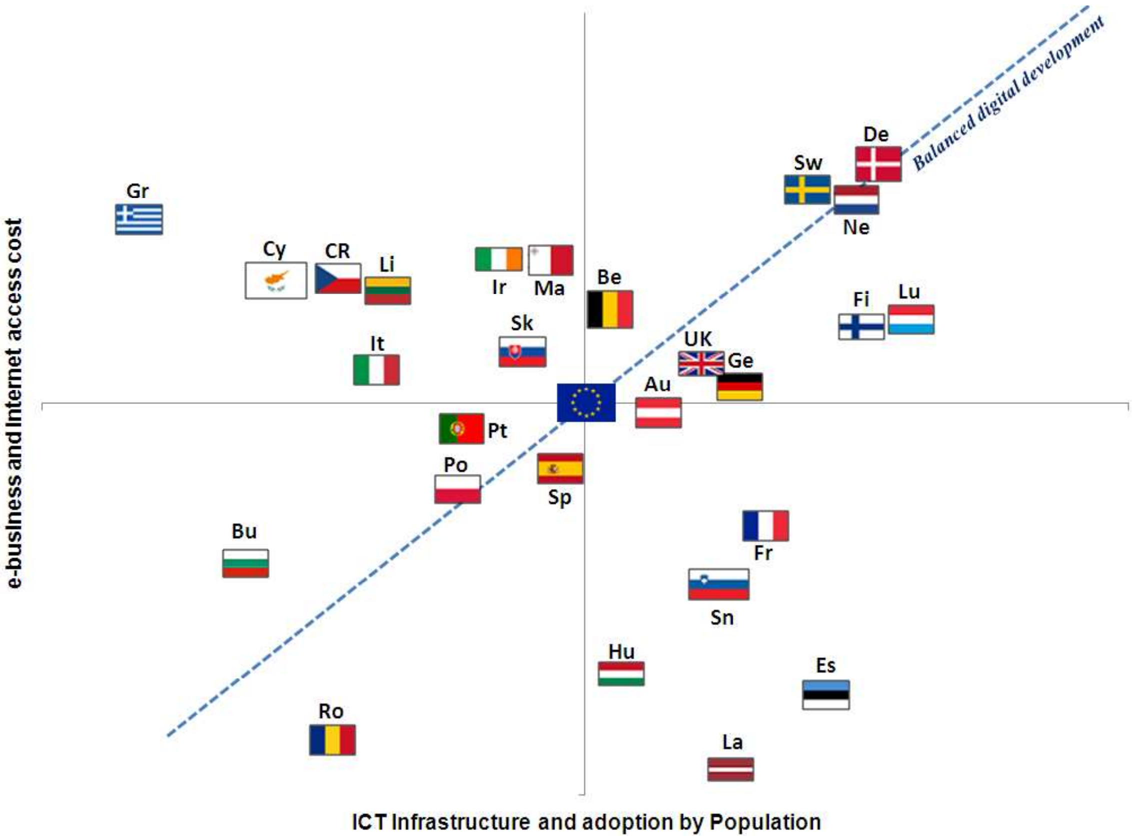
Note: variables are marked according to factor loading

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 usage of mobile devices to access the Internet, 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 by firms, and e-government, as well as the Internet access costs. We computed the factor scores for each country, and plotted it for a comparison analysis (see Figure 2.1).

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.* 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.

Fig. 3.1 - Countries' coordinates on extracted factors



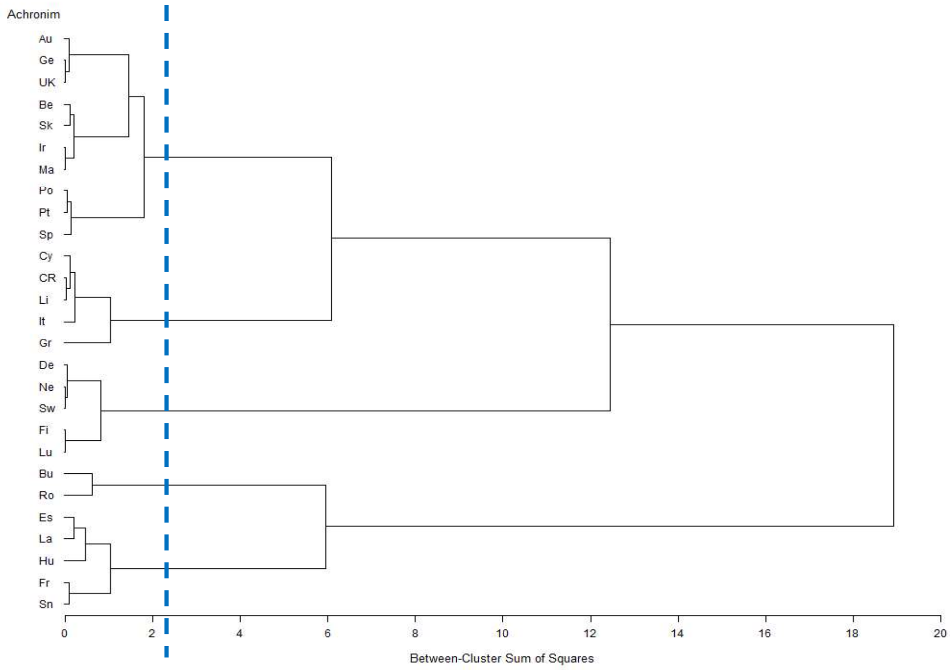
3.4.2 Cluster Analysis

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 16 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 16 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, Centroid, 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 initial seeds of the non-hierarchical algorithm – k-means. According to Sharma (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.

3.4.2.1 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 2.2). The horizontal axis measures the distance and the vertical axis represents the countries. From left to right, 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 with digital profiles that are most similar, followed by the Netherlands and Sweden, Germany and the United Kingdom, Finland and Luxembourg, and finally, the Czech Republic and Lithuania. 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 2.2 and Figure 2.7 in Appendix), the best solution.

Fig. 3.2 - Ward's dendogram for the digital divide across the EU-27 (factors).



From the analysis of the clusters' formation with the respective average level of each factor (see Table 3.5), we noticed that: Bulgaria and Romania form 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 the lowest. Hence these countries form the "*digital laggards*" cluster. Estonia, France, Hungary, Latvia, and Slovenia present 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. Therefore, we labelled these as the "*individual-side focused*" cluster. Cyprus, the Czech Republic, Greece, Italy, and Lithuania have 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. This group is labelled as the "*firm-side and low access costs focused*" cluster. Austria, Belgium, Germany, Ireland, Malta, Poland, Portugal, Slovakia, Spain, and the United Kingdom are comprised together, 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. Hence they are called the "*digital followers*" cluster, considering that there is other group more advanced in terms of digital development. Finally we have Denmark, Finland, Luxembourg, the Netherlands, and Sweden together. This group comprises the most digitally developed countries in the EU. These countries present the highest levels for both dimensions of digital development. Hence they are labelled as the "*digital leaders*".

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%.

Although the cluster analysis may be useful to quantify the digital asymmetries between European countries, it cannot provide explanations for why these disparities exist. Therefore, and considering the importance of understanding why there is a digital divide within the EU, based on the literature, we used some of the countries' characteristics to assess if they have explanatory power on these same differences. We found particularly interesting to consider the entrance year to the Union, the economic wealth of each country (expressed by the GDP per capita) (Billon et al., 2008; Brandtzæg et al., 2011; M. Chinn & Fairlie, 2007; Dewan et al., 2005; Kiiski & Pohjola, 2002) and also the educational attendance (expressed by the percentage of individuals with tertiary academic degrees) (Billon et al., 2008). When considering the entrance year to the Union, the newer members 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. We also used the Kruskal-Wallis test to verify whether the economic wealth of a country (GDP per capita in Euros) and the educational attendance (percentage of population with tertiary academic degrees) have statistically significant differences between the clusters of countries. The economic development of a country proven to be statistical significant different (p-value =0.0024), whereas the educational attendance showed no statistical differences (p-value =0.1865) between clusters.

Fig. 3.3 - Cluster analysis on factor scores.

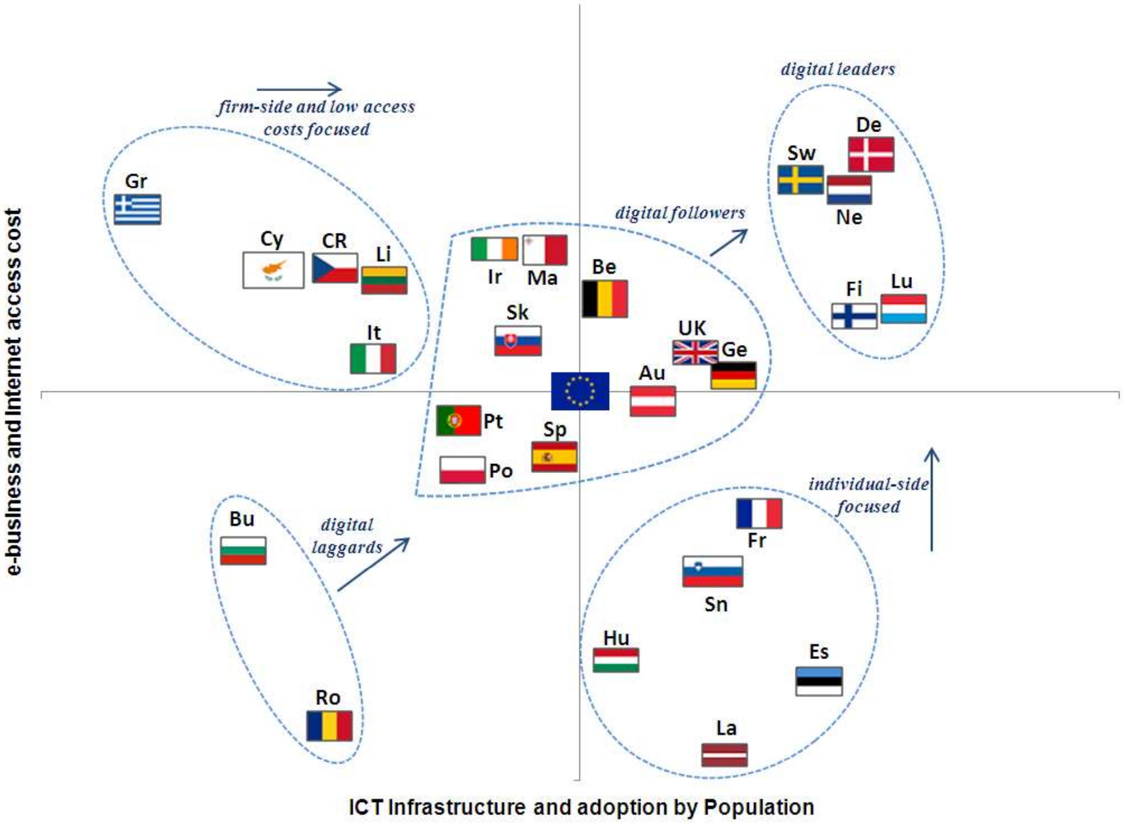


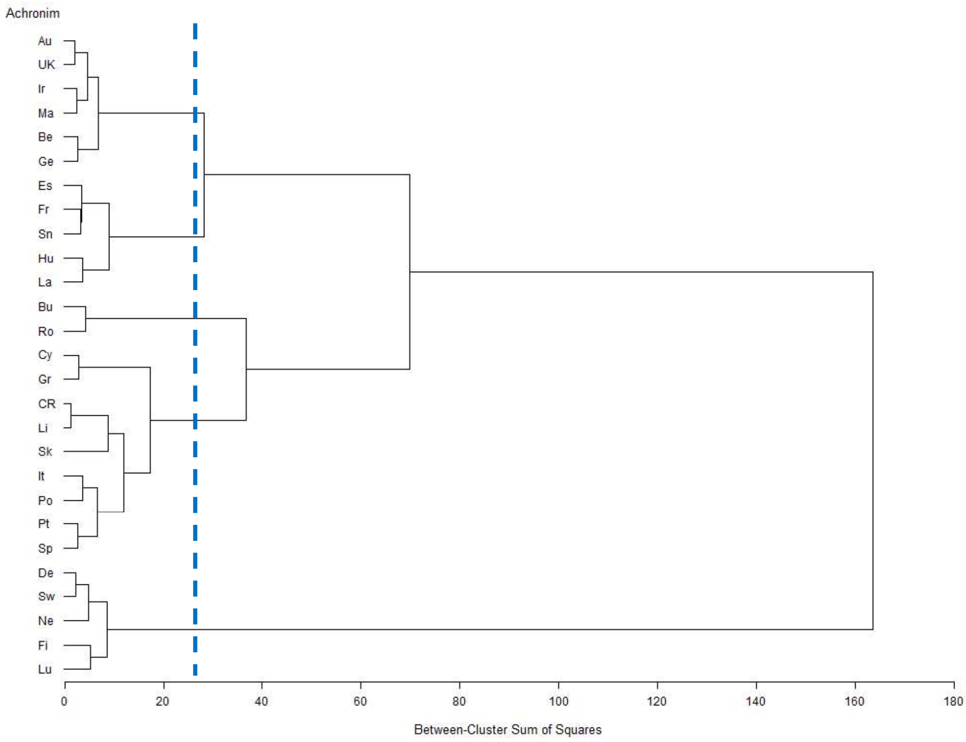
Table 3.5 - Descriptive statistics for the identified clusters (factors).

	digital laggards		individual-side		firm-side and costs		digital followers		digital leaders		Kruskal-Wallis
	Average	St Dev	Average	St Dev	Average	St Dev	Average	St Dev	Average	St Dev	p-value
Factor1	-1.37	0.3	0.67	0.4	-1.30	0.5	-0.04	0.5	1.26	0.1	0.0002
Factor2	-1.42	0.7	-1.41	0.6	0.68	0.3	0.17	0.5	0.95	0.5	0.0008

3.4.2.2 Cluster Analysis using Original 16 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 16 original variables was used, instead of the factor scores. Again the methodology was the same, hierarchical methods were used to define the number of clusters while non-hierarchical methods were used to obtain the final solution. Thus, the Czech Republic and Lithuania is the first pair of countries to form a group, followed by Austria and the United Kingdom, Denmark and Sweden, Ireland and Malta, and finally, Portugal and Spain. Once again, the hierarchical solution is given by the dendogram and R-Square (See Figures 2.4 and 2.8 in Appendix, respectively). The result is a five-cluster solution obtained by using the Ward's method. As in our previous cluster analysis (based on factor scores), the number of clusters and initial seeds were once again used as input for the k-means algorithm, which provides the final solution.

Fig. 3.4 - Ward's dendogram for the digital divide across the EU-27 (variables).



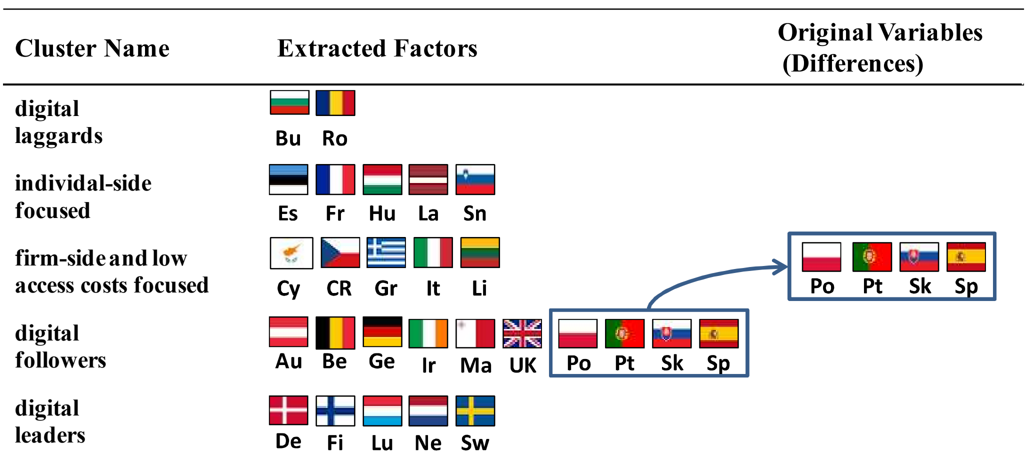
From the analysis of the averages of each cluster on the original 16 variables (see Table 3.6 in Appendix), some conclusions can be drawn. Bulgaria and Romania formed the group of countries with the lowest level in 15 of the 16 variables used, showing the high asymmetry between these countries and the rest of the EU. Estonia, France, Hungary, Latvia, and Slovenia are the group of countries which is in the mid-position in 8 of the 16 variables, i.e. half of the entire dataset. 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. Cyprus, the Czech Republic, Greece, Italy, Lithuania, Poland, Portugal, Slovakia, and Spain form the cluster with the second-poorest levels for 11 of the 16 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 and in the Internet access costs. 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, while the percentage of households without Internet because of the access costs is less than half of the previous two clusters. Austria, Belgium, Germany, Ireland, Malta, and the United Kingdom form the second-best ranked cluster in 9 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, Denmark, Finland, Luxembourg, the Netherlands, and Sweden are the high point of digital development in the EU-27. This group presents the highest levels in 15 of the 16 variables included. Moreover, if we had chosen to extract only two clusters from our dataset, these five countries would group together completely apart from the rest of the EU. This means that the average of European countries is more distant from the "*digital leaders*" countries than from the "*digital laggards*". This explains how digitally developed those countries really are.

The Kruskal-Wallis test shows that all variables except the eGovS present statistically significant differences at the 5 % 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 without, however, accomplish its final objective – the actual use. The relationship between the entrance year to the EU and the cluster membership continues to appear to be correlated. The newest members continue in a cluster apart, within the "*digital laggards*". The cluster comprising the "*digital leaders*" 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 the "*individual-side focused*" and "*firm-side and low access costs focused*" clusters, with Malta within the "*digital followers*". Despite some positive aspects of each cluster, they all continue to show imbalances in terms of digital development. When assessing the relationship between the digital divide with the economic wealth and education attendance, once again the economic wealth came up with statistically different values across the countries (p-value <0.001) while the education attendance presented marginal differences across the clusters (p-value =0.1102), reason why we rejected the null hypothesis that considers the education has an explanatory factor of the digital divide.

3.4.2.3 Differences between Cluster Analysis based on Factors and Original Variables

When comparing the results from the cluster analysis based on factor scores and those based on the original 16 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 2.5). From the 27 European countries, only four have changed their position. When considering the clusters based on factor analysis, the "*digital laggards*", "*individual-side focused*", and "*digital leaders*" clusters maintained exactly the same composition. Only the "*firm-side and low access costs focused*", and "*digital followers*" clusters showed slight differences – Poland, Portugal, Slovakia, and Spain moved from the first to the second. This movement is supported by an increased level of detail when using the 16 variables instead of the two latent dimensions. If in the cluster analysis based on factor scores, "firm-side and low access costs" cluster presented higher levels on *e-business and Internet access cost* than the "*digital followers*" cluster, using the original 16 variables for cluster analysis, this holds true only for some contributing variables of that dimension. Hence the first cluster present 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 16 variables was worth doing because it allowed us to assess the representativeness of the factor analysis in explaining the European digital divide. We can conclude, therefore, that the slight difference between the two cluster analyses reinforces the suitability of the two dimensions previously extracted.

Fig. 3.5 - Changes in cluster analysis (factors vs. variables).



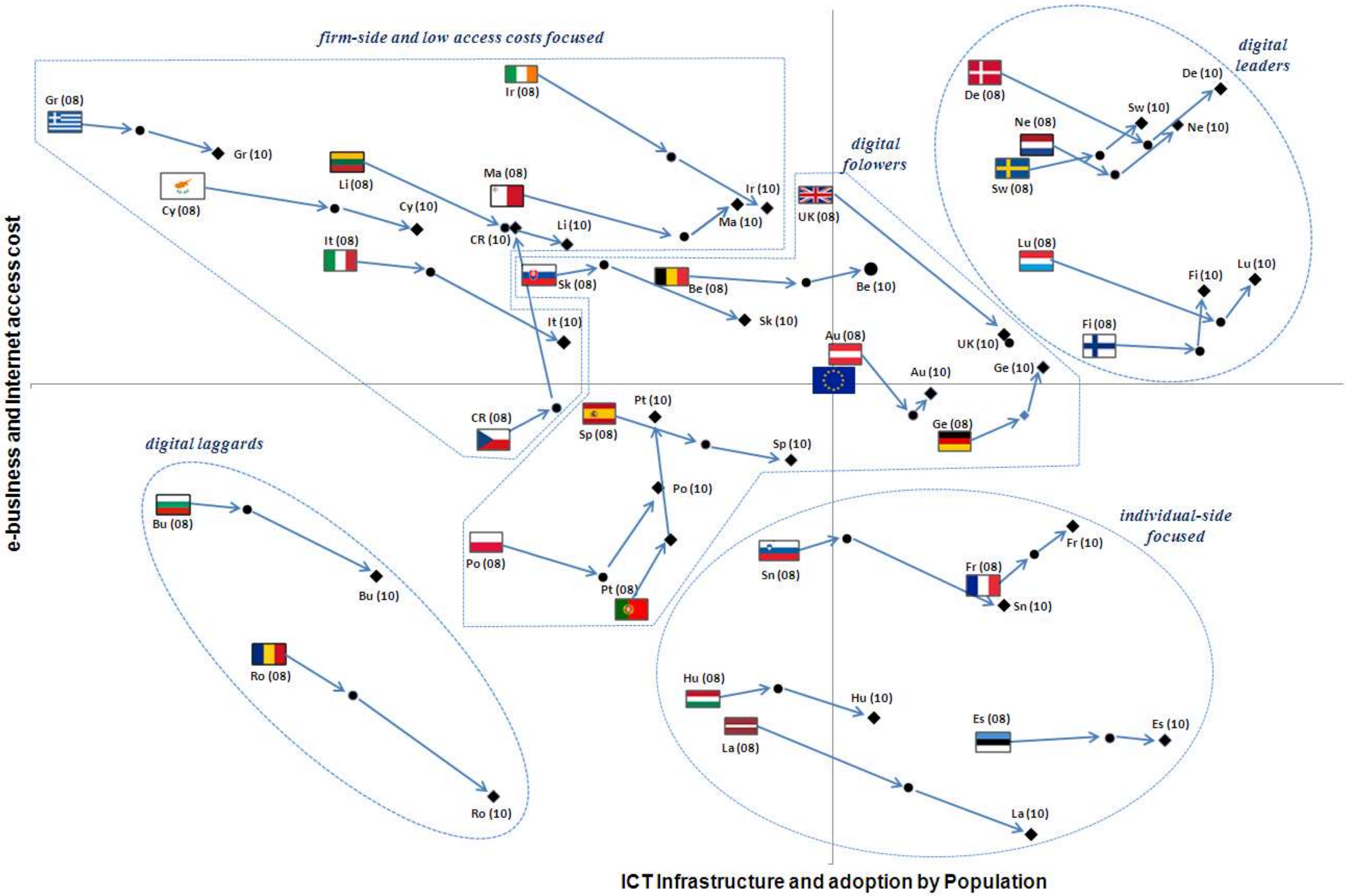
3.4.3 Short-term Digital Divide Evolution

After assessing the suitability of the two latent dimensions, confirmed by the slight differences between the two cluster analyses, the last step of our analysis of the European digital divide is to plot the path movements of each European country for the years between 2008 and 2010. For this purpose, the variables were previously normalized (as we used the correlation matrix in our factor analysis) with the averages and standard deviations of 2010. In this way, although losing scale, the values are still directly comparable across years. Following the normalization, we calculated the factor scores based on the standardized coefficients. Due to limitations of data availability, we were not able to extract the information on two of the 16 used. The percentage of individuals using mobile devices to access the Internet (Mob) started to be measured only in 2010, and information on the enterprises having a formally defined ICT security policy with a plan of regular review (eSafeE) is only included in a special issue of the Eurostat related to the use of ICTs by firms, which was produced for 2010. To overcome these missing values without compromising our analysis, we maintained the same values as those obtained for 2010.Hence, a short historical evolution of the European digital divide may be drawn without leading to bias in the conclusions, which would have been likely had we simply compared our results with those of earlier studies, since no other study used exactly the same combination of variables and methodologies, not to mention the 27 European Countries. The time period between 2008 and 2010 comprises the period immediately after to the last enlargement of the EU (2007). With this analysis we are hopeful that we will be able to determine whether the European digital divide has in fact been narrowing or widening, which is not consensual. The path movement of the countries is shown in Figure 2.6.

When analyzing the evolutions of each country individually, in the *ICT Infrastructure and adoption by Population*, some conclusions may be drawn from our results. Latvia was the country which has experienced the greatest improvement amongst all the EU members. This improvement was possible because Latvia was able to double the percentage of public services available online, which significantly boosted its usage by individuals. Moreover, the general use of ICTs and “advanced services” by individuals has grown considerably more than the average of the other European counterparts. Ireland and Denmark were the second and third countries, respectively, to present higher evolutions for this dimension. On the other hand, the Czech Republic and Portugal were the countries, respectively, that have grown the least. Although there was an improvement in the *ICT Infrastructure and adoption by Population,* this was practically negligible. Hence, all of the European countries grew in their levels of *ICT Infrastructure and adoption by Population* between the years of 2008 and 2010, which can be noted in the general shift from left to right that all countries experienced. With respect to the *e-business and Internet access costs,* the situation is different. The Czech Republic, Portugal, and Germany were the countries with the most significant improvements in dimension. Within the three years included in our analysis, both the Czech Republic and Portugal witnessed a very significant reduction in the percentage of households without Internet because of the access costs. Thus, the values in 2010 were about a third of those seen in 2008. Moreover, the Czech Republic was also able to significantly improve the percentage of firms selling online (eCom) and using e-government services within the time period under consideration. Countries that need to improve their levels of *e-business and Internet access costs,* i.e., above the horizontal axis, should definitely learn from the Czech Republic and Portugal the appropriate measures and policies to achieve this goal. Although in a more moderate way, Germany is also an example of a country which has successfully boosted its e-commerce levels while at the same time made the access to the Internet less expensive. Contrarily to what happens in the first dimension, several countries have, in fact, decreased their levels of *e-business and Internet access costs*. The United Kingdom, Ireland, and Romania were the countries which have had the most significant decreases. The percentages of firms selling online in the United Kingdom were, in 2008, more than twice what we see for 2010. Moreover, there was a decrease in the percentage of firms using e-government services, while the Internet access costs remained constant. Ireland had exactly the same problems, although in a more moderate way. Finally, Romania had an increase in the percentage of households without Internet because of the access costs, while the use of e-government services by firms also decreased. The percentage of firms selling online showed some growth, but this was insufficient to prevent a general decrease of the *e-business and Internet access costs* dimension.

Some countries significantly increased their values in the two dimensions simultaneously. Finland, France, Germany, the Netherlands, Poland, and Sweden achieved significantly positive evolutions, moving on a diagonal bottom-left to top-right path, and therefore show balanced digital development. Another interesting finding is that countries in the same cluster (for 2010) appear to behave in a very similar way. The "*digital leaders*" cluster was the only one that increased in the two dimensions simultaneously. Thus, the digital divide probably will continue to manifest itself in the near future.

Fig. 3.6 - Movement of the EU-27 countries in the two dimensions of the digital divide between the years of 2008 and 2010



3.5 Discussion

3.5.1 Discussion of Findings

The digital divide appears to have two independent and latent dimensions, which are the *ICT Infrastructure and adoption by Population* and the *e-business and Internet access costs.* The first dimension expresses the availability and use of ICT infrastructure by the population, which means for particular purposes. The "advanced services" are comprised on this dimension. The second dimension, on the other hand, expresses the commercial use of ICTs (e-business) and the Internet access costs. It is interesting to notice that these two dimensions are related to the sector to which they will be used, i.e., the individuals or the firms. If the behaviour of individuals and firms were directly correlated within each country, as one would expect, our two dimensions would probably be different. The price of Internet access (Cost) also emerges as a key determinant to the digital development, considering that this variable has a high negative influence (loading) on the diffusion of e-commerce, e-safety concerns and e-government indicators, meaning that higher costs are associated with lower levels on *e-business and Internet access costs*, as observed in earlier studies (Cuervo & Menéndez, 2006; Dewan et al., 2009; Unwin & de Bastion, 2009). In this way it becomes preponderant that public authorities ensure the low prices on Internet access in order to deter the digital divide within the EU-27 (Dewan et al., 2009).

Considering the factor scores of each European country, we have Denmark, the Netherlands and Sweden followed by Luxembourg and Finland as the countries with the highest levels for the two dimensions together, being the most advanced countries when it comes to the digital development. We therefore apply the label "*digital leaders*" to these countries. This situation is not surprising, considering that North European Countries are pioneers in promoting digital development (Castells & Himanen, 2002). The fact that some countries present high levels in one dimension and, at the same time, low levels on the other, reveals the imbalances in the digital development process itself. Greece, for instance, has the lowest level for *ICT Infrastructure and adoption by Population* and one of the highest levels for the *e-business and Internet access costs.* Estonia shows the inverse situation. These imbalances threaten the national and European *e-strategies*, because like economic development, digital development must be harmonized and horizontal to all sectors within each country. It is therefore imperative that countries strive to achieve a balanced and homogeneous digital development, i.e., focus both on *ICT infrastructure and adoption by population* and on the diffusion of e-business with low Internet access costs. The results from our factor analysis also tell us that it is not accurate to simply classify a country as digitally developed or not, since the majority of European countries present their own strengths and weaknesses, i.e., imbalances. This detail in our analysis is only possible to see because we collected a wide set of ICT related indicators for our multivariate analysis.

With the help of the cluster analysis we were able to identify five different digital profiles within the EU. With only a minor loss of information we are able to analyse the digital disparities not between 27 Countries but between five digital development stages, which greatly improves the ease of our analysis, as intended. Some interesting conclusions may also be drawn from the results of cluster analysis. Denmark, the Netherlands, Sweden, Luxembourg, and Finland are, from the two cluster analysis, identified as the "*digital leaders*" countries. Therefore, the difference between these countries *vis-à-vis* the remaining European ones is very important. The same fact is found with the less developed countries, Bulgaria and Romania, the "*digital laggards*". The edges of the spectrum are, therefore, well defined. To these two countries, efforts to achieve a digital development should be made toward the direction of the "*digital leaders*" cluster arrow (see Figure 2.3), focusing on both dimensions simultaneously. Earlier studies (Vicente & Gil-de-Bernabé, 2010) on this subject also pointed to these two countries as the least digitally developed ones in EU. Therefore, the digital divide has not narrowed, as hypothesised by other authors (Dewan et al., 2009), at least not to the less digitally developed European countries.

The cluster analysis was also useful in grouping countries with similar digital imbalances, whether these imbalances are related to the two dimensions or even to the overall 16 variables. When considering the cluster based on factor scores, countries within "*individual-side focused*" and "*firm-side and low access costs focused*" clusters must strive for homogenous digital development following their respective arrows (see Figure 2.3), in order to achieve the objectives expressed in the Digital Agenda for Europe, i.e., "*individual-side focused*" countries need to move toward "digital leaders" countries in a bottom to top vertical direction, emphasizing the development of *e-business and Internet access*, while "*firm-side and low access costs focused*" countries need to move in a left to right horizontal direction focusing on the *ICT Infrastructure and adoption by Population*. With this proposed movement we are not arguing that these countries should not try to improve the other dimension as well, but for a question of homogeneity between enterprises and individuals, if they had to choose one dimension only for improvement, they should focus on the one indicated as the more vulnerable at the time. Hence, unlike Bulgaria and Romania, these countries do not need to focus on the two digital dimensions simultaneously, which is an advantage. It is a priority that the national leaders of these imbalanced, or developing, countries can learn from their northern European counterparts so that the accurate measures can be taken in order to bridge this gap.

As we sought to arrive at some possible explanations for this European digital divide, the entrance year to the Union appears to have a word to say. Digitally speaking, the integration process within the EU is not yet completed, especially for the countries that entered in 2004 or thereafter. School attendance has a marginal effect on the digital divide, which contrasts with the views of some authors who hypothesised that this would be a significant factor (Billon et al., 2008; Billon, Ezcurra, et al., 2009; Goldfarb, 2006; Quibria, Ahmed, Tschang, & Reyes-Macasaquit, 2003)**.** This factor may be related to the recent entrance of eastern European countries that already have highly developed education systems with not so significant digital developments. Thus, we suspect that the use of ICT in these countries will accelerate soon, when the impact of the European structural funds, addressed to the information society programmes, strengthens. When that happens, these countries may show new infrastructures and highly educated individuals, who will be more likely to use them. As suggested in the literature, digital imbalances are directly related to economic wealth, since the GDP per Capita has been proven to be very significant, at a confidence level higher than 99.9%. The EU can be considered especially vulnerable to these two factors, considering that unlike the US, it is presently a mix of 27 different countries, with many profound differences amongst them.

Finally, the last step in our analysis of the European digital divide was to determine the paths of the European countries with regard to the two dimensions found, from 2008 to 2010. This movement is in respect to the two dimensions because the comparison between the two cluster analyses gave us the assurance that the two dimensions extracted are reliable in comparison to the whole dataset. The movement of the EU countries revealed a surprising fact: The clusters found for the year of 2010 appear to exist, at least since 2008, with exception to the frontier countries between "*firm-side and low access costs focused*" and "*digital followers*" clusters, emphasizing the reliability of our results. More importantly, the "*digital leaders*" countries even in 2008 showed significantly higher levels for the two dimensions than the rest of the EU in 2010. Hence, the "*digital leaders*" have, at the minimum, three years of advance in terms of digital development when compared to the EU average (note that the EU flag in Figure 2.6 represent the average of the two factors for 2010). The digital divide is, in fact, rooted within the EU. The only cluster that has overall improved the levels of *e-business and Internet access costs* was the one containing the "*digital leaders*". Coincidently, these countries are also the ones with higher levels of *ICT Infrastructure and adoption by Population*. One may ask, as a result, whether this fact means that it is only from a certain point of ICT infrastructures availability and individual adoption that e-business is effectively triggered? Finally, one last controversial (Dan M. Grigorovici, Jorge R. Schement, & Taylor, 2004) question, and perhaps the most important, must be asked: Is the European digital divide narrowing or widening? We argue that both processes are, in fact, taking place. That is, in one dimension – *ICT Infrastructure and adoption by Population* – there is evidence that this divide may be narrowing. Although all clusters in our analysis showed growth in this dimension, the "*digital laggards*", and those with digital imbalances were the ones that increased the most. Therefore, this gap is narrowing. On the other hand, the already "*digital leaders*" were the ones presenting positive developments in the second dimension – *e-business and Internet access costs*. Thus, the digital asymmetries between countries in this particular aspect of the divide are widening. Perhaps the financial and economic crisis of 2008, which originated in the US, has influenced the increasing percentage of households without Internet because of the access costs, and the reduction of e-commerce levels in some of these countries, which justifies in some way the fact that several countries showed decreasing levels of the *e-business and Internet access costs*.

Nevertheless, as pointed by Dimaggio (DiMaggio, Hargittai, Celeste, & Shafer, 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).

3.5.2 Limitations of the Study

In spite of our effort to offer a complete and multidimensional analysis, some limitations must be recognized. First, our empirical application consists of just 16 variables, and, some features of the information society may not be covered. Second, we analysed the digital divide within the EU, which means that all indicators used were concerned with aggregate national realities, meaning that internal, domestic digital divide gaps may not be covered. The third limitation is related to the lack of available data for the years of 2008 and 2009 for two of the 16 variables considered. As we did not wish to make any assumptions about its evolution, we had to use the levels of 2010. Finally, in fourth place, our analysis refers to the digital divide at a specific point in time, the years between 2008 and 2010. Changes in this context are likely to occur rapidly, and our findings may soon become outdated.

3.6 Conclusions

Based on multivariate statistical methods, we analyse the digital divide within the EU 27. We find that, in fact, a digital divide still exists within the EU, despite all the investments and policies to narrow it in recent years. Thus, the countries identified as the least digitally developed in earlier studies remain basically the same, whereas the same fact is obtained for the most digitally developed countries. The digital development has two independent dimensions, and we detect five digital profiles amongst the 27 Member States. The digital disparities are correlated by economic asymmetries between the countries, while the entrance year also appears to influence the divides. On the other hand, the school attendance of the population does not appear to have a significant importance on the digital divide, which goes against what some studies have reported in the past. Finally, we also concluded, based on the path movement of each country between 2008 and 2010 that in one dimension there is evidence that the European digital divide is narrowing, while in the other it appears to be widening.

3.7 Appendix

Fig. 3.7 - R-square plot for cluster analysis based on factor scores

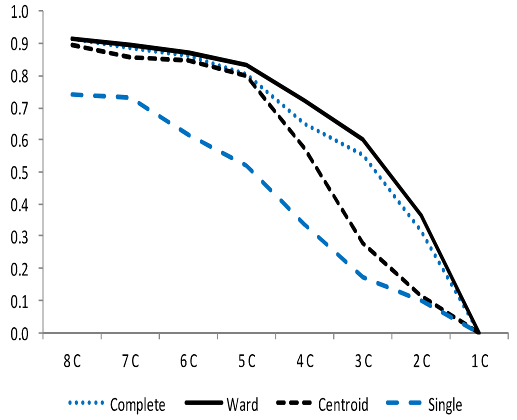


Fig. 3.8 - R-square plot for cluster analysis based on original 16 variables

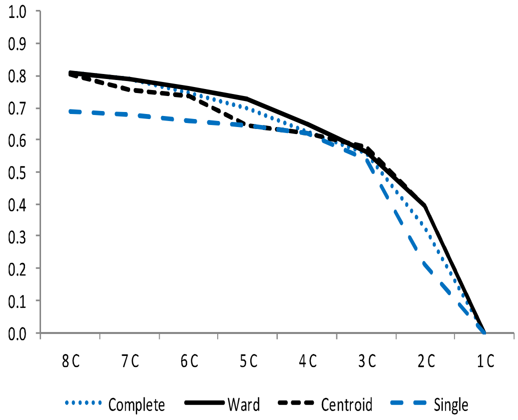


Table 3.6 - Descriptive statistics for the identified clusters (variables).

	digital laggards		individual-side		firm-side and costs		digital followers		digital leaders		Kruskal-Wallis
	Average	St Dev	Average	St Dev	Average	St Dev	Average	St Dev	Average	St Dev	p-value
HsInt	37.50	6.4	66.00	6.0	58.22	6.1	75.00	4.8	87.20	4.0	< 0.0001
BroRt	13.80	0.1	23.84	5.0	19.46	2.8	27.80	3.7	34.18	4.1	0.0003
IntPop	38.00	5.7	66.80	6.0	54.22	9.2	70.33	7.6	86.20	2.0	< 0.0001
Mob	6.50	2.1	24.20	8.2	17.67	8.5	31.50	7.9	40.80	11.2	0.0002
IntSrc	26.00	0.0	59.00	4.0	46.44	9.0	60.67	6.8	78.80	3.3	< 0.0001
Cost	15.50	9.2	15.60	4.5	7.00	2.1	3.83	1.7	1.80	2.2	0.0123
eBank	2.50	0.7	42.60	18.5	22.78	9.2	41.50	6.1	71.00	8.7	< 0.0001
eLearn	16.50	4.9	41.60	8.8	31.00	7.5	40.17	3.4	58.80	14.5	0.0008
email	33.00	2.8	61.20	6.7	49.11	11.1	66.00	8.3	82.80	3.6	< 0.0001
eHealth	16.00	4.2	37.40	4.5	26.89	5.6	35.83	7.0	51.40	7.2	0.0002
eGovI	11.00	5.7	36.80	7.9	22.44	7.1	33.83	5.6	61.20	6.5	< 0.0001
eGovE	57.00	9.9	77.80	6.9	82.00	9.2	75.00	7.5	92.60	2.8	0.0054
eGovS	65.00	7.1	86.57	12.3	76.02	19.3	95.29	8.4	91.37	10.9	0.0560
eCom	5.00	1.4	9.20	2.3	12.00	6.6	19.00	4.7	20.20	4.9	0.0304
Serv	56.54	23.7	276.15	111.0	285.37	293.4	997.63	342.3	1613.42	446.8	0.0007
eSafeE	8.00	1.4	14.60	5.0	28.00	9.1	27.83	2.1	36.60	8.1	0.0369

Chapter IV

4. The global digital divide: Evidence and drivers

Abstract. This paper presents an analysis of the global digital divide, based on data collected from 45 countries, including the ones belonging to the European Union, the OECD, with Brazil, Russia, India and China (BRIC). The analysis shows that one factor can explain a large part of the variation in the seven ICT variables used to measure the digital development of countries. This measure is then used with additional variables, which are hypothesised as drivers of the divide for a regression analysis, which shows economic and educational imbalances between countries, along with its geography, as drivers of the digital divide, whereas others variables such as individuals living in rural versus urban areas and official language are not.

Keywords: Digital Development, Digital Divide, ICT, Information Society, European Union, OECD, BRIC.

4.1 Introduction

Information and communication technologies (ICT) play an important role in the global economy (S. Y. T. Lee et al., 2005; World Bank, 2006, 2009). The belief that greater adoption and use of ICT may foster economic growth and development, trumping the present economic difficulties, has been supported by some of the most important nations and world organisations, such as the United Nations (UN) (e.g., Unesco, 2003, 2009), the United States of America (USA) (e.g., National Information Infrastructure Advisory Council, 1996; US Department of Commerce, 2000), the Organisation for Economic Co-operation and Development (OECD) (e.g., OECD, 2011), and the European Union (EU) (e.g., European Commission, 2010a, 2010b). All of these have developed some type of strategy for promoting digital development and intensified the use of ICT to engender economic growth and development. Besides its economic importance, it is widely accepted that these technologies also positively influence the individual´s quality of life and welfare (Dewan & Riggins, 2005; E. Kim et al., 2009). At the World Summit on the Information Society (WSIS), sponsored by the UN and International Telecommunications Union (ITU), 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).

Despite the recognised importance that ICT may have on economics and welfare, helping countries to achieve sustainable growth, the fact is that research about these issues is still, in some ways, limited. Within the academia, two main types of studies regarding the global digital divide can be distinguished: on the one hand, some studies focus on the measurement of the divide while, on the other hand, others focus in explaining what drives it (Billon, Marco, et al., 2009). Although our work covers both types simultaneously, we are particularly interested in the second type of research, i.e., to understand the divide´s drivers. We believe that measuring the global digital divide is indeed a subject worth to investigate. However, in order to effectively design and deploy efficient measures to narrow it, some light must be shed on the divide´s causes. Moreover, considering that most of the studies emphasising this particular aspect of the global digital divide are mostly related only with the use of Internet per se (Billon, Marco, et al., 2009), we also intend to provide a more comprehensive view of ICT adoption and use across countries using, to accomplish this aim, other measures of the digital development of countries other than merely the Internet usage. Additionally, another gap in the literature that we believe exists on this subject is the fact that studies regarding the digital divide across countries tend to be limited to specific groups of countries/geographic areas. This fact can be explained by the difficulty of finding relevant data. Studies with a significant number of countries are difficult to conduct because metrics/variables of ICT adoption are frequently not comparable. In this paper we intend to help fill these gaps, measuring and understanding the digital asymmetries across countries, taking a snapshot in terms of digital development of the 41 countries that belong to the EU or the OECD, along with Brazil, Russia, India and China (BRIC). We expect to help policy makers deploy efficient measures, by providing a complete-as-possible and up-to-date analysis of digital asymmetries between developed and rapidly developing countries. In particular, we intend to answer the following research questions:

1. What is the digital development levels of the 45 countries studied?
2. What drives asymmetries in the digital development of countries, i.e., the global digital divide?

In answering these questions, this paper is organised as follows: Section 2 includes a literature review of the digital divide; Section 3 presents a conceptual model for understanding the digital development of countries and, hence, the global digital divide; Section 4 includes the rationale behind the data used; Section 5 has the results of the analysis; Section 6 presents the discussion and the limitations of findings, while Section 7 presents the conclusions.

4.2 The spread of ICT and the emergence of a digital divide

In the last decades we have witnessed an intense proliferation in development and use of ICT (Frederico Cruz-Jesus et al., 2012). These technologies are here to stay, playing a decisive role in improving practically every aspect of our societies (Unesco, 2003; World Bank, 2009), such as the way individuals and firms interact and communicate, do business, pursue economic growth, improve welfare, and even the way politics are conducted (OECD, 2004; H. Zhao et al., 2007). Internet browsing, email, blogs, multimedia online streaming, social networking, on-line job seeking, wiki-sites, access to online libraries, e-commerce, and services like e-government, e-health, e-learning, and e-banking are examples of new possibilities that are shaping a new type of (improved) communications and interactions, between individuals and firms (Çilan et al., 2009; European Commission, 2006; Facer, 2007; Forman, 2005; Hajli, 2014; Mutula & Brakel, 2006; Niehaves & Plattfaut, 2013; Vicente & Gil-de-Bernabé, 2010; Vicente & Lopez, 2010b). The impact of ICT in the economic field is such that these technologies are classified as general-purpose technologies (GPT) – defined as technological innovations that have the potential to improve most industries and society sectors (Bresnahan & Trajtenberg, 1995; Doong & Ho, 2012), and have in the past also revolutionised the economy such as, the 19th century´s transportation and communications technologies, the Corliss steam engine, the internal combustion engine, or the electric motor (Carlsson, 2004; Frederico Cruz-Jesus et al., 2012; Cuervo & Menéndez, 2006). Moreover ICT appears to have an even greater impact on economic development than those GPT 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 gross domestic product” (Carlsson, 2004). Jalava and Pohjola (2008) have empirically demonstrated that the ICT contribution to Finland’s GDP between 1990 and 2004 was three times greater than the contribution of electricity from 1920 to 1938. ICT helps to create new industries that generate new employment opportunities (Castells, 2007b; Castells & Himanen, 2002). Shirazi et al. (2009) addressed the relationship between ICT and economic freedom, finding that ICT expansion in middle east countries has in fact been effective in supporting it. Even in politics, the Internet and other ICT related technologies are playing an increasingly relevant role, as in the awareness of individuals toward the differences in the ideologies within a political dispute (E. Kim et al., 2009; Wattal et al., 2010). The notion of literacy has also changed due to ICT, considering that the inability to use these technologies is creating an entirely new group of disadvantaged persons who were considered “literate” in the past (Unwin & de Bastion, 2009).

The advent of information technologies (IT) – initialised with the spread of personal computers (PC) and Internet – created, during the 1980s, the (utopian) idea of a whole new world of endless opportunities liberated from problematic sociocultural aspects, such as gender, age, race, and geography (Gunkel, 2003). However, it rapidly became clear that access (and later on, use) of ICT was limited by specific constraints and should not be assumed by researchers and policy makers to be either universal or instantaneous. It was within this context that the term “digital divide” appeared. Although the literature and forums on the subject regularly attribute the term to Larry Irving Junior, former Assistant Secretary for Communications and Information of the US Department of Commerce, the fact is that it was not authored by him as, he himself admitted years later (Gunkel, 2003). The “digital divide” term became popular in the third “Falling Through the Net” report, from the US Department of Commerce’s National Telecommunications and Information Administration (NTIA) (US Department of Commerce, 1999), which defined it as “the divide between those with access to new technologies and those without”. Within the series of these reports (US Department of Commerce, 1995, 1998, 1999, 2000, 2002) the definition of digital divide evolved from PC ownership, to the inclusion of Internet access, and later on, to the availability of broadband connections. Today however, **the digital divide should be thought of in terms of a mother that is 50 years old and cannot get a job because she does not know how to use a computer nor knows how to use the Internet**; **a student that cannot make his thesis properly because he does not have access to on-line libraries**; **a firm that has closed because it was unable to reach to its customers through a website**; or **a government that is not able to communicate on-line with its citizens because most of them does not have access to ICT**; amongst so many other examples of what inability to access and use ICT may cause.

These factors are drawing strong distinctions and inequalities between those who have access to privileged information and those who have not (Brooks et al., 2005), a reason why the original understanding of this phenomenon evolved from the binary understanding between "*has*" versus "*has not*" to focus on the reasons why disparities in access and use of ICT really existed. As a consequence, it was discovered that geographic areas (urban vs. rural) were an important factor in defining the divide between information haves and have-nots (US Department of Commerce, 1995). Individuals belonging to ethnic minorities, or with lower incomes, were also more vulnerable to asymmetries in the access to digital technologies (US Department of Commerce, 1998). In other words, the understanding of the digital divide phenomenon underwent considerable evolution as the subject started to be understood as a multidimensional issue. Thus, it is widely recognised today that the initial binary definition was narrow, since other factors need to be considered (Brandtzæg et al., 2011). One of the most widely accepted definitions of digital divide is provided by the OECD (2001), in which it refers to it as:

> *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.*

The digital divide is a phenomenon that can occur at different dimensions/levels. In terms of adoption units, digital asymmetries may happen between individuals, households, organisations, and countries (Dewan & Riggins, 2005). At an individual level digital inequalities are more likely to exist between individuals economically and sociologically disadvantaged, i.e., individuals with lower incomes or education levels, those with disabilities, living in rural areas, belonging to ethnic minorities, women, and the elderly (Azari & Pick, 2005; Crenshaw & Robison, 2006; Ferro et al., 2011; Hilbert, 2011; Lengsfeld, 2011; Payton, 2003; Vicente & Lopez, 2006; Vicente & Lopez, 2008, 2010b, 2010c). In addition to these sociodemographic characteristics of individuals, Venkatesh and Sykes (2013), found that social network aspects are also significant in explaining ICT use, and even value. In terms of organisations as adoption units, it is usually accepted that larger firms, as they usually possess more resources, tend to be more prone to adopt technological innovations, although some authors do not agree with this notion because larger firms are also more likely to suffer from inertia (Dewan &

Riggins, 2005; Oliveira & Martins, 2010; Rogers, 2005). Finally, at a country (global) level – individuals and organisations in aggregate – inequalities in terms of ICT access and use may occur between and within countries, which are named, respectively, international and domestic digital divides. In respect to the international digital divide, research usually indicates the economic wealth and educational attendance are key-factors in explaining the digital development level of a country (Frederico Cruz-Jesus et al., 2012; James, 2011; Shirazi, Gholami, & Higón, 2010).

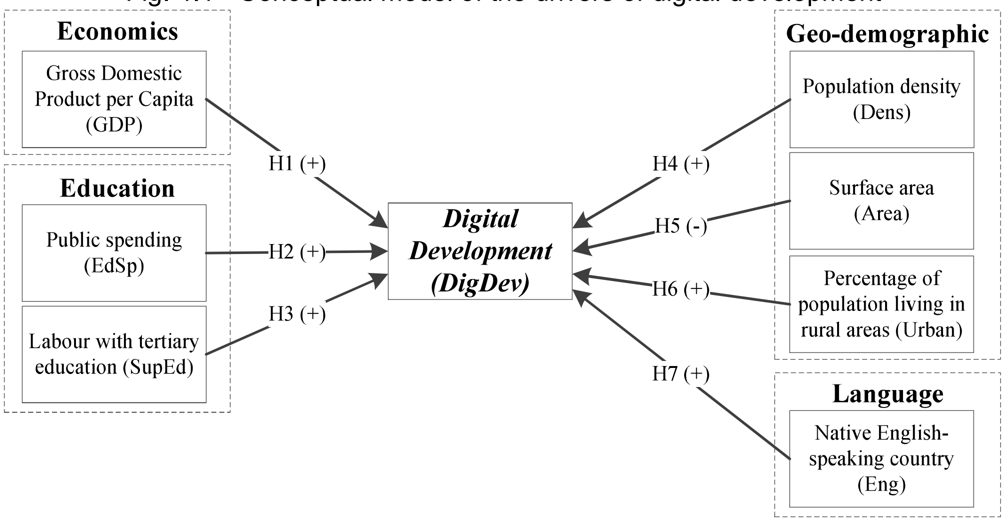
Besides the type of adoption unit, the digital divide may also be related to access or use of ICT, which may appear to be the same but in truth are not. Hsieh et al. (2008, 2011) showed noticeable differences in ICT access and use patterns between those who are economically advantaged and disadvantaged. Besides the intrinsic motivations for access ICT, these persons also have very different post-implementation behaviour regarding the use of these technologies. They concluded that economically advantaged people have a "higher tendency to respond to network exposure", using ICT with much more confidence than the disadvantaged. These two types of inequalities about access to and use of ICT are known as first- and second-order digital divides (Dewan & Riggins, 2005). In the first-order digital divide the inequalities are with regard to access ICT, while in the second-order the problem is postulated in terms of different use patterns and intensity amongst individuals/organisations that already have (very similar) access to ICT (e.g., using the Internet just for web-browsing or email vs. using it for e-learning, social-network, applying to jobs online, e-banking, e-health, etc.). As it is noted by Epstein et al. (2011), different types of inequalities (first- or second-orders) require different actions from different entities. Hence, inequalities in ICT access may be bridged through the subsidization of these technologies, which governments and organizations may well provide; whereas for inequalities in ICT usage patterns, possible solutions are in the hands of educational institutions and individuals themselves.

4.3 Conceptual model for understanding the digital development of countries

The first research question of our paper can be answered by measuring the digital development of countries. However, as we intend to go beyond the merely measure of the global digital divide (differences in digital development levels across countries), to shed some light on what drives it, we need to turn to the specific literature about why there are inequalities in terms of ICT adoption. Within the specialised literature of the subject, one can find several aspects that, allegedly, contribute to the digital divide across countries, such as economic, educational, demographical, geographical, etc. However, those same studies are usually limited in terms of width (number of countries) or in terms of depth (number of indicators).

In order to effectively understand the digital asymmetries across nations we need to develop a conceptual model for the digital development of countries, so that we can empirically test it. This conceptual model is grounded on the diffusion of innovations (DOI) theory (Rogers, 2005), one of the most prominent studies for understanding how and why innovations diffuse (Oliveira & Martins, 2011; Zhu, Dong, Xu, & Kraemer, 2006). Our model considers three contexts of a country which we believe influence its digital development level. These are the economic; educational; and geo-demographic. Additionally, countries in which English is the native language were also marked with a binary variable, as there is evidence that this factor can work as a driver of digital adoption. The integration of all four contexts is shown in Figure 4.1.

Fig. 4.1 - Conceptual model of the drivers of digital development



The link between economic development, particularly gross domestic product per capita (GDP), and access to ICT is well supported in the literature (Kauffman & Techatassanasoontorn, 2005). Considering that newer technologies tend to be more expensive, presenting naturally, higher risks for the ones which decide to adopt them, the DOI theory (Rogers, 2005) claims that wealthier individuals and firms - and thus wealthier countries in the aggregate - are more likely to adopt technological innovations (as is the case of ICT). Moreover, the digital revolution took place within the western developed world, i.e., almost all new products and technologies, particularly the case of ICT, originate in developed countries (James, 2011). These effects combined led the developed countries to rapidly adopt and increase their use of ICT for a wide variety of activities (e.g., individuals started using PC for personal purposes and firms for business). The developing countries, on the other hand, did not possess the same resources to effectively acquire ICT, and did not benefit from its use at the same scale as did the richer countries. During the early years of ICT the growing adoption rate was unquestionably several times higher in richer countries (Xiaoqun Zhang, 2013). The question whether this fact is still occurring today is not clear. Nevertheless, even today, countries with stronger economies are more likely to have the possibilities to use ICT. Moreover, as these countries tend to have more developed economies, in terms of information-, financial-, and innovation-based industries, the likelihood to present higher levels of ICT adoption is also greater. In order to measure the economic development level of a country, GDP is, perhaps, the most popular and accurate single indicator of economic development, measuring the overall output of the economy (Dewan et al., 2005). Thus we expect,

H1: The GDP is positively associated with digital development;

Education, along with economics, are frequently identified as predictors of digital development of countries (Frederico Cruz-Jesus et al., 2012; Kiiski & Pohjola, 2002; Shirazi, Ngwenyama, et al., 2010). As we wish to understand digital inequalities across countries, the focus on international socio-economic asymmetries is indispensable, especially considering that income and education exert the greatest influence in explaining ICT adoption versus non-adoption (Hsieh et al., 2008). The diffusion of innovations´ theory (as the case of ICT) claims that technological complexity is a major obstacle to adopting those technologies (Rogers, 2005). Thus, the ease of use of a technology is important to its adoption rate (Katz & Aspden, 1997). This fact makes educational aspects of individuals play an important role, considering that when facing a technical challenge, more educated individuals, are more prone to flexibly and effectively overcome ICT complexity´s constraints (H. Zhao et al., 2007). Thus, when interacting with an ICT, the relatively higher educational attainment should make it easier to cope with the complexity of the technology, thus minimizing the impact of the difficulties (Hsieh et al., 2008). In this sense, education facilitates the absorption and comprehension of information. It is also reasonable to hypothesise that more educated individuals are more likely to work in information-intensive industries, thus using ICT more often at work. As Peng et al. (2011) demonstrated, individuals who use PC at work or school are more likely to adopt ICT. A consistent finding has been demonstrated by Tengtrakul and Peha (2013), where these authors conclude that “the higher the educational level of students, the stronger the increase in likelihood of a household adopting ICT”. Applying this to the international context as measures of countries´ education, the spending in the education system, as a percentage of GDP (EdSp), reflects the importance of the government toward the education of its individuals; while the percentage of work force with tertiary (superior) education (SupEd) is an effective measure of how educated a country is. Thus,

H2: The EdSp is positively associated with digital development;

H3: The SupEd is positively associated with digital development;

Considering that population, and its characteristics in terms of demographic and geographic distributions, have an effect in information and knowledge about ICT, which is often transmitted through personal communications (Billon, Marco, et al., 2009), these contexts of countries may also have some influence on the digital development. The impact of these effects is, however, ambiguous (Dewan et al., 2005). We argue that denser and smaller areas are easier to connect than those that are more dispersed or larger. In denser areas it is more likely that innovations spread faster (Rogers, 2005), as innovations are more observable by other potential adopters. Thus, the population density (Dens) serve as a proxy variable for measuring the degree to which ICT are observable. This belief is consistent with Agarwal et al. (2009), that found a positive, although marginally statistically significant, moderated relationship between households´ density with the probability of adopting Internet in USA. In respect to countries´ surface area (Area), there are contradictory beliefs on its influence in ICT adoption. From one side, some authors argue that larger areas are more likely to adopt ICT because of the advantage of these technologies in replacing other ways of communication, which are usually more expensive as the distance increases (Forman, 2005). On the other hand, other authors posit that as larger areas tend to be more heterogeneous, as they are harder to connect (Frederico Cruz-Jesus et al., 2012; Emrouznejad et al., 2010). Additionally, we argue that countries with greater surfaces tend to need larger amounts of resources to be connect in terms of infrastructure coverage of all its territories (e.g., the price of optic fibre is significant for higher extensions). Finally there is evidence that the greater the proportion of persons living in urban areas (Urban), the greater the demand for information-intensive products and services (Billon, Marco, et al., 2009; M. Chinn & Fairlie, 2007; Dewan et al., 2005). For these reasons we expect that,

H4: The Dens is positively associated with digital development;

H5: The Area is negatively associated with digital development;

H6: The Urban is positively associated with digital development;

As the spread of ICT, especially through the Internet, began in the USA, most websites are in English. This trend continues to be valid, i.e., English is still the most commonly used language on the World Wide Web. This fact can be explained by the fact that even for native-speakers of languages other than English, this idiom is still the major international language, thus linking people of different areas and cultures. Hence, even those for whom English is not the native language end up contributing to its spread as long as their Web content is directed to foreign targets. This trend is also true in operating systems and other IT (Hargittai, 1999). For these reasons, some authors point to evidence that English-speaking ability is positively associated with ICT access and use (Ono & Zavodny, 2008). We argue that native English speaking countries (Eng) are more prone to be digitally developed, considering that their individuals will be more likely to speak English and thereby have easier understanding and proficiency in using the PC and the Internet. For these reasons we expect,

H7: The Eng is positively associated with digital development.

4.4 Data collection

4.4.1 Explanatory variables of the digital development

In order to empirical test our conceptual model for the digital development of countries; Table 4.1 presents the hypothesised as explanatory variables included in it to be tested. It should be kept in mind that this set of variables is limited by data availability. Thus, it is possible that some other potentially important digital divide´s explanatory factors are not included. The data was gathered from the World Bank database. The year of the analysis is 2011.

Table 4.1 - Digital divide´s explanatory factors included with their respective support

Code	Variable	Support
GDP	Gross Domestic Product per Capita (USD thousands)	(Billon et al., 2008; Billon, Ezcurra, et al., 2009; Frederico Cruz-Jesus et al., 2012; Cuervo & Menéndez, 2006; Dewan et al., 2005; Hargittai, 1999; Ono & Zavodny, 2007; Vicente & Lopez, 2010a)
EdSp	Public spending on education (% of GDP)	(Frederico Cruz-Jesus et al., 2012; Cuervo & Menéndez, 2006; Vicente & Lopez, 2006; Vicente & Lopez, 2008, 2010a)
SupEd	Percentage of labour with tertiary education	(Frederico Cruz-Jesus et al., 2012; Cuervo & Menéndez, 2006; Ono & Zavodny, 2007; Vicente & Lopez, 2006; Vicente & Lopez, 2008, 2010a)
Dens	Population density (thousands / square-miles)	(Agarwal et al., 2009; Billon et al., 2008; Billon, Ezcurra, et al., 2009; Billon, Marco, et al., 2009; Frederico Cruz-Jesus et al., 2012; Vicente & Lopez, 2010a)
Area	Surface area (million square-miles)	(Frederico Cruz-Jesus et al., 2012; Emrouznejad et al., 2010; Forman, 2005)
Urban	Percentage of population living in urban areas	(Billon, Marco, et al., 2009; M. Chinn & Fairlie, 2007; Dewan et al., 2005)
Eng	Native English speaking country (Y=1/N=0)	(Billon, Marco, et al., 2009; Hargittai, 1999; Ono & Zavodny, 2008; Vicente & Lopez, 2010a)

4.4.2 Data used to measure the digital development of countries

As we want to analyse the digital divide between different countries (global/international instead of intranational digital divide), we followed the recommendations of the OECD (2009) which defends that indicators for these studies should have to do with the aggregated national reality of each country in terms of ICT availability and use. Hence, our data consist of seven variables, which were chosen by combining their availability with the support from other relevant studies in the past. The rationale behind the inclusion of each variable is as follows: One major aspect of the digital development of a country is its ICT infrastructure (Frederico Cruz-Jesus et al., 2012). Thus, the percentage of households with computer (HsPC) and connected to the Internet (HsInt) is often used in the literature to measure the digital development/divide, expressing the countries´ connectivity level in terms of ICT infrastructure and general adoption. As the Internet is constantly evolving, in order to take full advantage of it, a broadband connection is often necessary, since the majority of websites contain bandwidth-intensive applications such as audio and video streaming, animated content, or interactive applets (Prieger & Hu, 2008). We therefore included the broadband (BroRt), which is a pre-requisite to participate fully in cyberspace. Like the fixed (wired) broadband, mobile wireless connections are becoming a significant and increasingly popular way to access the Internet in places other than the household or workplace (International Telecommunication Union, 2011). For this reason we also included the mobile broadband subscriptions per 100 inhabitants (MobRt) in our analysis. As the

Internet speed is probably one of the most important characteristics of Internet service (Vicente & Gil-de-Bernabé, 2010), we included the international Internet bandwidth per Internet user (Speed). The Internet secure servers (Serv) are a specific ICT infrastructure of e-commerce, allowing secure electronic business transactions, a reason why it, too, is considered in our study. Finally, web browsing is probably the most general and popular action that individuals can perform through the use of ICT. Hence, we used the percentage of population regularly using the Internet in our analysis (IntPop) is an effective way to assess the use of ICT of individuals for general purposes. The variables were extracted from the ITU´s World Telecommunication Indicators and from the World Bank´s database, and are for the year 2011. The data, their source, and the respective theoretical and empirical support are in Table 4.2.

Table 4.2 - Acronyms, descriptions and literature support of variables for measuring DigDev

Code	Variable	Support
HsPC	Percentage of households with computer	(Billon, Marco, et al., 2009; M. Chinn & Fairlie, 2007; Cuervo & Menéndez, 2006)
HsInt	Percentage of households with Internet	(Billon, Marco, et al., 2009; Brandtzæg et al., 2011; M. Chinn & Fairlie, 2007; Çilan et al., 2009; Frederico Cruz-Jesus et al., 2012; Cuervo & Menéndez, 2006; Vicente & Lopez, 2010a)
BroRt	Fixed (wired)-broadband subscriptions per 100 inhabitants	(Billon, Marco, et al., 2009; Brandtzæg et al., 2011; Çilan et al., 2009; Frederico Cruz-Jesus et al., 2012; Cuervo & Menéndez, 2006; Dwivedi & Irani, 2009; Vicente & Lopez, 2010a)
MobRt	Mobile (wireless)-broadband subscriptions per 100 inhabitants	(International Telecommunication Union, 2011; Thompson Jr & Garbacz, 2011)
Speed	International Internet bandwidth (bit/s) per Internet user	(Billon, Marco, et al., 2009; Vicente & Gil-de-Bernabé, 2010)
Serv	Number of secure servers per million inhabitants	(Billon, Marco, et al., 2009; Brandtzæg et al., 2011; Çilan et al., 2009; Frederico Cruz-Jesus et al., 2012; Cuervo & Menéndez, 2006)
IntPop	Percentage of individuals regularly using the Internet	(Billon et al., 2008; Billon, Marco, et al., 2009; Çilan et al., 2009; Frederico Cruz-Jesus et al., 2012; Vicente & Lopez, 2010a)

The variables included in our analysis shows considerable disparities across the 45 countries: in the countries belonging to the EU 74% of the households have, on average, a PC and 71% are connected to the Internet, while in the members of OECD, these values are, respectively 78% and 74%, and in the BRIC 37% and 30%. There is, on average, almost twice the percentage of individuals regularly using the Internet in the EU countries belonging to the EU or the OECD, than the BRIC. Individually speaking, in India only 7% of the households have a PC, while in Iceland this value stands at 95%. The percentage of households with Internet in India figures around 6%, in South Korea this value is about 97%, 17 times more. While in China there are 2.43 secure Internet servers per million inhabitants, in Iceland there are more than 3,000. We also see extreme asymmetries in the overall profile of the 45 countries. Iceland is the highest ranked country for four of the seven variables used, while India is the poorest-ranked in five of them. These uneven distributions tell us a great deal about the digital divides that exist between these countries. Nevertheless, with the dimensionality of the data used – seven variables – combined with the 45 countries included, it becomes impossible to address digital divides with simple univariate statistics. For this reason we grounded our research in a multivariate model for measuring the global digital divide. The descriptive statistics of the variables are in Table 4.3.

Table 4.3 - Descriptive statistics of the variables used for measure the digital development

Variable	Mean	S. D.	Minimum	Maximum
HsPC	71.41	18.99	6.85	94.50
HsInt	67.98	20.29	6.00	97.20
BroRt	23.91	9.37	1.03	39.20
MobRt	39.76	24.97	1.85	105.05
Speed	73,243	63,787	2,692	287,139
Serv	877.93	851.64	2.43	2.43
IntPop	69.39	18.46	10.07	10.07

4.5 Results

4.5.1 Digital development of countries

With the seven ICT-related indicators for each of the 45 countries, the first step of our analysis was to measure the digital development of each. For this purpose, we ground on factor analysis, which uses the correlations between the variables in order to find latent dimension(s) within them (Spicer, 2005). This technique reduces the dimensionality of our data, transforming our seven original variables into a smaller number of new dimensions that maximizes the information originally presented. This multivariate approach entails several advantages over the popular alternative which consists in using one of the popular digital divide indices available (Bruno et al., 2010), such as elimination of data redundancy and weighting each variable according to its importance (OECD, 2008; Vehovar et al., 2006). Although this analysis is recognised as a fairly robust technique, without demanding too many assumptions, we still need to follow some steps in order to efficiently conduct it. As the use of this technique depends on the correlation structure within the input data, the first step is to confirm that this correlation exists, otherwise the factor analysis may provide weak results (Hair et al., 1995). For this purpose we calculated the correlation matrix (see Table 4.4), which shows that all of the variables significantly correlated.

Table 4.4 - Correlation Matrix

Variable	HsPC	HsInt	BroRt	MobRt	Speed	Serv	IntPop
HsPC	1	0.98**	0.86**	0.66**	0.52**	0.71**	0.96**
HsInt		1	0.91**	0.71**	0.54**	0.78**	0.97**
BroRt			1	0.59**	0.59**	0.78**	0.87**
MobRt				1	0.36 *	0.62**	0.68**
Speed					1	0.60**	0.55**
Serv						1	0.75**
IntPop							1

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

The second step was confirming the suitability of the data which is generally made by the Kaiser–Mayer–Olkin (KMO) measure. Its value is 0.87, which expresses a very good suitability of our data to conduct this analysis (Sharma, 1996). In order to decide the number of factors to extract, we consider both the context of the analysis as well as the statistical criteria. The Pearson's, Kaiser's, and the Scree Plot criteria point to a one-factor solution. Accordingly, the context of the analysis – in which we wish to transform our seven ICT-related variables into one new metric that can properly classify the countries in terms of digital development - encourages this one-factor solution. Finally, in order to test its reliability, Cronbach's Alpha was calculated. It measures the internal consistency of each factor within itself and a value over 0.7 is generally considered good (Nunnaly, 1978). The value returned is 0.98, which confirms the extremely high reliability of our one-factor solution. The results of the factor analysis are shown in Table 4.5. As one can see, the percentage of variance retained with this solution is 78%. Hence, we reduced seven ICT-related variables into a single new measure of digital development with a minor loss of information.

Table 4.5 - Results of factor analysis and Cronbach's alpha

Original Variables	Digital Development (DigDev)
HsInt	0.98
IntPop	0.96
HsPC	0.95
BroRt	0.93
Serv	0.86
MobRt	0.75
Speed	0.66
Variance (%)	78%
Cronbach´s Alpha	0.98

Based on factor analysis, we obtained the digital development score (DigDev) for all the countries (see Table 4.8, in Appendix). Iceland, the Netherlands, Denmark, Sweden, and South Korea are the most digitally developed countries. These countries present the highest levels in the digital development dimension extracted from our factor analysis. At the other end of the spectrum, as the less digitally developed countries, we have, India, Mexico, China, Brazil, Turkey, and Chile. The results from the factor analysis – the DigDev score – allow us to measure the digital development of countries, thus answering the first research question of our paper.

4.5.2 Drivers of digital development

In the previous subsection we were able to measure the digital development across 45 countries. The first research question of our paper has thus been answered. However, the ability to become aware about the differences in digital development of countries, i.e. the digital divide, although useful for some purposes, does not allow us to understand what drives it. In order to do so we need to test if the national aspects of countries referred on section 3, theorised as possible explanatory of the digital development of countries, actually work as such. The descriptive statistics of the variables used are in Table 4.6.

Table 4.6 - Descriptive statistics of the digital divide´s explanatory factors

Variable	Mean	S. D.	Minimum	Maximum
GDP	33.75	24.35	1.49	114.51
EdSp	5.43	1.21	3.21	8.72
SupEd	28.03	11.80	11.80	62.00
Dens	0.16	0.22	< 0.01	1.30
Area	1.67	3.71	< 0.01	17.10
Urban	74.48	13.99	31.30	97.49

In order to test our conceptual model, an integrative perspective is proposed through an econometric ordinary least squares (OLS) model, mathematically expressed as follows:

$$DigDev_i=\beta_0+\beta_1*GDP_i+\beta_2*EdSp_i+\beta_3*SupEd_i+\beta_4*Dens_i+\beta_5*Area_i+\beta_6*Urban_i+\beta_7*Eng_i+\varepsilon_i \quad (1)$$

where β_0 is the constant term and β_1 through β_7 are the coefficients to be estimated by the OLS, ε_i is the error term of the i^{th} country, GDP_i = the gross domestic product of the i^{th} country, $EdSp_i$ = the public spending on education of the i^{th} country, $SupEd_i$ = the percentage of labour with tertiary education of the i^{th} country, $Dens_i$ = the population density of the i^{th} country, $Area_i$ = the area of the i^{th} country, $Urban_i$ = the percentage of population living in urban areas of the i^{th} country, and Eng_i = 1 if the country has English as native language, and 0 if not.

The OLS was estimated using the software Statistical Analysis System (SAS®). As recommended by Neter et al. (1974), we conducted a series of tests in order to confirm the suitability of the OLS. We analysed the residual´s distribution in order to confirm its normality. Visually, the residual´s normal distribution assumption appears to be verified (see Figure 4.5, in Appendix). In order to demonstrate the normality assumption, the Shapiro-Wilk test (1965) was performed, and for a 5% significance level, the assumption of the residuals´ normality is not violated ($p > 0.10$). The correlations between the explanatory variables and values for variance inflation factors (VIF) indicate that multicollinearity is not a problem, considering that in our case the highest value is 1.84, well below the limit of 10 (Belsley, Kuh, & Welsch, 1980; Dewan et al., 2005). With respect to a possible heteroscedasticity problem in our model, we used the White´s test (White, 1980), which indicated no presence of heteroscedasticity ($p > 0.10$), confirming the visual analysis of the DigDev´s residuals (see Figure 4.6, in Appendix). For a 1% significance level, the overall model is significant ($p < 0.01$). The results are in Table 4.7.

Table 4.7 - Results of ordinary least squares model

Ordinary Least Squares Model´s Results			
Variable	**Parameter $\hat{\beta}$**	**t Value**	**p –value**
Intercept	-2.9946	-5.81	< 0.001
GDP	0.0191***	4.74	< 0.001
EdSp	0.2063**	2.48	0.018
SupEd	0.0222**	2.49	0.017
Dens	0.5424	1.26	0.217
Area	-0.0494*	-1.88	0.068
Urban	0.0081	1.05	0.301
Eng	-0.0002	< 0.00	0.999
R-Square		77%	
F		17.20 (p < 0.001) ***	

Note: ***Effect is significant at the 0.01 level (2-tailed); ** Effect is significant at the 0.05 level (2-tailed); * Effect is significant at the 0.10 level (2-tailed).

The GDP (H1: β1 = 0.0191, p < 0.01), the EdSp (H2: β2 = 0.2063, p < 0.05), the SupEd (H3: β3 = 0.0222, p < 0.05), and the Area (H5: β5 = -0.0494, p < 0.01), are confirmed to be statistically significant explanatory factors of the digital development of countries. All of these effects, with the exception of Area, were proven to be digital development promoters, while Area works as an inhibitor. In contrast to our expectations, the Dens (H4: β4 = 0.5424, p > 0.10), Urban (H6: β6 = -0.0081, p > 0.10), and Eng (H7: β7 = -0.0002, p > 0.10) have no significant impact on the digital development of a country. Overall, the model explains 77% of the variation (R-Square) of DigDev. The hypotheses H1, H2, H3, and H5 appear to be supported.

4.6 Discussion

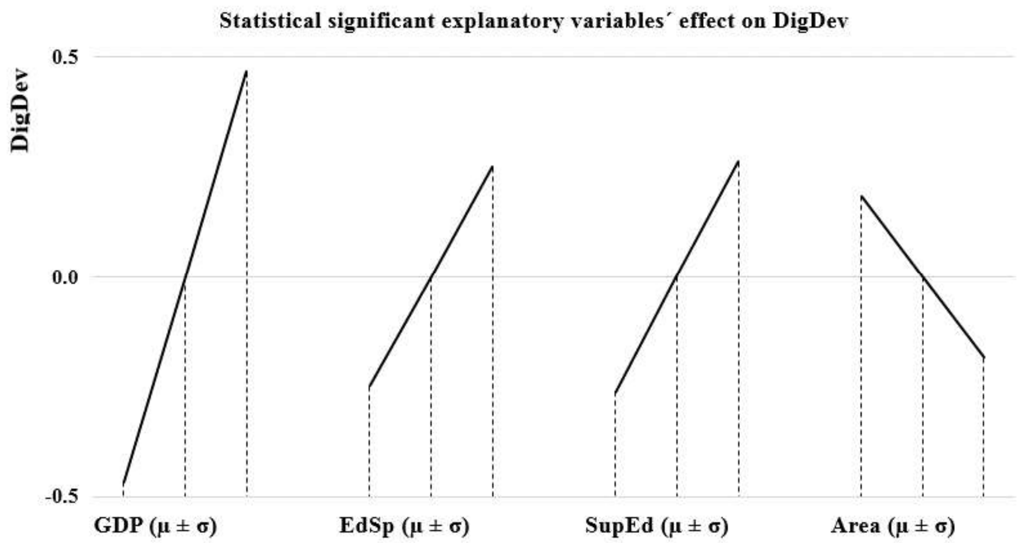
4.6.1 Discussion of findings

We undertook ourselves to analyse the international digital divide across 45 countries from different contexts and realities. In order to do so we ground our work on a multivariate framework to measure and understand digital disparities across countries. Our first aim is to measure the digital development of the countries. We find that Iceland, the Netherlands, Denmark, Sweden, and South Korea are, respectively, the most digitally developed countries of those analysed (see Table 4.8 in Appendix). The USA appears in a relatively modest position (15th). At the other end of the spectrum, with no surprise, India, Mexico, China, Brazil, and Turkey appear as the least digitally developed. It is interesting to note that the European countries are the ones leading the digital development in 2011, considering that nine of the top-10 digitally developed countries are from this continent and that of these, six belong to the EU. Moreover, it came as some surprise that the eastern European countries are doing relatively well in ICT in comparison to what we had expected. Estonia, Slovenia, the Czech Republic, Slovakia, Latvia, and Poland present higher digital development levels than other older EU countries such as Portugal, Italy, and Greece. Policy makers of these countries should definitely learn from their European counterparts the measures to improve their digital performance. The USA, the country which originated the digital revolution during the 1980s, occupies a relatively modest 15th position in the ranking, closing the first third part. The BRIC are all within the bottom-10 countries in terms of DigDev. Russia stands in the 37th position, while Brazil, China, and India occupy, respectively, the 42nd, 43rd and 45th positions. Moreover, of the bottom-10 digitally developed countries, only three belong to the EU (Bulgaria, Romania, and Greece). This fact is in line with Cruz-Jesus et al. (2012), in which these countries were classified as the least digitally developed EU countries.

In our attempt to understand what drives the international digital divide, we made use of an OLS model. We hypothesised, as DigDev´s explanatory factors, seven characteristics of a country. The OLS confirmed only four of them. Contrary to our expectations, although the Dens and Urban have some influence over the countries´ DigDev, these are not strong enough to be statistically significant. The Eng, on the other hand, was completely rejected by the OLS as a significant driver of digital development. As we theorised that Dens would affect ICT adoption by increasing its observability, it seems that greater observability of ICT does not necessarily lead to higher adoption rates. Thus, ICT adoption is not affected by its exposure at the same level of other technological innovations. This result does not contradict Roger´s DOI theory, since it posits that there are different degrees to which "the results of an innovation are visible to others" and, consequently affect its adoption rate (Rogers, 2005). Regarding the Urban, it appears that there are other factors than the demand for information-intensive products and services to greatly influence DigDev. We argue that Urban´s effect is mitigated by the GDP and educational aspects of countries which are more important. To support this belief we used an OLS with Urban as the only explanatory variable and the results were proven to be statistically significant ($p < 0.01$). Finally, it seems that although it is possible that English native speakers were more prone to use ICT in the beginning, as the majority of websites and IT were in English, this proficiency is no longer necessary, nor is it important to use the Internet and other related technologies effectively. According to our expectations, the GDP, EdSp, SupEd, and Area all explain the digital asymmetries across countries.

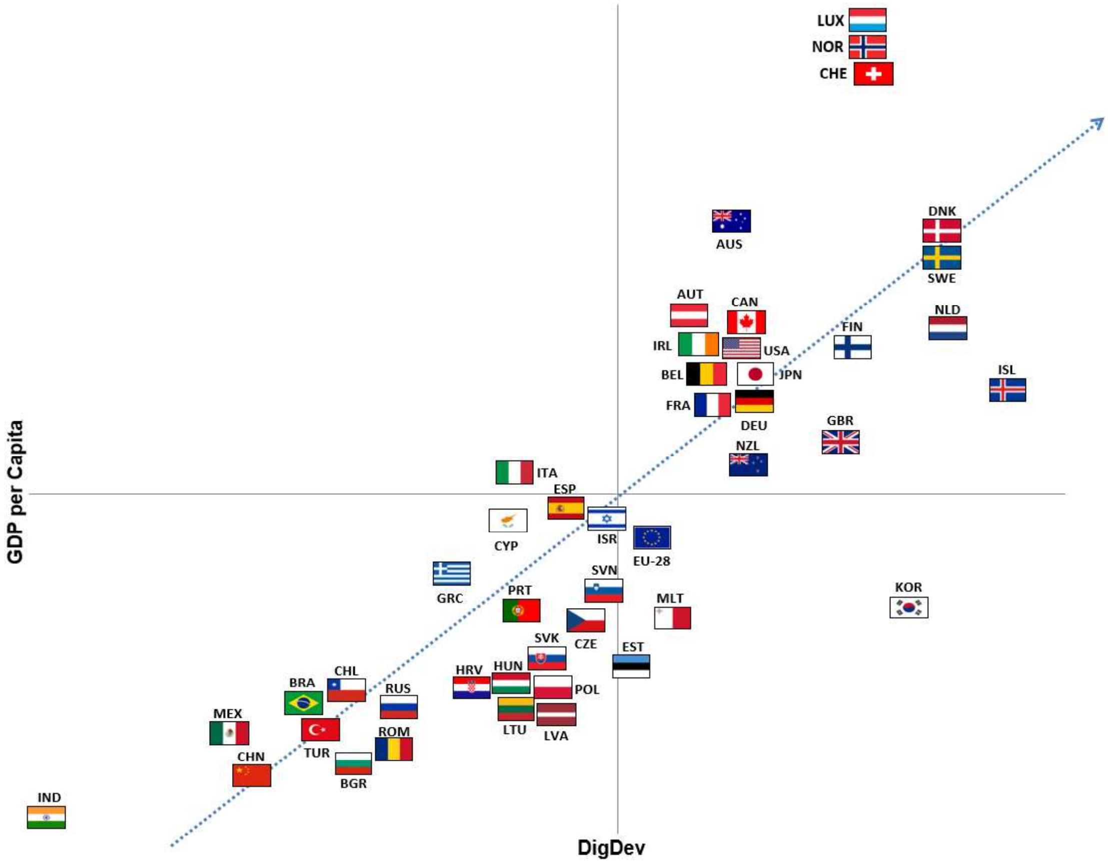
In order to obtain a more fine-grained understanding of the impact of each digital development´s explanatory factors, we graphed their effects. For each explanatory variable we present three levels, calculated as one equal to the average (μ) level of the variable; other adding another standard deviation (σ); and another by subtracting one from the average (see Figure 4.2). All the digital development´s explanatory factors, except the Area, show positive slopes, according to the respective parameter (β). Moreover, the range (and hence the impact) is highest for the GDP (0.932), followed by the SupEd (0.523), the EdSp (0.498), and finally the Area (-0.367), following, as expected, the same order as the significance level (p) of the OLS. As the GDP is the variable that has the greatest effect on digital development, it seems that digital inequalities are mainly a direct consequence of economic ones.

Fig. 4.2 - Statistical significant ($p < 0.10$) explanatory variables´ effect on digital development, maintaining all the others constant (= μ)



The pattern in terms of GDP versus DigDev can be easily assessed by plotting the countries regarding the bi-dimensional relation. In Figure 4.3 the horizontal axis measures the DigDev, while the GDP is measured on the vertical one. The most noticeable thing in this figure is related to what clearly appears to be a linear trend line relating these two dimensions. This is so noticeable because of the impact that the economy has on digital development. Luxembourg, Norway, Switzerland, and South Korea are the exceptions to this trend. The first three countries are doing worse on DigDev than what the GDP would suggest, while South Korea has the opposite condition, i.e., it is clearly emphasising its DigDev more than what its GDP would suggest.

Fig. 4.3 - Countries' projections in terms of digital and economic developments



4.6.2 Limitations and future work

In spite of our effort to offer a complete and multidimensional analysis, some limitations must be recognised. Firstly, although we included 45 countries in our analysis, our empirical application consists of just seven variables and, therefore, some features of the information society may not be covered. This limitation also affects the ability of variables to explain the divide. Secondly, we analysed the digital divide at a country level, which means that all indicators used were concerned with aggregate national realities, meaning that internal, domestic digital divide gaps may not be covered. Thirdly, our analysis refers to the digital divide at a specific point in time, the year of 2011. Changes in this context are likely to occur rapidly, and our findings may soon become outdated. The fourth limitation is in respect to the inclusion of countries. We intend to expand this base in the future, to make it more representative of the globe, especially giving more attention to developing countries such as those from Africa and South America, where unfortunately, the absence of available data is clear. Thus, although useful, it should be noted that caution should be exercised when extrapolating the results from our analyses to other contexts, namely other geographic areas. Finally, the explanatory factors of the digital development and divide also present some limitations, especially regarding the economic context.

4.7 Conclusions

Based on multivariate statistical methods, we analyse the digital divide between the countries of the EU, OECD, and BRIC. There is a severe digital divide between these 45 countries. The most digitally advanced countries are mainly in Europe, while the BRIC and eastern EU members are at the other end of the spectrum. The digital divide appears to be a direct consequence of economic and educational asymmetries between countries, whereas the size (area) of countries also has a word to say in this matter. Moreover, there is some evidence that domestic digital divides, specifically the differences between urban and rural areas, also appears to influence the digital development of a country.

4.8 Appendix

Table 4.8 - List of countries ordered by digital development

Rank	Country	Code	DigDev
1	Iceland	ISL	1.802
2	Netherlands	NLD	1.503
3	Denmark	DNK	1.476
4	Sweden	SWE	1.473
5	Korea, Rep.	KOR	1.301
6	Switzerland	CHE	1.194
7	Luxembourg	LUX	1.138
8	Norway	NOR	1.134
9	Finland	FIN	1.050
10	United Kingdom	GBR	0.996
11	Japan	JPN	0.626
12	Canada	CAN	0.598
13	Germany	DEU	0.598
14	New Zealand	NZL	0.596
15	United States	USA	0.520
16	Australia	AUS	0.480
17	France	FRA	0.421
18	Ireland	IRL	0.384
19	Belgium	BEL	0.370
20	Austria	AUT	0.332
21	Malta	MLT	0.273
22	Estonia	EST	0.043
23	Slovenia	SVN	-0.036
24	Israel	ISR	-0.088
25	Spain	ESP	-0.173
26	Czech Republic	CZE	-0.191
27	Slovak Republic	SVK	-0.337
28	Latvia	LVA	-0.339
29	Poland	POL	-0.346
30	Portugal	PRT	-0.430
31	Cyprus	CYP	-0.443
32	Italy	ITA	-0.447
33	Lithuania	LTU	-0.483
34	Hungary	HUN	-0.545
35	Croatia	HRV	-0.608
36	Greece	GRC	-0.767
37	Russia	RUS	-0.937
38	Romania	ROM	-0.978
39	Bulgaria	BGR	-1.144
40	Chile	CHL	-1.212
41	Turkey	TUR	-1.341
42	Brazil	BRA	-1.377
43	China	CHN	-1.642
44	Mexico	MEX	-1.779
45	India	IND	-2.661

Fig. 4.4 - Visual analysis of OLS´ residuals normal distribution assumption

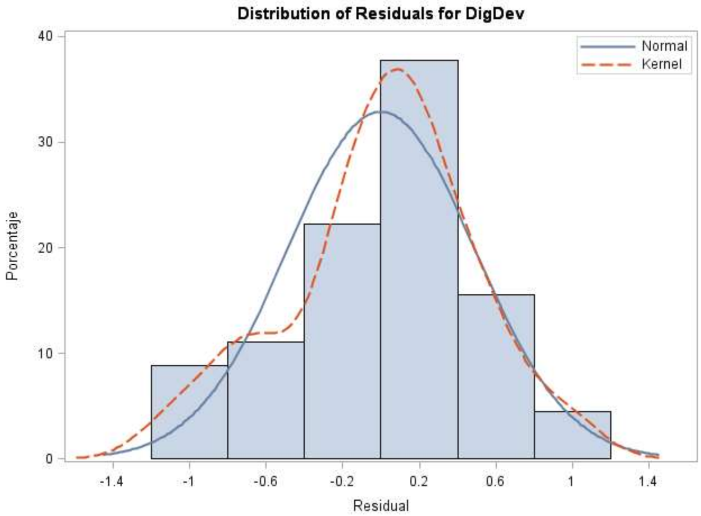
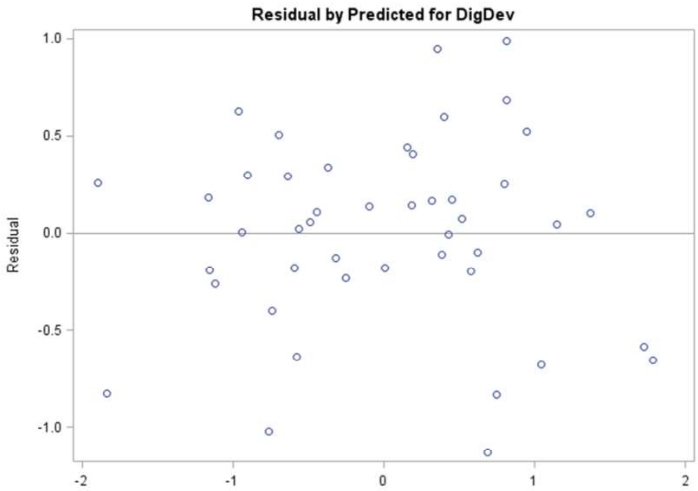


Fig. 4.5 - Visual analysis of OLS´ possible heteroscedasticity problem



Chapter V

5. Assessing the pattern between economic and digital development of countries

Abstract. This paper analyzes the digital development of 110 countries and its relationship with economic development. Using factor analysis, we combined seven ICT-related variables into a single measure of digital development. This measure was then used as the dependent variable in an OLS model that allows non-linear effects, with the GDP per capita of countries as the explanatory variable. Our findings are substantive in that the correlation between economic and digital development was not linear, being much stronger in poorer countries, a hypothesis not commonly seen in the literature. As a result, future studies that focus on the relationship between economic and digital developments may benefit from our findings, by postulating this type of relationship. In our model we were able to explain 83% of the variation in the digital development of countries, compared to just 72% if considering only a linear relationship.

Keywords: Digital Divide, Information society, E-inclusion, Diffusion, Developing countries, Technology adoption

5.1 Introduction

The importance of information and communications technologies (ICT) for the economic and social development of countries is now well supported by researchers and policy makers (S. Y. T. Lee et al., 2005; World Bank, 2006). International players often argue that greater adoption and use of ICT helps countries, communities, firms, and individuals to boost development and welfare, especially in times of economic crisis, such as the one currently facing the world (Ashraf, Hanisch, & Swatman, 2009). The United Nations (UN) (see, for example, WSIS, 2003; WSIS, 2005), the Organization for Economic Cooperation and Development (OECD) (see, for example, OECD, 2004; OECD, 2011), the United States of America (USA) (see, for example, US Department of Commerce, 2000, 2002), and the European Union (EU) (see, for example, European Commission, 2010a, 2010b, 2013), have all deployed strategies to achieve digital development and thereby benefit from the use of ICT. Many other countries have also created their own public entities to engender economic growth through ICT supply and adoption (Ma & Huang, 2014). However, their policies now appear to be contributing to a widening of the digital divide between developing and developed countries (Dwivedi & Irani, 2009). Within the European Union there is evidence that the most digitally developed countries are increasing their adoption and use of ICT in certain areas, compared to those that are not as digitally developed, thus widening the digital divide even within Europe (Frederico Cruz-Jesus et al., 2012).

The literature is rich in studies in which the main findings, especially those offering empirical evidence, show how close the link is between disparities in ICT diffusion and economic development. Hence, as with past technological innovations, economic wealth is a prerequisite for ICT diffusion and the main determinant of the global digital divide. In fact, "*some authors consider digital divide to be a new expression of the traditional technological dualism between rich and poor countries*" (Billon, Marco, et al., 2009). However, although the importance of economic imbalances in defining digital gaps is well documented, there is a missing link in the literature with regard to analyzing the pattern of this important relationship. To the best of our knowledge, studies in which this link is assessed in detail are, to say the least, scarce. Thus, one may ask whether the impact of economic wealth in ICT diffusion is constant regardless of the different economic stages of countries. There are conflicting opinions expressed in the literature about this subject. For example, Zhao et al. (2014) report that, "surprisingly" GDP per capita was not a significant predictor of the digital divide in their investigation, whereas most studies present the opposite conclusion (Dewan & Riggins, 2005). We therefore seek to answer the following research question:

RQ - Is the relationship between economic and digital developments of countries linear? Or is it that GDP has an effect to a certain level on ICT usage and then flattens out as adoption becomes more of an issue, making this relationship a nonlinear one?

This question is of special importance because, to the best of our knowledge, most of the empirical evidence from studies on this subject is grounded in statistical methodologies that assume a linear effect between these two important aspects of countries (e.g., OLS, PLS, etc.). Our intention is to shed some light on this issue by analyzing this relationship in detail. If, as it is hypothesized, this relationship is not linear, then one might expect that from this point forward, future works in the literature may advance this non-linearity hypothesis. Moreover, policy makers of regions/countries with relatively high economic levels may take into consideration that, in their cases, aspects other than those that are income-related may be more important in engendering ICT, whereas for developing countries, policies should focus first and foremost on this fact. With this in mind, we present an exploratory analysis of the important relationship between digital and economic development of 110 countries spread around the globe. In the context of this paper, digital development is the level of ICT diffusion within a country and is measured by a construct of seven ICT-related variables, while economic development is proxied using the gross domestic product per capita (GDP) as this is perhaps the most popular and accurate single indicator of the economic development of a country, measuring the overall output of the economy (Dewan et al., 2005). Hence, the most important priority of the data collection methodology was to include the greatest number of countries possible, even if only to achieve that some shortcomings had to be recognized in terms of data inclusion.

The remainder of the paper is organized as follows: In Section 2 we conduct a literature review of the digital divide; in Section 3 we present the framework and methodology for measuring the digital development of countries; Section 4 assesses the relationship between the economic and digital development of countries; Section 5 presents the implications and limitations of the paper; and Section 6 presents the conclusions.

5.2 Surveying the literature

The development and use of ICT have undergone exponential growth in recent decades. It is only some 30 years ago that electronic calculators began to penetrate mass markets in developed countries. Today, most people in these countries are using or are familiar with devices that can store entire libraries of books, music, videos, and have thousands of times more processing ability than those calculators. Similarly, 30 years ago, long-distance communications were mainly via postal services or telephone, but today much of the world is connected via digital networks that allow incredible volumes of text, images, sound, and video to be exchanged instantly. The pace of innovation and adoption of ICT has been astounding. Its impact reaches from science, engineering, and services, to manufacturing. ICT adoption has gone hand in hand with innovation, creating a snowball effect that individuals, firms, communities, and countries can benefit from.

The new positions that ICT-enabled products and services have acquired in modern economies have given birth to the concept of the "digital economy" (Ayres & Williams, 2004). These technologies are playing a decisive role in improving almost every aspect of our societies (Gripenberg, 2011; World Bank, 2009), including education, business transactions, communications, economics, and politics (OECD, 2004). Carlsson (2004) studied the effects of 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 19th century, the Corliss steam engine, and 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 contribution of ICT to Finland's GDP between 1990 and 2004 was three times greater than the contribution of electricity between 1920 to 1938. Mo et al. (2013) report empirical evidence that ICT use in education, specifically in the context of the *One Laptop per Child* (OLPC) program, benefits children in developing their computer skills and math scores. Moreover, students' self-esteem is also improved by having access to a PC at home for as little as six months. Similar benefits regarding the availability and use of a PC for students were found by Hatakka et al. (2013), although these authors also drew attention to the possibility of the negative effects of PCs, such as distraction from school, isolation, or social media abuse, adding much needed criticism to the negative effects of ICT. For civic and political matters, Wattal et al. (2010) studied the impact of the Web 2.0, in particular the influence of social networks on politics in the 2008 US Primary Presidential Campaign, and concluded that the Internet is changing the very nature of political competition. Accordingly, some authors concluded that ICTs are playing an increasingly important role in the awareness of individuals towards differences in political ideologies (E. Kim et al., 2009; Wattal et al., 2010), thereby improving the way that democracy works. Shirazi et al. (2009) studied the relationship between ICT and economic freedom, and found that ICT expansion in the Middle East countries has been effective in supporting that freedom, as ICT has facilitated the "Arab Spring" revolution (Sandoval-Almazan & Ramon Gil-Garcia, 2014). On the other hand, even for countries in the EU, civic and political participation on the Internet depends upon the individual's income and education levels, as socioeconomically advantaged individuals are more likely to participate in civic matters online (Vicente & Novo, 2014). Andrade and Doolin (2015) addressed the benefits that ICT could bring to a specific group of disadvantaged people – refugees. By interviewing 53 refugees in New Zealand, they concluded that ICT helped in five dimensions: "(1) participating in an information society; (2) communicating effectively; (3) understanding a new society; (4) being socially connected; and (5) expressing a cultural identity".

New types of ICT-enabled applications, or advanced services, are becoming more and more common. These include e-commerce, e-government, e-health, e-learning, e-banking, e-finance, social networks, and others (Çilan et al., 2009; European Commission, 2006; Facer, 2007; Krishnan & Lymm, 2016; Vicente & Gil-de-Bernabé, 2010; Vicente & Lopez, 2010b; Fang Zhao et al., 2012). Actions and technologies, like Internet surfing, YouTube, social networking, on-line job seeking, email, wiki-sites, and access to online libraries, are gaining room in our daily routines, changing the way people interact with each other. As Gurstein (2003) argues, "*ICT provides the basic infrastructure for production, and dissemination in any area of activity which has a significant information, knowledge or learning component*". ICT positively affects the economy and welfare in several important aspects of life (Çilan et al., 2009; World Bank, 2006), as it creates competitive advantages in enterprises, improves national health systems (Bakker, 2002) through e-health, and improves educational systems (Cukusic et al., 2010; Hsieh et al., 2008) through e-learning, which in turn creates new opportunities, all of which reduces distance constraints and creates new industries that generate new employment opportunities (Castells, 2007b; Castells & Himanen, 2002).

For these benefits to be realized certain obstacles need to be overcome, especially inequalities between and within countries regarding access to, and use of, these technologies. Thus, inequalities in access to and use of ICT draw marked distinctions between those who have access to privileged information and those who have not (Brooks et al., 2005), which is exactly what the digital divide is. This idea is even changing the notion of literacy in the sense 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).

The term digital divide became popular in the mid-1990s, when the former Assistant Secretary for Communications and Information of the United States Department of

Commerce, Larry Irving Junior, used it to describe a new inequality in the access to ICT (Dragulanescu, 2002). According to the 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*" (OECD, 2001). Initially, in the early days of the digital revolution, the digital divide was understood in binary terms, meaning that the differences were simply "has" or "has not" access to ICT. Today, however, this binary difference is considered narrow, since other factors need to be considered (Barzilai-Nahon, Gomez, & Ambikar, 2010; Brandtzæg et al., 2011). Digital divide is today understood to be a complex, multidimensional phenomenon (Bertot, 2003; Hsieh et al., 2008; Okazaki, 2006; Warschauer, 2002). There are two types of digital divides, those that are analyzed across different countries – the global digital divide – and those within a single country – the domestic digital divide.

Regarding the domestic digital divide, i.e., ICT access and use disparities at an intra-national level, digital divide gaps often occur as a result of access to and use of ICT between regions or groups of individuals, when characteristics of a different nature exist (Ono & Zavodny, 2007; Unesco, 2003). One of the most common types of domestic digital divide, for both developing and developed countries, is between rural and urban areas, because setting up and maintaining ICT services in remote rural areas can be very costly. Some authors have demonstrated that the domestic digital divide is characterized by a higher risk of digital exclusion of the elderly, women, the population with a lower income and educational attainment, those with disabilities, those living in rural areas, and ethnic minorities (Choi & Park, 2013; Crenshaw & Robison, 2006; Middleton & Chambers, 2010; Niehaves & Plattfaut, 2013; US Department of Commerce, 1995, 1998, 1999, 2000, 2002; Vicente & Lopez, 2006; Vicente & Lopez, 2008, 2010b, 2010c). Hsieh and Rai (2008) showed that economically advantaged and disadvantaged people also demonstrate very different post-implementation behavior 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 a greater complexity to the phenomenon and its study. (2008) hypothesize that a household's adoption of ICT may be influenced by the cultural aspects of individuals, adding Hofstede´s cultural dimensions as moderators to the Model of Adoption of Technology in Households (MATH). 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 is a complex issue that can represent a threat to all of the e-strategies around the world, including the Digital Agenda for Europe (Frederico Cruz-Jesus et al., 2012; Cuervo & Menéndez, 2006; OECD, 2009).

As countries are individuals and firms in the aggregate, research on the global digital divide usually indicates that ICTs are a potential contributor for a nation's socio-economic, technical, and cultural development. Developing countries have therefore rushed to implement ambitious ICT projects, with the direct/indirect supervision of institutions, such as the World Bank, the UN, and other donor/local agencies (Ashraf, Swatman, & Hanisch, 2007). In developing countries the digital divide occurs where there is a lack of infrastructure (such as electricity supply and telephone lines) or lack of access to modern technology (the Internet, computers, or mobile phones) (Ashraf et al., 2009; James, 2007). Across developed countries the digital divide is usually measured using different access patterns to ICT, especially those that focus on the extent to which individuals and firms make use, in terms of extent and intensity, of the wide possibilities that ICT provides (see, for example, Frederico Cruz-Jesus et al., 2012; Cuervo & Menéndez, 2006). In any of these cases, there is consensus within this field of study that the digital divide is mainly a consequence of economic inequalities between countries (Xiaoqun Zhang, 2013). For example, Dewan et al. (2005) analyzed the drivers of three generations of IT (mainframes, PC, and Internet) and found that all three were positively associated with national income. When examining the determinants of the global digital divide, these authors found evidence that although there are several factors that influence IT adoption, among the most significant is GDP. Chinn and Fairlie (2007) *"confirm the importance of per capita income in explaining the gap in computer and Internet use"*. In a later work (2010), these same authors confirmed that GDP *"remains the single largest factor"* in their regression analysis of the digital divide drivers. Billon et al. (2008) found that GDP per capita is a predictor of the likelihood of adoption and the extent of use of the Internet because, among other reasons, he argues that "*it is related to infrastructure communications*". Moreover, *"when specialized infrastructures for adopting innovations are required, it is expected that innovations will be located in those areas with higher level of infrastructure"*. As a result, it could be predicted that the higher the level of the GDP per capita, the higher the level of funding invested in ICT, and thus, the higher the diffusion rate of the Internet. Billon et al. (2009) found that within the European Union *"the degree of Internet adoption is positively correlated with the level of GDP per capita"*.

More recently, Doong and Ho (2012) used cluster analysis to classify countries with similar digital development levels and found, by using a probit model, that the national income had a significant positive impact on the digital development of each country. That is, "*countries with higher national income tended to enjoy a higher ICT development status*".

Another important feature of the global digital divide is whether it is narrowing or widening. Although there is no consensus in the literature, there appears to be evidence that the digital gap between countries is not likely to narrow in the near future, as empirical and qualitative studies on this subject show that "*the relatively low rate of investment in IT in developing countries appears to refute the hypothesis that diffusion patterns are somehow converging*", i.e., that the digital divide between developed and developing countries is narrowing (Indjikian & Siegel, 2005). Xiaoqun Zhang (2013) found that, even though the digital divide between high- and low-income OECD countries is narrowing, the gap between the developed and developing countries is widening. This fact was seen as natural considering "the positive correlations between GDP per capita and the slope of diffusion curve". A contributing cause for this situation may be related to the fact that developing countries cannot engender digital development with stand-alone policies focusing on increasing access to ICT, or by subsidizing these technologies, as these options would place a heavy financial burden on their limited financial resources. This constraint also affects countries with greater economic power, given that most of them are currently facing significant budget/expenditure cuts (e.g., European Union countries).

Another obstacle that developing countries face in pursuing digital development is a lack of knowledge about "best practice" in ICT investments, together with ICT-related skill deficiencies in the population (Indjikian & Siegel, 2005). Zhao et al. (2014) used a multidimensional framework to analyze the digital divide and its effects on e-government adoption. Their findings suggest that ICT infrastructure and socio-demographic characteristics of countries are significant predictors of the global digital divide whereas, surprisingly, the GDP per capita is not. Indeed, this is one of the few studies that does not point to the economic development of countries, expressed by GDP per capita, as a significant driver of the global digital divide.

Despite the richness of the literature in analyzing the impact of economics in digital development, not much attention has been paid to the nature of this relationship. One exception is the study by Beilock and Dimitrova (2003), which is one of the first to hypothesize a possible non-linear relationship between income and Internet penetration. However, perhaps due to the fact that this was not the main focus of their paper and the unclear nature of their results (and particularly the fact that the overall explanatory value was not enhanced by including the non-linear relation), their study did not receive the attention that it probably deserves. Nevertheless, to the best of our knowledge, almost every empirical study focusing on the digital divide assumes that theoretically and empirically, due to the statistical techniques used, economic effects on the global digital divide are linear, while there is nothing that suggests, or assures, that this is indeed so. For this reason, the main objective in this current paper is to focus on the digital/economic binomial, including as many countries as possible, in order to embrace the global spectrum to the greatest extent possible.

5.3 Measuring the digital development of countries

5.3.1 Framework

In order to measure the digital development of countries we needed to decide whether to do so by using one of the information society/digital divide indices that are already available, or to use ICT-related variables that need to be analyzed later. Each of these options presented pros and cons. With regard to using ICT variables, researchers are able to gain better control over the analysis by considering and choosing the technologies that they find suitable for the scope of the study, thereby achieving an improved awareness about how/why each country is classified in terms of digital development. However, the availability of consistent data for a large number of countries, that we seek to achieve in this study, is very limited. Thus, when using ICT-related variables, there is a trade-off between the *depth* and the *width* of the analysis (Frederico Cruz-Jesus et al., 2012). In other words, the more indicators that are used, the fewer the countries that can be included (Cuervo & Menéndez, 2006). This constraint seriously affects accurate measures of the global digital divide, because ultimately the trade-off in terms of priority (*width* or *depth)* of the analysis' outcome must be considered. It is therefore necessary to be aware that if the data used are limited in terms of *width* (number of countries) the conclusions may be limited, as it is possible that they are not found in contexts other than the one being studied (e.g. within the European Union the relationship between digital and economic development may be linear, as all of the EU countries have a minimum level of wealth). On the other hand, if the data used are limited in terms of *depth* (number of variables), the conclusions may be misleading in the sense that digital development measures may have contradictory variables (e.g. unlike the general expectation, one country may have lower levels of Internet adoption by individuals than another country, but at the same time have a higher level of broadband penetration).

The alternative to using ICT-related indicators is to use society/digital divide indices. Using these indices counters the limitations of the ICT-related indicators mentioned earlier. Among the most popular of these are the IDC´s Information Society Index; the United Nations Development Program´s Technology Achievement Index; the ITU´s Digital Access Index and Digital Opportunity Index; and the Infostate Index (Sciadas et al., 2005). However, along with the widespread use of these indices, the problem arises that there are no standardized guidelines or consensus about using one index over another. Moreover, different indices may lead to different results (Vicente & Lopez, 2010a), which may lead to partial choices about which index to use. This choice can also be made purely on an "easier to obtain" basis. In answering this issue some authors have even proposed using second-order indices (Emrouznejad et al., 2010), which can comprise other indices - not variables, as theory would suggest. The main advantages of using indices instead of ICT variables resides in the fact that they have the ability to summarize what is a complex and multidimensional phenomenon, provide easily interpretable results and comparisons, and also allow for quite simple analysis across different time series. On the other hand, the indices also entail several limitations. They may oversimplify complex interrelationships, i.e. reduce the information regarding society/digital divide to a single value, which may be misleading (Vehovar et al., 2006), and the composition of the indices (in terms of contributing variables) is always a subjective choice (OECD, 2008; Unesco, 2003). Thus, besides technologies that are already in widespread use, it is important to be aware of new types of ICT.

Finally, there is the issue that the weight of each variable (or index in the case of second-order ones) *"could be the subject of political dispute"* (Bruno et al., 2010; OECD, 2008), and as such be unreliable for a specific subset of countries' ICT dimensions. These limitations are mitigated when using ICT-related indicators. Being well aware of the advantages and disadvantages of indices, we consider that using ICT-related indicators is, wherever possible, the most reliable option. Some previous authors have followed the same methodology in their studies of the global digital divide (see, for example, Çilan et al., 2009; Frederico Cruz-Jesus et al., 2012; Cuervo & Menéndez, 2006; Dewan et al., 2005; Vicente & Lopez, 2010a).

In order to reduce possible negative implications associated with the use of original ICT variables, we turn to the literature for guidance in choosing which to include in our analysis. Moreover, although it is a relatively common practice due to data limitations, we did not want to proxy the digital development with only one ICT indicator. As for some other studies focusing on the digital divide, we sought to include indicators that measure the ICT infrastructure of each country along with their pervasiveness. For each indicator included there is a *rationale* associated with it, which is as follows: as one major feature of the digital development of a country is its ICT infrastructure, this feature should be measured (Billon, Marco, et al., 2009). Accordingly, we included the fixed-telephone subscriptions per 100 inhabitants (FixTel) (Cuervo & Menéndez, 2006) and mobile cellular telephone subscriptions per 100 inhabitants (MobTel) (Billon, Marco, et al., 2009; Doong & Ho, 2012; D. Kim & Hwang, 2012; Okazaki, 2006); along with the percentage of households with a computer (HsPC) (M. Chinn & Fairlie, 2007; Cuervo & Menéndez, 2006; Nishida, Pick, & Sarkar, 2014), and connected to the Internet (HsInt) (Çilan et al., 2009; Frederico Cruz-Jesus et al., 2012). Regarding the first two variables (FixTel and MobTel), although developed countries have seen stagnation in telephone density in recent years, this density continues to grow in developing countries. As for the last two variables, HsPC and HsInt are often used in the literature to measure the digital development, by measuring the countries' connectivity level in terms of ICT infrastructure and general adoption. These four variables therefore provide an important basis upon which to assess the level of first and second generation ICT diffusion.

As the Internet is constantly evolving and becoming more and more demanding in terms of resources, to make the best use of it a broadband connection is often necessary, as the majority of websites contain bandwidth-intensive applications, such as audio and video streaming, animated content, or interactive applications. We therefore chose to include the fixed (wired) broadband subscriptions per 100 inhabitants (BroRt) (Brandtzæg et al., 2011; Vicente & Lopez, 2010a), which are a prerequisite for full participation in cyberspace. Like the fixed (wired) broadband, a mobile (wireless) broadband connection (MobRt) (Brandtzæg et al., 2011; D. Kim & Hwang, 2012; Vicente & Lopez, 2010a) is becoming an important and increasingly popular way to access the

Internet in places other than the household or workplace, making it a further important measure of ICT adoption. Finally, as Internet browsing is perhaps the most popular action that individuals can perform through the use of ICT, we have also included the percentage of the population regularly using the Internet (IntPop) (Brandtzæg et al., 2011; Nishida et al., 2014; Vicente & Lopez, 2010a) as an effective way to assess the intensity of use of ICT of individuals. It is important to keep in mind that we do not claim that this set of variables is exhaustive in terms of expressing the digital development, but we do believe that by considering the limitations of data availability, these variables can efficiently measure each of the 110 countries' digital development to a considerable and meaningful extent. Moreover, for the skills dimension of digital development, frequency of use can be a reasonable proxy. All of the variables are sourced from the ITU's World Telecommunication ICT Indicators and were available, as was our objective, for an elevated number of countries – 110. These countries include both developed and developing ones (including the BRICS – Brazil, Russia, India, China, and South Africa), and is also geographically representative, including 42 countries from Europe (all of the EU-28 and others); 25 from Africa; 22 from Asia; 11 from North America, 8 from South America; and 2 from Oceania. The descriptive statistics are presented in Table 5.1.

Table 5.1 - Acronyms, descriptions and univariate statistics of variables

Code	ICT Variable	Source	Mean	S Dev	Min	Max
FixTel	Percentage of fixed telephone subscriptions	ITU	23.5	18.0	0.1	63.1
MobTel	Percentage of mobile/cellular telephone subscriptions	ITU	106.0	41.5	4.5	243.5
HsPC	Percentage of households with a computer	ITU	45.2	30.9	1.5	94.5
HsInt	Percentage of households with the Internet	ITU	41.0	30.5	1.0	97.2
BroRt	Percentage of Fixed (wired) broadband subscriptions	ITU	12.5	11.8	0.0	39.2
MobRt	Percentage of active mobile broadband subscriptions	ITU	23.0	29.8	0.0	216.1
IntPop	Percentage of individuals regularly using the Internet	ITU	45.5	28.2	1.1	95.0

5.3.2 Methodology

In order to compare the digital and economic development of countries it was necessary to obtain a single measure for their digital development. As there is no suitable way to choose one from the seven variables already mentioned – the choice would always be subjective – a new measure of digital development that includes information from all of the seven variables described was required. For this we used factor analysis. Factor analysis is a multivariate technique that examines the latent (unobservable) patterns of complex and multidimensional phenomena, summarizing them in a smaller set of new measures, the factors, and thus making its interpretation easier (Hair, 2014). This technique is especially suitable for the analysis of the digital divide, considering the pervasiveness of ICT (Frederico Cruz-Jesus et al., 2012) and its wide set of applications, which require considering multiple dimensions. In order to use this technique correctly, we followed certain steps. As factor analysis depends on the correlation structure within the input data, the first step was to confirm that this correlation exists, otherwise the factor analysis could provide meaningless results (Hair et al., 1995). We therefore calculated the correlation matrix of our data (see Table 5.2). The second step was to confirm the suitability of the data, which is generally done by using the Kaiser–Mayer–Olkin (KMO) measure (Sharma, 1996). Finally, as a third step, we extracted the new factor and performed a reliability analysis of the original variables.

Table 5.2 - Correlation matrix

	FixTel	MobTel	HsPC	HsInt	BroRt	MobRt	IntPop
FixTel	1						
MobTel	0.99**	1					
HsPC	0.83**	0.85**	1				
HsInt	0.63**	0.60**	0.52**	1			
BroRt	0.87**	0.90**	0.91**	0.49**	1		
MobRt	0.66**	0.69**	0.56**	0.55**	0.64**	1	
IntPop	0.95**	0.95**	0.84**	0.64**	0.87**	0.63**	1

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

The correlation matrix (see Table 5.2) showed that every correlation was statistically significant at the 0.01 level ($p < 0.01$), thereby assuring us that all of the variables share an underlying common phenomenon – the digital development of countries. To confirm the suitability of the data for factor analysis, we calculated the KMO, obtaining a value of

0.86, which expressed a very good suitability. The number of factors to extract depends on the data and context of analysis. From a statistical point of view, there are three criteria, Pearson's, Kaiser's, and the Scree Plot, for deciding how many factors should be retained in this analysis. All of these pointed to a one-factor solution. Accordingly, the context of the analysis, in which we wished to transform our seven ICT-related variables into a single new measure of the digital development of countries, also encourages the one-factor solution. Thus, the statistical criterion coincided with the analysis framework. As shown in Table 5.3, the factor loadings, i.e., the correlations between the original variables with the extracted factor, range from 0.69 up to 0.97. The HsInt (0.97), HsPC (0.97), and IntPop (0.96) are the original variables with higher correlations, whereas the MobTel (0.69) is the variable with the lower correlation. The percentage of variance retained in this factor was 78%. We thereby reduced the seven ICT-related variables into a single new measure of digital development with a minimal loss of information. In order to measure the scale reliability of this new measure, Cronbach's alpha was calculated. This evaluates the internal consistency of the factor within itself, and a value over 0.7 is generally considered to be good (Nunnaly, 1978). The value returned was 0.92, confirming the extremely high reliability of our solution, without contradictory values.

Table 5.3 - Results of factor analysis (loadings) and Cronbach's alpha

	Factor Analysis Results
Original Variables	Digital Development (DigDev)
HsInt	0.97
HsPC	0.97
IntPop	0.96
BroRt	0.93
FixTel	0.90
MobRt	0.75
MobTel	0.69
KMO	0.86
Variance (%)	78%
Cronbach´s α	0.92

With this methodology, we obtained the digital development score (**DigDev**) for the 110 countries (see Table 5.6, in the Appendix). With the DigDev measure we were then in a position to analyze the relationship between economic and digital development for a large number of countries.

5.4 Assessing the pattern between economic and digital development

5.4.1 Theoretical background and hypothesis testing

The link between economic development, particularly GDP, with access and use of ICT is well supported in academic literature (Kauffman & Techatassanasoontorn, 2005). The explanation is rather simple: in order for an individual to access and use ICT, some type of financial capability to do so is usually required. Simultaneously, given that newer technologies tend to be more expensive, their adoption naturally presents higher risks, especially for those who have limited resources. The diffusion of innovations (DOI) theory (Rogers, 2005), which is one of the most prominent in IS research, especially in the digital divide field, focuses on explaining how technological innovations are communicated through channels, over a period of time and among the members of social systems (Ashraf et al., 2007; Sey, 2008). The DOI theory claims that wealthier individuals and firms – and thus, wealthier countries in the aggregate – are more likely to adopt technological innovations (as is the case with ICT). Moreover, the digital revolution took place within the Western (developed) world and, as a result, the developed countries rapidly adopted and increased their use of ICT for a wide variety of activities (e.g. individuals started using PCs for personal purposes and firms for business use). The developing countries (most of Africa, South America, and Asia), on the other hand, did not possess the same resources to effectively acquire ICT, nor did they benefit from its use on the same scale as the wealthier countries. During the early years of the ICT revolution the adoption rate was unquestionably several times higher in richer and more developed countries. However, the question as to whether this fact still holds true today is not yet clear. Nevertheless, countries with stronger economies are more likely to have the possibility of using ICT. Additionally, as these countries tend to have more developed economies in terms of information-, financial-, and innovation-based economic activities, the likelihood of presenting higher levels of ICT adoption is also greater.

Moreover, higher ICT adoption and use is likely to lead to higher levels of economic growth, generating a snowball (bi-dimensional) effect that leads to an increasing digital divide between developing and developed countries. On the other hand, it seems plausible that continued increases in GDP result in ever smaller increases in ICT adoption, as there is a finite limit to its level, and its financial constraints lose importance.

As this takes place factors other than economic ones gain importance, such as educational, demographic, or geographic ones. Education may affect a country's digital development because of ICT complexity, a major obstacle for adoption (Rogers, 2005). Hence, as the ease of use of a technology is important to its adoption rate (Katz & Aspden, 1997), when facing a technical challenge the more educated individuals are more prone to flexibly and effectively overcome the constraints of ICT complexity (H. Zhao et al., 2007). There is evidence in the literature that in the context of ICT adoption, user friendliness, or effort expectancy, is an important factor (Y.-S. Wang & Shih, 2009). Thus, countries with relatively higher educational attainment should present higher digital development. Accordingly, as Peng et al. (2011) demonstrate, those who use a PC at work or school are more likely to adopt ICT, and as Tengtrakul and Peha (2013) found, "the higher the educational level of students, the stronger the increase in likelihood of a household adopting ICT".

Besides education, at the country level other factors may affect the digital development, including the country's demographic and geographic distributions (Billon, Marco, et al., 2009), Although the impact of these effects is ambiguous (Dewan et al., 2005), one might argue that denser and smaller areas are easier to connect than those that are more dispersed or larger. In denser areas it is more likely that innovations spread faster (Rogers, 2005), as innovations are more observable by other potential adopters. Some authors argue that larger areas are more likely to adopt ICT because of the advantage of these technologies in replacing other ways of traditional communication, which usually grow more expensive as the distance increases (Forman, 2005). Contrarily, other authors believe that as larger areas tend to be more heterogeneous, they are harder to connect (Frederico Cruz-Jesus et al., 2012; Emrouznejad et al., 2010). Moreover, greater surfaces tend to need greater amounts of resources to be connected, in terms of the infrastructure coverage of all of its territories. The literature also theorizes other aspects of countries as drivers or inhibitors of digital development. However, as mentioned above, the scope of this paper is the specific role of economic development, and we therefore focus on that issue.

In regard to other studies explaining digital development/divide, previous researchers have often employed multiple regression analysis, explaining one, or several single dependent variables using separate models. Some examples include Hargittai (1999) (Internet connectivity); Kiiski and Pohjola (2002) (Internet hosts and telephone main lines); Guillén and Suárez (2005) (Internet users); Kauffman and Techatassanasoontorn (Kauffman & Techatassanasoontorn, 2005) (digital mobile phones); Dewan et al. (2005) (mainframes, PCs, and Internet users); and Chinn and Fairlie (2007) (PCs and Internet users). However, all of these authors examined the digital development of countries with a single technology separately, which does not provide much information about the real level of digital development, a limitation that we believe the present study avoids as we combine seven ICT-related variables into one measure. As Wolcott, Press, McHenry, Goodman, and Foster (2001) have pointed out, a single dependent variable is not enough to study the Internet, for example, because it is the result of the combination of a group of interrelated and clustered innovations. From another perspective, most studies of this type have used the economic development of countries as the explanatory factor of the digital development/divide (see Table 5.4).

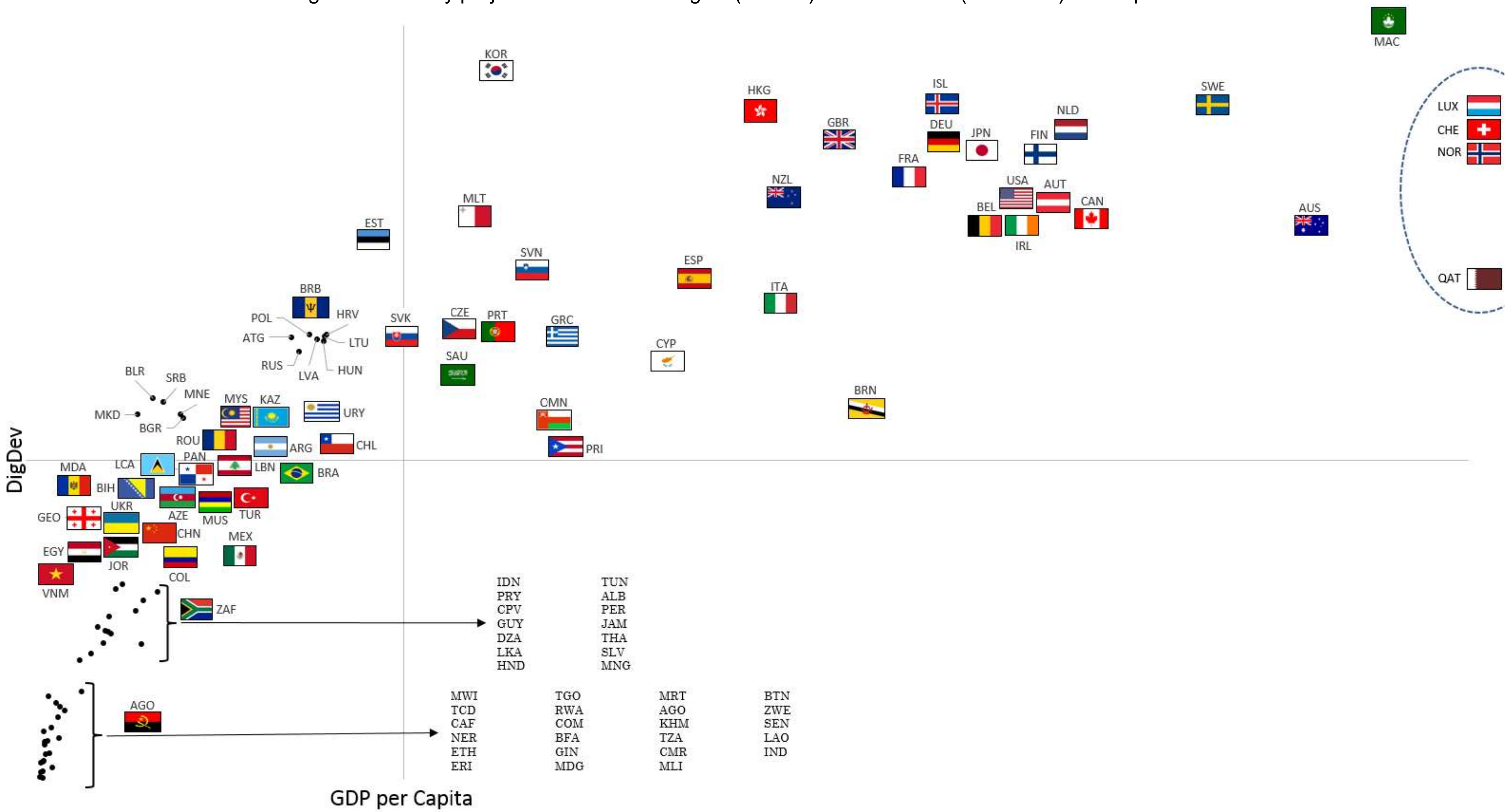
Table 5.4 - Review of earlier studies using GDP to explain the digital development/divide

Reference	Journal	Data
(Dewan et al., 2005)	Journal of the Association Information Systems	- Explanatory variables: Tel lines, Tel subscription cost, local call cost, urban population, GDP, years of schooling, and trade in goods. - Dependent variable(s): Mainframes/1000 inhabit. PCs/1000 inhabit. Internet users/1000 inhabit. - Countries: 40
(Hargittai, 1999)	Telecommunications Policy	- Explanatory variables: GDP, Gini coefficient, enrolment ratios, English language, monopolies in the telecommunications sectors, Internet costs, telephone density, and mobile phones subscribers. - Dependent variable: number of Internet hosts /10kcap. - Countries: 18
(Kyle Robison & Crenshaw, 2002)	Social Science Research	- Explanatory variables: energy consumption per capita, telephone density, general openness of political institutions, secondary school enrolments, and labour force in the tertiary sector - Dependent variable(s): number of Internet hosts /10kcap. - Countries: 74
(Kiiski & Pohjola, 2002)	Information Economics and Policy	- Explanatory variables: GDP, Internet cost, telecoms competition, average years of schooling, and English proficiency - Dependent variable(s): Internet hosts per capita - Countries: 23
(M. Chinn & Fairlie, 2007)	Oxford Economic Papers	- Explanatory variables: income per capita, years of schooling, illiteracy, trade openness, (youth and age dependency ratios), urbanization rate, telephone density, electricity consumption, telecommunications pricing measures, and regulatory quality - Dependent variable(s): PCs and Internet penetration - Countries: 30

(Vicente & Lopez, 2010a)	Telecommunications Policy	- Explanatory variables: GDP, unemployment rate, individuals with tertiary degrees, HR in Science & Technology, Innovation score, population density, population > 65 years, and employment in services. - Dependent variable(s): factor analysis index based on Internet penetration, broadband penetration, individuals regularly using Internet, individuals who never used a PC, and individuals who used Internet for ordering goods/services. - Countries: EU-27 at regional level
(F. Zhao et al., 2014)	Information Technology & People	- Explanatory variables: GDP, adult literacy & enrolment, population age, gender ratio, Internet access, broadband, secure servers, government effectiveness, corruption control, and Hofstede´s cultural dimensions - Dependent variable(s): Internet users - Countries: from 76 to 151
(Guillén & Suárez, 2005)	Social Forces	- Explanatory variables: GDP, phone lines, cost of local calls, democracy index, competition, privatization, and country location (core or semi-peripheral) - Dependent variable(s): Internet users - Countries: 118
(Billon et al., 2008)	European Planning Studies	- Explanatory variables: GDP, unemployment rate, population with tertiary degrees, employment in service sector, population, population aged over 55, and population density - Dependent variable(s): Individuals using the Internet - Countries: EU-15 at regional level
(Carter & Bélanger, 2005)	Information Systems Journal	- Explanatory variables: Compatibility, perceived ease of use, and perceived trustworthiness - Dependent variable(s): Utilization of e-government services - Countries: N/A (individual-level)

As mentioned above, the economic development level of a country is proxied by the GDP. The correlation between the DigDev (coming from the factor analysis with the seven ICT-related variables) with the GDP was positive (0.78) and statistically significant at a level of 0.01 ($p < 0.01$). The pattern in the relationship between economic and digital development can be assessed more easily by visualizing the 110 countries in this bi-dimensional relationship (see Figure 5.1). The horizontal axis represents the GDP of countries, while the DigDev is projected on the vertical one. Each axis represents the respective average values of the countries.

Fig. 5.1 - Country projections in terms of digital (vertical) and economic (horizontal) development.



Macau, one of the two Special Administrative Regions of China, is the most digitally developed "country". This fact comes as no surprise considering that this region has a very high GDP, stemming mainly from the gaming industry. In addition, its administrative system and laws were developed based on Western culture (Macau was administered by Portugal until the end of 1999, which was responsible for developing the present laws), and it is a very small territory with an astonishing diffusion of ICT. Moreover, in the last few years Macau´s government has deployed important measures to provide the territory with ICT, for example, local communications are free; Internet access is very affordable; the territory is completely covered by a 3G network; the price of equipment (e.g. cell phones, PCs, and tablets) is modest; and there are almost no restrictions on access to Internet content. All of this stands in marked contrast to the situation in mainland China. At the other end of the spectrum, Eritrea is the least digitally developed country. This is because the country is one of the poorest on the globe and, as a result, its citizens and firms are unable to adopt ICT, and its infrastructure remains insufficiently developed. The values of DigDev for the 110 countries are given in Table 5.6 in the Appendix.

Figure 5.1 helps us to see some interesting aspects about the behavior of countries in regard to economic and digital developments, some of which show atypical patterns. Qatar, Norway, Switzerland, and Luxembourg are four examples. Their GDP is extremely high and for this reason they were rescaled to fit within the plot area, which explains the dashed line separating them from the other countries (they were originally more horizontally apart from the other countries). Given the strong relationship between GDP and DigDev, one might say that these four countries are doing worse in DigDev than their GDP would suggest. However, this can be easily understood by looking at their economic context. The economies of Qatar and Norway are strongly supported by natural resources where, in both cases, high natural reserves of oil makes their GDP so high, i.e., inflated. On the other hand, Switzerland and Luxembourg, although at a different scale, have unusual financial and tax systems, and operate as hosts for many international companies and institutions, thereby also inflating their GDP to off-the-scale levels. The GDP of these countries can thus be considered inflated with regard to the real output of their national economies and, naturally, to their economic ability to adopt ICT for their citizens and firms. South Korea presents the opposite condition, i.e., it is a case in which digital development is higher than its economic development would suggest. The pattern in this country is explained by the emphasis that the South Korean government and policy-makers have placed on ICT adoption, making it a priority.

In answer to our research question, the slope of the pattern between economic and digital development appears to behave differently in countries with below average GDP, in comparison to those with above average, i.e., between the countries located to the left and right of the vertical axis, respectively. In fact, for the first group the correlation is 0.89, contrasting with the 0.47 of the second group, although the two correlations are statistically significant at 0.01 level ($p < 0.01$). Note that the overall correlation is 0.78. Thus, the correlation between the two developments does not appear to be linear, depending on the level of GDP.

In order to test the non-linear relationship between GDP and DigDev, we calculated two ordinary least squares (OLS) models, both with DigDev as the dependent variable. The difference between the two resides in the fact that the first had only GDP as an independent variable, while the second had GDP and GDP-squared to allow for a non-linear effect (Klasen, Lechtenfeld, & Povel, 2014). If the second model was statistically better than the first, then our hypothesis of a non-linear pattern would be confirmed. The models were mathematically expressed as follows:

$$DigDev_i = \beta_0 + \beta_1 * GDP_i + \varepsilon_i \qquad (1)$$

$$DigDev_i = \beta_0 + \beta_1 * GDP_i + \beta_2 * GDP^2_i + \varepsilon_i \qquad (2)$$

where β_0 is the constant term and β_1 and β_2 are the coefficients to be estimated by the OLS, and ε_i is the error term of the i_{th} country.

As there were severe outliers in our data, particularly the four countries with off-the-scale GDP, these were excluded from the analysis, leaving a remainder of 106 countries. Also, as recommended by Neter and Wasserman (1974), we conducted a series of tests to confirm the suitability of the models. We analyzed the residuals' distribution and in order to demonstrate their normality we used the Shapiro-Wilk (1965) test. For a 5% significance level the assumption of the residuals' normality was not violated ($p > 0.10$). With respect to a possible heteroscedasticity problem in our model we used White's test (White, 1980), which indicated no presence of heteroscedasticity ($p > 0.10$) (see Figure 5.4 in the Appendix). At a 1% significance level the two models were significant ($p < 0.01$); the second model, however, explained more than 10 p.p. of DigDev´s variation, achieving the remarkable value of 83%, and is statistically significant at the 1% significance level ($p < 0.01$). We therefore confirmed that there is a non-linear relationship between the economic and digital development of countries. The results can be seen in Table 5.5.

Table 5.5 - Results of OLS models

Variables	Model 1 Parameter β^	Model 2 Parameter β^
Intercept	-0.7989***	-1.1256***
GDP	0.0494***	0.1120***
GDP^2	-	-0.0012***
R^2	72.6%	83.1%
Adj. R^2	72.3%	82.7%

Note: ***- Effect is significant at the 0.001 level.

Although the OLS did not establish any direction of causality between explanatory and dependent variables – these were hypothesized *a priori* in Subsection 4.1 – these results were strong evidence that the economic level of a country is indeed decisive in ICT adoption, especially in its initial stages. Thus, economic power is a prerequisite for countries to have the capacity to acquire ICT. However, our analysis appears to reveal that for those countries that already have the (financial) ability to adopt ICT, GDP is not as important as it is for poorer countries. One might therefore argue that for richer countries digital development is influenced by other factors that are not purely economically based.

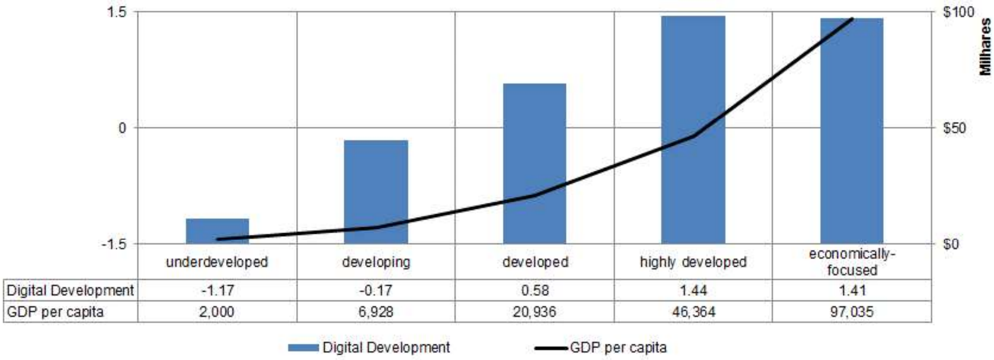
5.4.2 Classification of countries

In order to classify the 110 countries in terms of their joint economic and digital developments together, we made use of cluster analysis. Using the DigDev and the GDP together in this analysis allows us to obtain a classification for each country based on these two types of developments, grouping the countries according to a similarity criterion regarding their performance in these two dimensions. This multivariate technique allowed us to optimally group the countries into clusters in such a way as to maximize the information retained on each individual country. The aim of using it was to classify each country, and then geo-reference its profile cartographically on a map of the world. It is then possible to recognize important insights about the geographical distribution of the pattern between economic and digital development of countries across the globe.

In cluster analysis we used several hierarchical clustering algorithms to determine the number of digital profiles present in the dataset and also the initial seeds to perform a non-hierarchical algorithm (k-means), an approach that, according to Sharma (1996), tends to yield better results. Among the four hierarchical clustering algorithms that we used (Complete, Centroid, Ward, and Single), the Ward method achieved the best results, pointing to a five-cluster solution, according to the dendogram and R-Squared criteria (see Figure 5.5 in the Appendix). The averages of each cluster provided by this algorithm were used as initial seeds in k-means.

The first group of countries included 34 homogeneous nations and presented the lowest level of economic and digital developments. These countries are labeled "*economically-digitally underdeveloped*". The second group included 30 countries with the second lowest level of these two developments. These countries are labeled as "*economically-digitally developing*". The third cluster comprised 23 countries that together rank as third in the averages of the two developments. These countries are labeled "*economically-digitally developed*". The fourth group comprised 18 countries with the highest level of digital development and the second highest level of economic development, and is thus named "*economically-digitally highly developed".* The last group included the five bi-dimensional *outliers*, i.e. the countries with the second highest level of digital development and extremely high levels of GDP. We named these "*economically-focused*". The descriptive statistics of each cluster are given in Figure 5.2. The complete list of countries is given in Table 5.6 in the Appendix.

Fig. 5.2 - Average level of DigDev and GDP per cluster



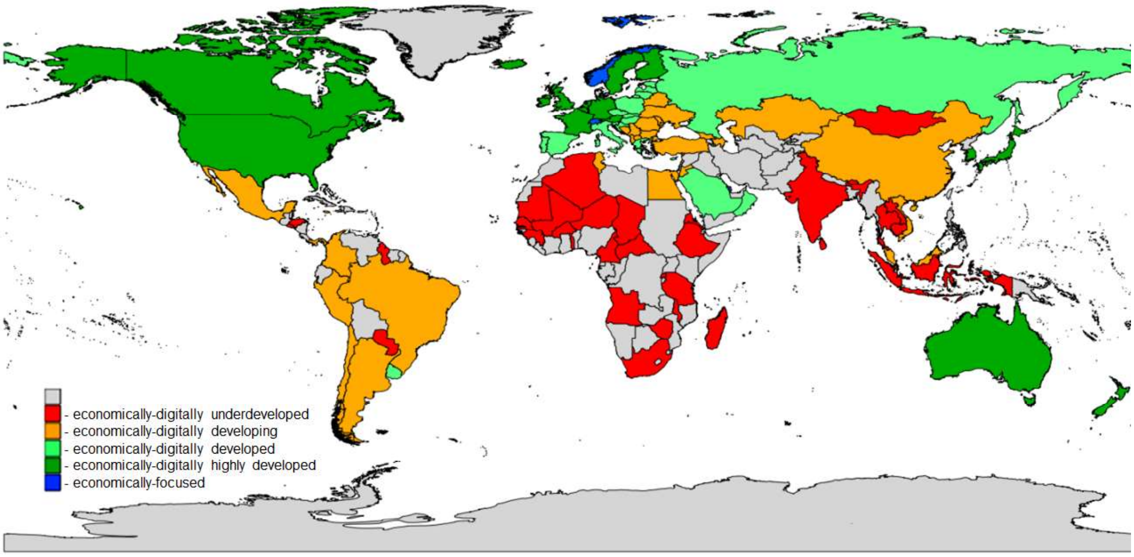
	underdeveloped	developing	developed	highly developed	economically-focused
Digital Development	-1.17	-0.17	0.58	1.44	1.41
GDP per capita	2,000	6,928	20,936	46,364	97,035

Note: The 'economically-digitally' names were trimmed due to space limitations

As the geographical distribution of the countries in terms of economic and digital development profiles is also interesting (illustrating how countries are scattered across the globe), we geo-referenced the countries on a World map (Figure 5.3). Some interesting considerations emerged from the analysis of this Figure:

- The geographic location of each country appears to have something to say regarding the link between economic and digital developments. Of the 34 "*economically-digitally underdeveloped*" countries, 22 (65%) are African, followed by 8 (24%) from Asia; The 31 "*economically-digitally developing"* countries are more evenly spread around the globe, although 14 (45%) are from the extreme East of Europe; and the 23 "developed" countries include 15 (65%) from the EU-28.
- From another point of view, 88% of African countries are classified as "*economically-digitally underdeveloped"*; Asian countries are relatively well spread across all profiles, although the relative majority (36%) is classified as "*economically-digitally underdeveloped*"; South American countries are mainly classified as "*economically-digitally developing*" (63%); there are no European countries classified as "*economically-digitally underdeveloped*".
- It did not come as a surprise that the economic/digital leaders of the world are located in North America (Canada and USA), Europe (particularly countries in the North and Center), Oceania (Australia and New Zealand), and East Asia (Macau, Hong Kong, Japan, and South Korea).
- The least *"economically-digitally developed*" countries in the world are mainly located in Africa and South Asia.
- Russia is the only one among the BRICS countries that achieved a good classification ("*economically-digitally developed*").

Fig. 5.3 - World map of the countries in terms economic and digital developments



5.5 Implications and Limitations

5.5.1 Implications

Implications for researchers and policy-makers can be drawn from the present study. One of the main implications comes from the close relationship between digital and economic development. As with technological innovations in the past, economic wealth is a critical prerequisite for ICT diffusion and is a main antecedent of the digital divide. As ICT depends upon specific infrastructures, more often found in richer areas, it is reasonable to expect that those having higher levels of infrastructures will be the ones with greater digital development. This result is not considered to be surprising. As the empirical results have demonstrated, this link between infrastructures and digital development is even stronger in countries with lower levels of economic development, where (even before other aspects come into play) the first thing needed in order to use ICT is the financial ability to do so.

As in the context of the digital divide, linear effects are usually assumed from the outset of the research, and misleading conclusions may have been drawn in the past regarding the role of economic development in the digital divide, with obvious implications in the policy-making definition. As such, those seeking to narrow the digital gaps, whether in developing or developed countries, should keep in mind that it is only when the ability to effectively acquire ICT is achieved, that other factors come (increasingly) into play to explain variations in its use. We therefore separate the implications for developing countries from developed ones, as the main conclusion of this study shows that in promoting digital equality, these different types of country need to have different strategies.

For developing countries, and from a supply perspective, some actions might promote digital development, especially in the case of simpler technologies, such as the Internet and PCs. It is often suggested in the literature, and eventually followed in practice, that liberalization and deregulation, with the aim of lowering prices or subsidizing purchase, may effectively nurture ICT. Some authors argue that doing this could in fact drive the interest of private organizations from developed economies to invest in developing economies, thereby increasing digital development. Another implication for developing countries has to do with trying to explain the reasons behind the failure of one of the most common initiatives policy-makers and private organizations have developed in order to foster ICT adoption and use in developing countries, the telecenters or information kiosks (Gomez, Ambikar, & Coward, 2009). These telecenters and information kiosks should enable "*poor people to receive information about their governments, market prices, health and education*" (Ashraf et al., 2007). Moreover, these "kiosks" could and should, theoretically, be used by members of any income group, especially those who cannot afford to own a computer but who need access to these services (Kuriyan, Ray, & Toyama, 2008). However, there is evidence that this is not what actually occurs in practice, as most of these "kiosks" are underutilized, especially by those considered most disadvantaged or those who could benefit the most (Sey, 2008). We posit that the reason behind this is that the same effect found at the country level holds true at the individual level, i.e., it is imperative to first provide the financial conditions to adopt ICT to those with lower incomes, something that the "kiosks" are unable to do, as they treat users as consumers and do not provide regular and free access to ICT. Moreover, as individuals' financial capabilities grow, so does their ability to acquire additional and more advanced ICT goods and services, increasing the overall digital development level. In Internet kiosks this does not happen, as individuals are simply given access to the Internet, which is almost the same as remitting them to the initial conception of digital divide (has/has not).

As for developed countries, policy-makers should encourage digital diffusion of more advanced technologies. In particular, economic development associated with an increase in the role of services (in terms of GDP) might boost Internet use, broadband use, and e-commerce development by firms and the public sector. As our results appear to demonstrate, improving quality in public services, such as education and infrastructure, is likely to boost digital development, thereby promoting ICT-based educational resources and highlighting the opportunities and uses associated with ICT adoption. From this approach, new digital services, new e-learning content, e-business, e-health, and e-government could help to promote advanced ICT diffusion. Additionally, instead of providing hidden subsidies to technology, resources could and should be directed at developing useful and usable applications for those for whom such applications might be of immediate benefit, who are already likely to have access to ICT. What is needed in particular, is the means to use ICT in an effective way to respond to real crises in health care, education, economic development, and resource degradation, which could be achieved through education and IT formation (Gurstein, 2003).

In summary, developing countries should facilitate general ICT adoption, such as the Internet, whereas developed countries should give more attention to actions devoted to promoting the use of the more advanced applications allowed by ICT, by means of improving education and infrastructure, as these gain importance after the acquiring conditions have been met.

5.5.2 Limitations and future work

In spite of our efforts to offer a complete and updated analysis of the pattern between digital and economic development of countries, some limitations must be acknowledged. Although we included 110 countries in our analysis, our empirical application for measuring the digital development of countries comprised just seven variables and, therefore, some features of the information society may not be covered, and also there are other countries that could not be included due to data availability constraints. The analysis was conducted at country level, which means that all indicators used are concerned with aggregated national realities, so therefore domestic/intra-national digital divides are not covered. Note that these potential domestic divides are more likely to be present in larger, and therefore more heterogeneous, countries, as well as in those presenting lower economic development as they are potentially more likely to reveal domestic digital disparities, because smaller and richer societies are easier to connect than those which are bigger and poorer (Dewan et al., 2005; Emrouznejad et al., 2010). Hence, for future work, it would be of interest to extend the study of the digital divide to the intra-national level. Using prominent IS theories, such as the Venkatesh et al. (2012) UTAUT2, a better understanding of general-ICT adoption decisions by individuals might be achieved. Finally, this analysis refers to a specific point in time, the year 2011. Although this limitation was derived from the objective of this paper in including the highest number of countries possible (no data are available for other years without reducing the number of variables or countries), changes in this context are likely to occur rapidly and our findings may soon become outdated.

In future work, it is our intention to broaden our analysis of the digital divide, especially through the inclusion of other features of countries that, as our analysis seems to reveal, may be especially important in explaining the digital gaps between the wealthier countries.

5.6 Conclusions

We measured the digital development of 110 countries from all over the world. As our aim was to explore the link between economic and digital developments, we assessed the pattern between the score of a factor analysis based on seven ICT-related indicators of countries, with their gross domestic product per capita. The link between the two types of developments was analyzed using an OLS with the GDP and GDP^2, which revealed a nonlinear relationship between economic and digital development of countries. This methodology allowed us to explain 83% of the variation in the digital development of countries (the global digital divide) with our model, a result that exceeds the explanatory power of most similar studies reported in the literature. Finally, with the use of cluster analysis, we profiled each country's economic and digital development and geo-referenced them on a world map, where some interesting insights were revealed. There are five groups of homogeneous countries regarding the digital and economic development. The less "economically-digital" groups are located in Africa and Southeast Asia. Progressively, countries with higher "economically-digital" development are located in South America, Europe, and North America and Oceania.

The main conclusion of our study is that, although the correlation between economic and digital development of countries is very high, it appears to be even stronger in developing countries. Thus, one might assume that for those countries with the conditions to acquire ICT, other factors emerge regarding the actual use of these technologies.

Table 5.6 - List of countries included ordered by digital development (DigDev)

#	Country		DigDev	Cluster
1	Macao	MAC	2.043	highly developed
2	South Korea	KOR	1.850	highly developed
3	Luxembourg	LUX	1.734	economically-focused
4	Sweden	SWE	1.694	highly developed
5	Iceland	ISL	1.688	highly developed
6	Hong Kong	HKG	1.660	highly developed
7	Switzerland	CHE	1.636	economically-focused
8	Netherlands	NLD	1.578	highly developed
9	UK	GBR	1.520	highly developed
10	Germany	DEU	1.511	highly developed
11	Japan	JPN	1.476	highly developed
12	Finland	FIN	1.443	highly developed
13	Norway	NOR	1.434	economically-focused
14	France	FRA	1.348	highly developed
15	New Zealand	NZL	1.251	highly developed
16	United States	USA	1.238	highly developed
17	Austria	AUT	1.189	highly developed
18	Canada	CAN	1.167	highly developed
19	Malta	MLT	1.157	developed
20	Ireland	IRL	1.132	highly developed
21	Australia	AUS	1.115	highly developed
22	Belgium	BEL	1.105	highly developed
23	Estonia	EST	1.038	developed
24	Slovenia	SVN	0.902	developed
25	Spain	ESP	0.863	developed
26	Qatar	QAT	0.852	economically-focused
27	Italy	ITA	0.734	developed
28	Barbados	BRB	0.705	developed
29	Czech Rep.	CZE	0.615	developed
30	Portugal	PRT	0.601	developed
31	Croatia	HRV	0.589	developed
32	Poland	POL	0.588	developed
33	Greece	GRC	0.580	developed
34	Slovak Rep.	SVK	0.577	developed
35	Lithuania	LTU	0.575	developed

#	Country		DigDev	Cluster
36	Latvia	LVA	0.571	developed
37	Antigua Barbuda	ATG	0.570	developed
38	Hungary	HUN	0.558	developed
39	Russia	RUS	0.512	developed
40	Cyprus	CYP	0.469	developed
41	Saudi Arabia	SAU	0.396	developed
42	Belarus	BLR	0.287	developing
43	Serbia	SRB	0.268	developing
44	Brunei	BRN	0.243	developed
45	Uruguay	URY	0.221	developed
46	Macedonia	MKD	0.211	developing
47	Montenegro	MNE	0.202	developing
48	Kazakhstan	KAZ	0.195	developing
49	Bulgaria	BGR	0.191	developing
50	Malaysia	MYS	0.183	developing
51	Oman	OMN	0.178	developed
52	Romania	ROU	0.068	developing
53	Chile	CHL	0.064	developing
54	Puerto Rico	PRI	0.052	developed
55	Argentina	ARG	0.041	developing
56	Lebanon	LBN	-0.001	developing
57	Brazil	BRA	-0.051	developing
58	Saint Lucia	LCA	-0.055	developing
59	Moldova	MDA	-0.108	developing
60	Panama	PAN	-0.121	developing
61	Bosnia Herzegovina	BIH	-0.135	developing
62	Turkey	TUR	-0.165	developing
63	Azerbaijan	AZE	-0.170	developing
64	Mauritius	MUS	-0.206	developing
65	Georgia	GEO	-0.305	developing
66	Ukraine	UKR	-0.335	developing
67	China	CHN	-0.338	developing
68	Jordan	JOR	-0.395	developing
69	Mexico	MEX	-0.451	developing
70	Egypt	EGY	-0.462	developing

#	Country		DigDev	Cluster
71	Colombia	COL	-0.488	developing
72	Vietnam	VNM	-0.529	developing
73	Tunisia	TUN	-0.601	developing
74	Albania	ALB	-0.619	developing
75	Peru	PER	-0.633	developing
76	Jamaica	JAM	-0.674	developing
77	Thailand	THA	-0.726	underdeveloped
78	South Africa	ZAF	-0.727	underdeveloped
79	El Salvador	SLV	-0.756	underdeveloped
80	Mongolia	MNG	-0.801	underdeveloped
81	Indonesia	IDN	-0.819	underdeveloped
82	Paraguay	PRY	-0.823	underdeveloped
83	Cape Verde	CPV	-0.828	underdeveloped
84	Guyana	GUY	-0.873	underdeveloped
85	Algeria	DZA	-0.882	underdeveloped
86	Sri Lanka	LKA	-0.925	underdeveloped
87	Honduras	HND	-0.959	underdeveloped
88	Bhutan	BTN	-1.104	underdeveloped
89	Zimbabwe	ZWE	-1.126	underdeveloped
90	Senegal	SEN	-1.160	underdeveloped
91	Lao	LAO	-1.181	underdeveloped
92	India	IND	-1.195	underdeveloped
93	Mauritania	MRT	-1.232	underdeveloped
94	Angola	AGO	-1.251	underdeveloped
95	Cambodia	KHM	-1.275	underdeveloped
96	Tanzania	TZA	-1.294	underdeveloped
97	Cameroon	CMR	-1.322	underdeveloped
98	Mali	MLI	-1.342	underdeveloped
99	Togo	TGO	-1.342	underdeveloped
100	Rwanda	RWA	-1.354	underdeveloped
101	Comoros	COM	-1.393	underdeveloped
102	Burkina Faso	BFA	-1.400	underdeveloped
103	Guinea	GIN	-1.434	underdeveloped
104	Madagascar	MDG	-1.435	underdeveloped
105	Malawi	MWI	-1.439	underdeveloped
106	Chad	TCD	-1.462	underdeveloped
107	Cent. African Rep.	CAF	-1.477	underdeveloped
108	Niger	NER	-1.483	underdeveloped
109	Ethiopia	ETH	-1.505	underdeveloped
110	Eritrea	ERI	-1.508	underdeveloped

Note: The "*economically-digitally*" names were trimmed due to space limitations

Fig. 5.4 - Analysis of a possible heteroscedasticity problem in OLS

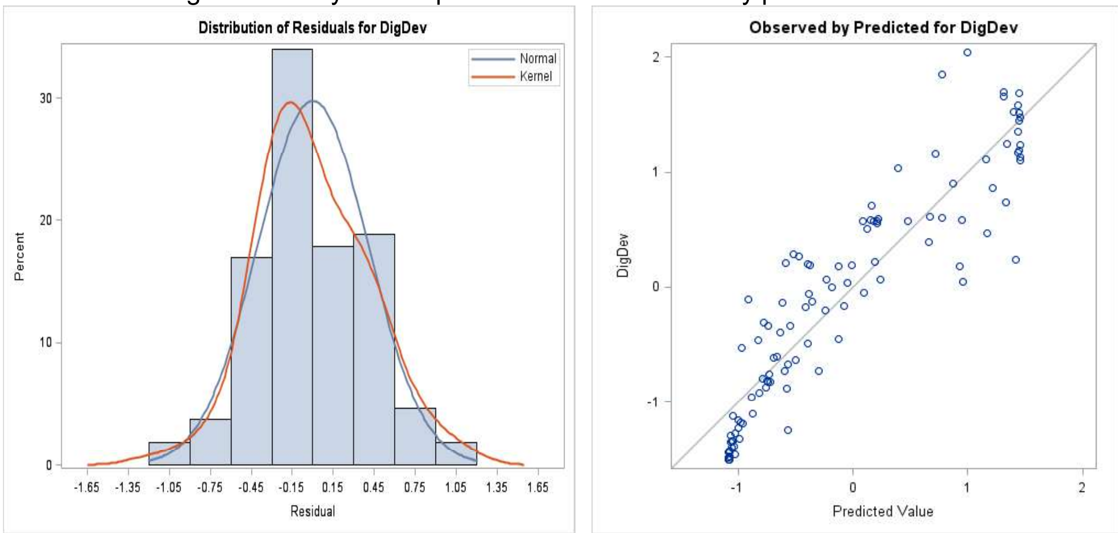
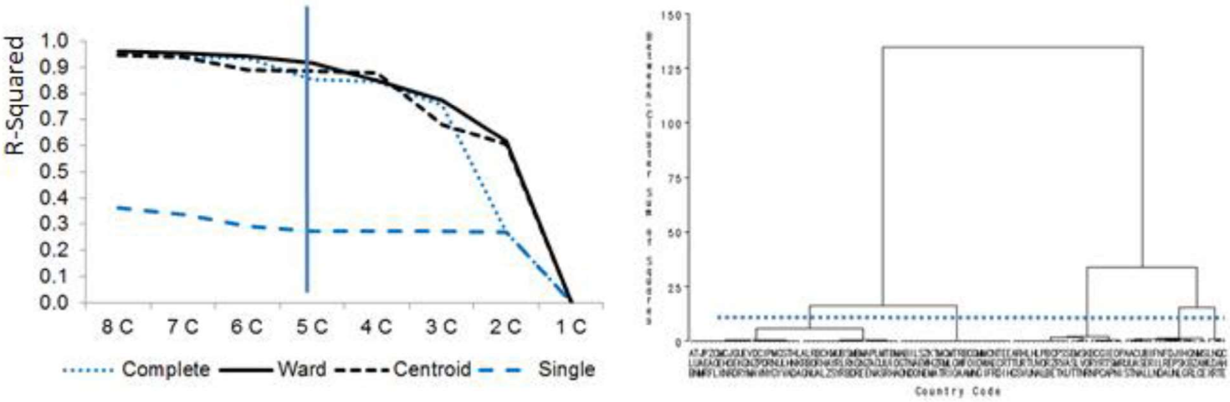


Fig. 5.5 - R-squared and dendogram of the hierarchical cluster analysis



Chapter VI

6. The education-related digital divide: An analysis for the EU-28

Abstract. This paper addresses the international and internal digital divides that exist across and within the European member states according to the educational attainment of their populations. Our results suggest that even for those European countries that are outperforming their counterparts in terms of digital development, such as Finland, some internal gaps still remain and need to be addressed. In other countries, as in the cases of Malta, Spain, and Portugal, the divides are a matter for concern. These findings would probably be overlooked if we worked only with aggregate levels, as is usual. Consequently, this paper draws attention to the importance of complementing cross-country analysis of the digital divide with an assessment of internal gaps.

Keywords: digital divide, digital development, ICT, education, digital agenda, European Union

6.1 Introduction

Although Information and Communication Technologies (ICT) are today profoundly intertwined with almost every aspect of economic and social activities, they still continue to hold the promise of tremendous innovation and development opportunities, provided that the right enabling conditions are put into place (European Commission, 2013). The conviction that greater adoption and use of ICT will foster growth and development, trumping the present economic difficulties, has been supported by some leading nations and world organizations (European Commission, 2010a, 2010b; National Information Infrastructure Advisory Council, 1996; OECD, 2011; Unesco, 2009; US Department of Commerce, 2000, 2002). At the World Summit on the Information Society (WSIS), sponsored by the United Nations (UN), 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).

In this context, the existence of the digital inequalities both between and within countries, poses a major threat to the fulfilment of ICT potential. The digital divide has been defined as "t*he 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."* (OECD, 2001).

There have been multiple efforts to quantify/measure the international digital divide, that is, the digital gap across countries (Frederico Cruz-Jesus et al., 2012; Cuervo & Menéndez, 2006; Dewan et al., 2005). However, these efforts have generally neglected the fact that within each country there might also be digital inequalities related to population's socio-economic imbalances. Research on digital divide has shown that several socio-economic factors lead to asymmetries in ICT adoption and use between individuals: income, age, and educational attainment, among others (Dewan & Riggins, 2005). Education, in particular, reveals itself as an extremely important factor because, not only are more educated individuals more likely to have less difficulty coping with technology´s complexity (Rogers, 2005), but they will also most likely be exposed to ICT in their professional and personal lives. This paper focuses on measuring the education-related digital divide, i.e., the digital gap between countries, controlling for the level of education of their population, which is to say, the digital asymmetries that may exist in each country due to differences in education level of the country's population.

The context of our study is the European Union (EU), which is not immune to the digital divide, and recognizes that developing a digital economy based on knowledge and innovation is a critical issue for the Union's present and future growth and competitiveness (European Commission, 2010b). The European Commission´s (EC) 2020 Strategy seeks "*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). The Digital Agenda for Europe, included in the Europe 2020 Strategy as the first of the seven strategy´s flagships, aims to reboot Europe's economy and help Europe's citizens and businesses to get the most out of ICT (European Commission, 2010a). Hence, detecting and correcting digital inequalities becomes a must in order to avoid jeopardizing 2020 Strategy's objectives.

The goal of this paper is to address the role that educational imbalances have on the digital divide among the citizens of the 28 member states of the European Union (EU-28). In particular, the research questions of this paper are the following: (1) what are the most important features of the digital divide across the 28 member states of the European Union? (2) To what extent is there an educational-related domestic digital divide in the EU-28 and how does it shape countries´ imbalances? In answering these questions the remainder of the paper is organized as follows: section 2 presents the theoretical background; section 3 describes the data; section 4 presents the methodology, analysis, and discussion of the results; section 5 draws some concluding remarks.

6.2. Theoretical background

6.2.1 Literature review

Recent decades have witnessed the emergence of ICT as, perhaps, the key general purpose technology (GPT – technological innovations that have the potential to improve most industries and society sectors) of present times (Bresnahan & Trajtenberg, 1995; Doong & Ho, 2012; European Commission, 2013). This “digital” revolution began with the automation and computerization of manufacturing, and was followed by the widespread of personal computers (PC) and the Internet, which led to the fact that broad sectors of the economy, previously untouched by ICT, benefited from these through investment and productivity improvements. Tertiary (market services) sectors, which account for the major portion of Gross Domestic Product (GDP) in developed economies, have experienced considerable benefits from these technologies. Thereafter, non-market sectors such as financial, health, education, and even government-services have become more prone to the positive growth effects from ICT (European Commission, 2013).

ICT in general and the Internet in particular have allowed the implementation of a whole range of new services that have completely changed the way individuals and firms interact and communicate, do business, pursue economic growth, improve welfare, and even the way politics are conducted (OECD, 2004; H. Zhao et al., 2007). Internet browsing, email, VoIP, blogs, multimedia online streaming, social networking, on-line job seeking, wiki-sites, access to online libraries, e-commerce, and services like e-government, e-health, e-learning, and e-banking are examples of new possibilities that allow new types of communications and interactions for individuals, firms, and governments (Çilan et al., 2009; European Commission, 2006; Facer, 2007; Forman, 2005; Hajli, 2014; Mutula & Brakel, 2006; Niehaves & Plattfaut, 2013; Vicente & Gil-de-Bernabé, 2010; Vicente & Lopez, 2010b).

Despite the multiple benefits that ICT may bring, not everything regarding these technologies does necessarily leads to positive outcomes. The idea that ICT will enable a whole new world of endless opportunities, liberated from problematic sociocultural aspects, such as gender, age, race, and geography is utopic (Gunkel, 2003). As the spread of ICT became wider, it quickly became clear that access (and later on, use) was limited by specific constraints and should not be assumed by researchers and policy makers to be either universal or instantaneous. It was within this context that the term "digital divide" appeared. Although the literature and forums on the subject regularly attribute the term to Larry Irving Junior, former Assistant Secretary for Communications and Information of the US Department of Commerce, the fact is that it was not authored by him, as he himself admitted years later (Gunkel, 2003). The "digital divide" term became popular in the third "Falling Through the Net" report, from the US Department of Commerce's National Telecommunications and Information Administration (NTIA) (US Department of Commerce, 1999), which defined it as "*the divide between those with access to new technologies and those without*". Within the series of these reports (US Department of Commerce, 1995, 1998, 1999, 2000, 2002) the definition of digital divide evolved from merely PC ownership, to the inclusion of Internet access, and later, to the availability of broadband connections and the types of online usages. In fact, literature distinguishes between the inequalities about access to and use of ICT, the so-called first- and second-order digital divides first- and second-order digital divides (Dewan & Riggins, 2005; DiMaggio et al., 2004). In the first-order digital divide the inequalities are with regard to ICT access, while in the second-order the problem is postulated in terms of different use patterns and intensity among individuals/organizations that already have (very similar) access to ICT (e.g., using the Internet just for web-browsing or email vs. using it for e-learning, social-network, applying to jobs online, e-banking, e-health, etc.).

Research has shown that both types of divides are mainly shaped by socio-economic inequalities among countries and individuals. Hence, those who are economically and sociologically disadvantaged (i.e., individuals with lower incomes or education levels, those with disabilities, living in rural areas, belonging to ethnic minorities, women, and the elderly) are more likely to suffer from digital inequalities (Azari & Pick, 2005; Crenshaw & Robison, 2006; Ferro et al., 2011; Hilbert, 2011; Hill, Betts, & Gardner, 2015; Lengsfeld, 2011; Novo-Corti, Varela-Candamio, & García-Álvarez, 2014; Payton, 2003; Vicente & Lopez, 2006; Vicente & Lopez, 2008, 2010b, 2010c; Wu, Chen, Yeh, Wang, & Chang, 2014). In addition to whom the problem of digital divide may affect, it may also be related to the type of digital divide, i.e., access or use of ICT - which may appear to be the same, but are not (e.g., Goldfarb & Prince, 2008; Orviska & Hudson, 2009). Hsieh et al. (2008, 2011) showed noticeable differences in ICT access versus use patterns between those who are economically advantaged and disadvantaged. Besides the intrinsic motivations for access to ICT, these individuals also have very different post-implementation behavior regarding the use of these technologies. Hsieh et al. concluded that economically advantaged people have a "*higher tendency to respond to network exposure*", using ICT with much more confidence than the disadvantaged. Novo-Corti and Barreiro-Gen (2015) studied the ICT adoption in households of different Spanish regions, finding that besides ICT infrastructure, households' characteristics such as income, education, and age of its individuals, affect ICT adoption. Wu et al. (2014) addressed the digital divide between children with and without learning disabilities in Taiwan, and although he concluded that there was no divide in ICT access, a different conclusion was drawn for ICT use. In other words, "*there was a significant difference in ICT competencies between children with and without learning disabilities*". In addition to these socio-demographic characteristics of individuals, Venkatesh and Sykes (2013) found that social network aspects are also significant in explaining ICT use, and even value. As noted by Epstein et al. (2011), different types of inequalities (first- and second-orders) require different actions: Inequalities in ICT access may be bridged, for example, through the subsidization of these technologies, since they are mainly due to economic constraints, which leads to lack of conditions to have access to ICT; whereas for inequalities in ICT use (not access) dependent more on lack of skills and awareness toward ICT, in which education and training appears as a critical factor.

6.2.2 Education as a driver of ICT

Inequalities in education attainment of individuals is one of most mentioned reasons for the digital divide (Frederico Cruz-Jesus et al., 2012; Kiiski & Pohjola, 2002; Shirazi, Ngwenyama, et al., 2010). The theoretical foundations for this cause-effect relationship are multiple and can be found in several different theories. The diffusion of innovations theory (DOI), claims that complexity is a major obstacle for technology´s adopters (Rogers, 2005). Hence, the easier a technology is to adopt, the faster is its adoption rate (Katz & Aspden, 1997). This fact makes of individuals´ educational features to play a critical role, as when technically challenged, more educated individuals are more likely to be more prone to flexibly and effectively overcome complexity´s constraints (H. Zhao et al., 2007). Thus, as in the case of ICT, when one is interacting with it, the relatively higher educational attainment should make it easier to cope with the complexity of the technology, minimizing the impact of the difficulties (Hsieh et al., 2008). In this sense education facilitates the absorption and comprehension of information, leading to an increasing information divide between higher- and lower-educated individuals. This is, in fact, the main argument lying behind the knowledge gap theory (Tichenor et al., 1970), developed within the context of the mass media´s (TV, radios, etc.) wide dispersion. Tichenor et al. (1970) posit that, "*as the infusion of mass media information into a social system increases, higher socioeconomic status segments tend to acquire this information faster than lower socioeconomic status population segments so that the gap in knowledge between the two tends to increase rather than decrease*". If this is so in mass media technologies, which are far less complex and challenging than the Internet-related ones, then in the case of these last, that fact should be even more noticeable. Mass media technologies are not as demanding as are ICT, since they do not require a set of actions by its users. ICT and Internet related activities, however, require that the users navigate throughout a great amount of information instead of being (almost) as mere receptors of information (Bonfadelli, 2002). Moreover, in case of ICT, although access is a prerequisite, it is not enough, *per se*, for taking all the advantages these technologies can bring, as important differences may remain in the nature of Internet use (van Dijk, 2005). As Vicente and Lopez (2006) point out "not only does the user need access to infrastructure but also he needs the ability to access to information, to look for it and to use it". Moreover, it is also reasonable to hypothesize that more educated individuals are more likely to work in information-intensive industries, thus using ICT more often and intensively whether at work or at home. Accordingly, Howard et al. (2001) found that more educated individuals will tend to employ the Internet more productively and to greater economic gain than those with lower educational attainments, consistent with the findings of Hargittai and Hinnant (2008). More recently Peng et al. (2011) found that individuals who use PC at work or school are more likely to adopt ICT. A consistent finding has been demonstrated by Tengtrakul and Peha (2013), in which authors conclude that "*the higher the educational level of students, the stronger the increase in likelihood of a household adopting ICT*".

6.3 Data

Consistent with our theoretical framework, in which ICT are classified as GPT, we measured their use across the citizens of the EU-28. The indicators were selected based on the literature and the availability of educational breakdowns for them. The variables were extracted from the Digital Agenda Scoreboard database – all pertaining to the year 2013. The fact that all variables were obtained from the official Digital Agenda Database (Digital Agenda key indicators) guarantees that the results of the analysis enjoy a high degree of reliability. Table 6.1 shows the variables collected and makes reference to other earlier research that used these variables to measure the digital divides.

Table 6.1 - Description of variables and earlier evidence on their importance used

Code	Variable	Support
IntPop	Individuals regularly using the Internet (every day or almost every day)	(Billon et al., 2008; Billon, Marco, et al., 2009; Çilan et al., 2009; Frederico Cruz-Jesus et al., 2012; Vicente & Lopez, 2010a)
IntSrc	Individuals looking for information about goods and services online	(Frederico Cruz-Jesus et al., 2012; Cuervo & Menéndez, 2006)
Mobile	Individuals using a mobile device to access the Internet, away from home or work	(International Telecommunication Union, 2013; Kauffman & Techatassanasoontorn, 2005; Okazaki, 2006; Thompson Jr & Garbacz, 2011; Vicente & Lopez, 2006; Vicente & Lopez, 2008)
eHealth	Individuals seeking online information about health	(Frederico Cruz-Jesus et al., 2012; European Commission, 2010a)
eLearn	Individuals looking online for information about education, training or course offers	(Çilan et al., 2009; Frederico Cruz-Jesus et al., 2012; European Commission, 2010a)
eBank	Individuals using online banking	(Frederico Cruz-Jesus et al., 2012; European Commission, 2010a)
eCivic	Individuals taking part in online consultations or voting to define civic or political issues	(Epstein, Newhart, & Vernon, 2014; Helbig, Ramón Gil-García, & Ferro, 2009; Vicente & Novo, 2014; Warren, Sulaiman, & Jaafar, 2014; Wattal et al., 2010)
eGov	Individuals interacting online with public authorities, last 12 months	(Çilan et al., 2009; Frederico Cruz-Jesus et al., 2012; European Commission, 2010a)
eCom	Individuals ordering goods or services online	(Frederico Cruz-Jesus et al., 2012; Cuervo & Menéndez, 2006; European Commission, 2010a; Turban, King, Lee, Liang, & Turban, 2015)
eCom_CB	Individuals ordering goods or services online, from sellers from other EU countries	(European Commission, 2010a, 2013; Turban et al., 2015)

All these indicators refer to different types of usages, and allow us to assess the differences not only across countries, but also within different educational levels. As our study focuses on measuring the digital adoption of individuals, we make our best efforts to include indicators that measure the ICT pervasiveness at multiple educational levels (low, medium, and high) for individuals. Our rationale is the following. Web-browsing and using the Internet to search for information about goods and services are some of the most general activities individuals use the Internet for; therefore, the percentage of individuals regularly using the Internet (IntPop) and looking for information about goods and services online (IntSrc) is an effective measure for assessing the use of ICT of individuals for general purposes (Frederico Cruz-Jesus et al., 2012). The recent emergence of the mobile Internet access is also an important feature of the information society (Okazaki, 2006). For this reason, we find it especially interesting to measure the percentage of population using mobile devices to access the Internet (Mob). Considering that we are attempting to analyze the digital divide at a European level, it is also important to consider the position of the European entities concerning the digital divide. Via the Digital Agenda for Europe (European Commission, 2010a), the European Commission, emphasizes the role of specific electronic services, more specifically 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 the use of these advanced services also allows us to analyze the so called "second-order digital divide", expands our focus from mere ICT adoption, to include the manner in which it is used by individuals (Hsieh et al., 2008). For these reasons, the percentage of individuals using e-health, e-learning, e-banking, and e-government services (eHealth, eLearn, eBank, and eGov, respectively) were included in our analysis.

Moreover, ICT allows that "*an increasing number of people engage themselves and others in e-participation, that is, in social and political participation*" (Vicente & Novo, 2014), as demonstrated in the popular example of the 2008 US Primary Presidential Campaign (Wattal et al., 2010). ICT are becoming a critical tool not only for politics, but also for individuals to engage in public and political activities, serving as a bridge between political entities and citizens. Interestingly, as Vicente and Novo (2014) posit, there are mixed conclusions when it comes to the causes of asymmetries in e-participation, as some authors find no evidence on the effect individuals´ education over e-participation, while others do. Nevertheless, the use of ICT for civic participation (eCivic) allows individuals to get information on public issues in a faster and easier way than with traditional (offline) methods, which ultimately facilitates political and civic engagements and minimizes social constraints (Anduiza, Gallego, & Cantijoch, 2010). For this reason, eCivic measure was included in our framework. Finally, in our analysis, we also pay special attention to e-commerce (eCom), considering the importance of it in the global economy (Turban et al., 2015). The European Commission recently drew four scenarios for the role of ICT in European economic growth, and the one with the highest expected growth rate (average 2.5% GDP per year) is the one in which EU nation-based ventures go across borders and compete globally. If this is accomplished, it is expected that 60% of the EU economic growth (around 1.5% a year) is due to ICT contribution. It is estimated that in 2010 92% of Europeans who ordered goods or services over the Internet did so from national sellers, rather than cross-border ones (European Commission, 2010a). For these reasons, cross-border e-commerce (eCom_CB) was included in our set of variables.

Data on these 10 variables are available by educational breakdown. In particular, three levels of education are available and were considered: no formal, primary or lower secondary education (ISCED 0, 1 or 2); Upper or post-secondary education, but not tertiary (ISCED 3 or 4); and Tertiary education (ISCED 5 or 6). Each of these classifications are named low, medium, and high education class, respectively, hereafter.

The data (see Table 6.2) show noticeable imbalances in ICT adoption and use of the individuals belonging to the 28 European countries: in Romania only 45% of the population uses the Internet regularly, while in Luxembourg 93% do so, more than twice. These same two countries are also at different ends of the spectrum in the use of mobile devices to access the Internet (Mobile), with values of 7% and 43%, respectively. In the use of e-banking services, the percentage of individuals using these services ranges from 4% in Romania up to 84% in Finland, a value 21 times higher. The higher asymmetries are present in the percentage of individuals using cross-border e-Commerce, as in Romania only 1% do so whereas in Finland this value figure is 64%. We also notice extreme asymmetries in the overall profile of the 28 European countries. Luxembourg is the best-ranked country in 4 of the 10 variables used, followed by Finland with 3, while Romania is the poorest-ranked with 8. These uneven distributions can tell us a great deal about the asymmetries that exist between countries. Nevertheless, the dimensionality of the data used - 10 variables for 28 countries - makes it impossible to address the digital divide with simple descriptive statistics. This is why the use of multivariate statistical methods is more appropriate for analyzing all these digital asymmetries.

Table 6.2 - Data and descriptive statistics of the variables used for measuring the digital development

Country	Int Pop	IntSrc	Mobile	eHealth	eLearn	eBank	e Civic	e Gov	eCom	e Com_CB
Austria	0.77	0.67	0.26	0.49	0.35	0.49	0.11	0.54	0.54	0.39
Belgium	0.80	0.67	0.24	0.43	0.20	0.58	0.04	0.50	0.48	0.28
Bulgaria	0.51	0.35	0.14	0.27	0.22	0.05	0.03	0.23	0.12	0.06
Croatia	0.63	0.46	0.22	0.35	0.37	0.23	0.07	0.25	0.26	0.07
Cyprus	0.62	0.56	0.15	0.32	0.19	0.23	0.03	0.30	0.25	0.21
Czech Rep.	0.70	0.63	0.18	0.41	0.13	0.42	0.03	0.29	0.36	0.07
Denmark	0.91	0.82	0.35	0.54	0.41	0.83	0.12	0.85	0.77	0.32
Estonia	0.77	0.60	0.33	0.39	0.33	0.73	0.06	0.48	0.23	0.13
Finland	0.89	0.79	0.37	0.60	0.32	0.84	0.19	0.69	0.65	0.32
France	0.78	0.68	0.27	0.49	0.31	0.58	0.10	0.60	0.59	0.18
Germany	0.80	0.77	0.27	0.58	0.36	0.47	0.11	0.49	0.69	0.11
Greece	0.56	0.50	0.13	0.34	0.21	0.11	0.05	0.36	0.25	0.09
Hungary	0.71	0.58	0.16	0.49	0.34	0.27	0.03	0.37	0.28	0.06
Ireland	0.75	0.61	0.39	0.38	0.33	0.46	0.04	0.45	0.46	0.24
Italy	0.56	0.37	0.13	0.32	0.26	0.22	0.06	0.21	0.20	0.07
Latvia	0.71	0.52	0.16	0.37	0.31	0.55	0.04	0.35	0.32	0.15
Lithuania	0.65	0.57	0.09	0.41	0.24	0.46	0.06	0.34	0.26	0.10
Luxembourg	0.93	0.70	0.43	0.58	0.48	0.63	0.13	0.56	0.70	0.64
Malta	0.66	0.50	0.28	0.41	0.42	0.43	0.09	0.32	0.46	0.39
Netherlands	0.92	0.83	0.36	0.57	0.29	0.82	0.07	0.79	0.69	0.15
Poland	0.60	0.46	0.20	0.27	0.18	0.32	0.02	0.23	0.32	0.03
Portugal	0.58	0.46	0.19	0.42	0.35	0.23	0.07	0.38	0.25	0.11
Romania	0.45	0.26	0.07	0.27	0.22	0.04	0.02	0.05	0.08	0.01
Slovakia	0.74	0.56	0.27	0.44	0.29	0.39	0.03	0.33	0.45	0.17
Slovenia	0.69	0.55	0.19	0.50	0.32	0.32	0.08	0.52	0.36	0.15
Spain	0.66	0.48	0.23	0.44	0.46	0.33	0.10	0.44	0.32	0.11
Sweden	0.92	0.81	0.36	0.56	0.35	0.82	0.14	0.78	0.73	0.23
U.K.	0.87	0.70	0.35	0.45	0.34	0.54	0.08	0.41	0.77	0.14
Minimum	0.45	0.26	0.07	0.27	0.13	0.04	0.02	0.05	0.08	0.01
Maximum	0.93	0.83	0.43	0.60	0.48	0.84	0.19	0.85	0.77	0.64
Average	0.72	0.59	0.24	0.43	0.31	0.44	0.07	0.43	0.42	0.18
Std. Dev.	0.13	0.15	0.10	0.10	0.09	0.23	0.04	0.19	0.21	0.14

6.4 Analysis

6.4.1. Methodology: Factor analysis

Factor analysis is a multivariate technique that focuses on examining the underlying patterns of complex and multidimensional phenomena and allows to summarizing it in a small set of factors, thereby making its interpretation easier (Hair, 2014). This technique is especially suitable for the analysis of the digital divide, given the pervasiveness of ICT across the full society and economy (Frederico Cruz-Jesus et al., 2012) and its wide set of applications (e-health, e-banking, e-learning, etc.), which require taking into account multiple dimensions.

The application of this technique is in several steps (Sharma, 1996). The basis for its use is that data present an underlying correlation structure. If so, then it is possible to proceed with the analysis and obtain the factors. Once these have been calculated, the next step is to select the least number of factors that facilitate the interpretation of the phenomenon under analysis, while keeping the maximum of the original information. Finally, the selected factors are interpreted according to the factor loadings, i.e., correlation with original (contributing) variables.

The next two subsections describe the factor analysis performed on the ICT variables. The factor analysis is first carried out using aggregated data at country level for each of the member states. Second, data are disaggregated by educational level in order to assess the internal digital divides. The first procedure allows us to assess the digital divide across the member states of the European Union. By comparing its results with those of the second, it is possible to assess the extent to which an aggregate analysis can hide important insights about the digital divide. That is, while a country might be on average well positioned, there might be groups in its population suffering from digital exclusion. Only by running these two analyses simultaneously is it possible to expose the partial nature (if such is the case) of the picture provided by an analysis performed only at the country-level, which is the standard practice in the literature.

6.4.2 The digital divide across EU-28

As mentioned above, the success of factor analysis depends on the correlation structure in the input data (Hair et al., 1995). We therefore need to confirm that this correlation exists, otherwise the factor analysis may provide weak results.

The correlation matrix (see Table 6.3) shows that each variable has at least one absolute correlation coefficient of 0.60 with another variable. Although this correlation value is not extremely high, it ensures that all variables are measuring the same phenomenon – ICT adoption of individuals. We notice that some pairs of variables have very high correlation levels. The percentage of population regularly using the Internet (IntPop) has a correlation of 0.94 with the percentage of individuals using the Internet for finding commercial information about products or services (IntSrc) and a value of 0.92 with the percentage of individuals using e-banking services (eBank). At the other end of the spectrum we have the percentage of individuals looking online for information about education, training or course offers (eLearn) with a correlation level of 0.30 with the percentage of individuals using the Internet for finding commercial information about products or services (IntSrc).

Table 6.3 - Correlation Matrix

	IntPop	IntSrc	Mobile	eHealth	eLearn	eBank	eCivic	eGov	eCom	eCom_CB
IntPop	1	0.94 **	0.86 **	0.86 **	0.45 *	0.92 **	0.62 **	0.87 **	0.91 **	0.61 **
IntSrc		1	0.74 **	0.86 **	0.30	0.87 **	0.60 **	0.89 **	0.89 **	0.50 **
Mobile			1	0.68 **	0.58 **	0.78 **	0.61 **	0.74 **	0.82 **	0.67 **
eHealth				1	0.56 *	0.75 **	0.75 *	0.85	0.83 *	0.55 **
eLearn					1	0.36	0.63 **	0.44 *	0.46 *	0.53 **
eBank						1	0.62 **	0.86 **	0.79 **	0.53 **
eCivic							1	0.70 **	0.67 **	0.59 **
eGov								1	0.81 **	0.53 **
eCom									1	0.60 **
eCom_CB										1

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

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

Some more insights on the correlations of the data can be assessed by means of the Kaiser-Meyer-Olkin measure (KMO), in which values over than 0.5 indicate that the correlation is enough as to proceed with factor analysis. In the present analysis, the value of the KMO measure was 0.85, which expresses a very good suitability (Jolliffe, 2005; Sharma, 1996).

In order to obtain the factors, we used the standard factor analysis, which is widely used in Marketing and the Social Sciences (Peres-Neto et al., 2005). Then, we have to decide how many factors are to be extracted from the analysis in order to facilitate the understanding of the phenomenon, while keeping as much information as possible. There are several criteria on the number of factors to extract (Sharma, 1996): Pearson's (variance explained above 80%); Kaiser's (eigenvalues above 1); and the Scree Plot (visually interpretation of the solutions, selecting the one immediately before a breaking point). All of these methods were considered and yielded the same solution: the optimal number of factors to be extracted is two. As shown in Table 6.4, the percentage of variance retained by these two factors is 84%. To measure the scale reliability of each factor, Cronbach's alpha was also calculated. It measures the internal consistency of each factor within itself. The values returned were 0.96 for factor 1 and 0.70 for factor 2, which confirm the high scale reliability of the two factors extracted (Nunnaly, 1978).

The next step is to provide meaning to the two factors identified. The rotation of factors makes this task much easier as it allows a better split of the original variables between the factors (Sharma, 1996). Although there are several types of rotation, including orthogonal and oblique methods, the orthogonal ones seem to be the most widely used (Sharma, 1996). Varimax rotation is applied in the case of our study. We observe that out of the 10 original variables, seven of them are highly correlated (correlation over 0.7) with the first factor, while the remaining three have large correlations with second factor. By paying attention to the variables correlated with each factor, it is possible to interpret the meaning of them. The first dimension is related to the widespread of ICT among individuals, and could be labelled the *general ICT adoption by individuals*. This dimension includes the Internet use for a wide variety of activities, ranging from simple browsing to the use of specific advanced services, and the usage of mobile devices to access them. The second dimension is labelled *eLearning, cross-border eCom, and civic participation* since it is highly correlated with the take up of these services by Europeans.

Table 6.4 - Results of factor analysis

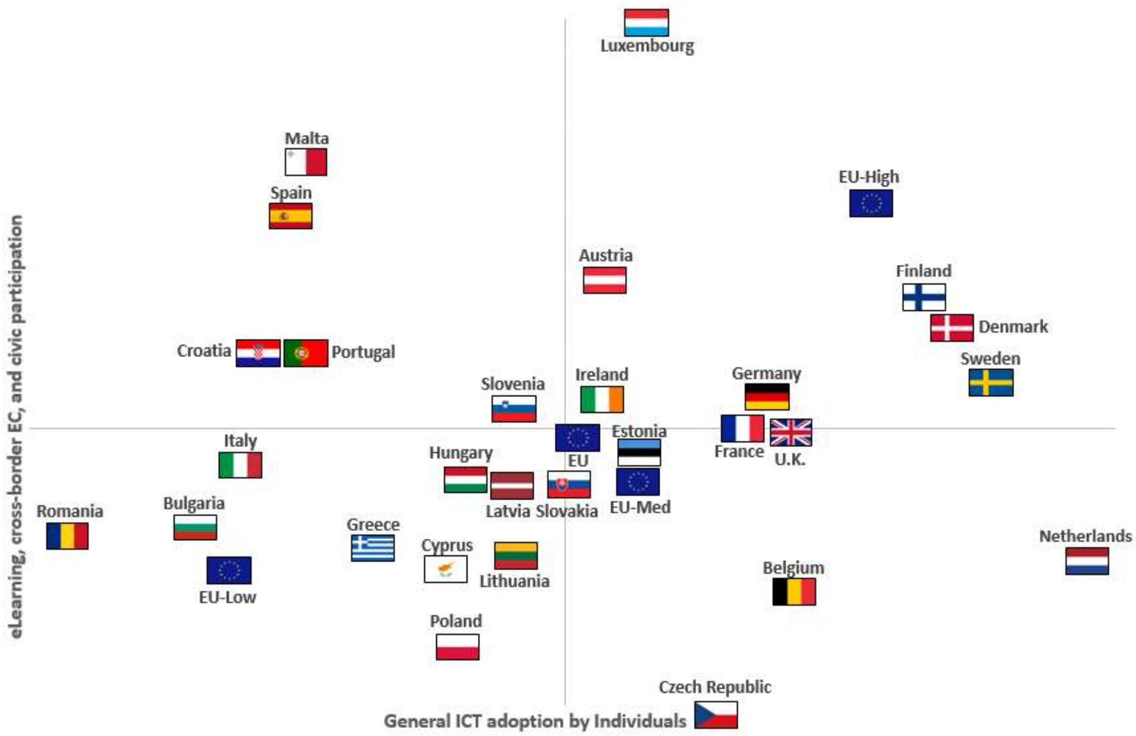
Rotated factor model: Varimax		
	Factor 1	Factor 2
IntSrc	**0.96**	0.19
IntPop	**0.92**	0.34
eBank	**0.89**	0.26
eGov	**0.86**	0.34
eCom	**0.85**	0.39
eHealth	**0.77**	0.48
Mobile	**0.71**	0.49
eLearn	0.12	**0.92**
eCom_CB	0.38	**0.71**
eCivic	0.48	**0.70**
Variance (%)	55%	28%
Variance Total	55%	84%
Cronbach´s Alpha	0.96	0.70

In order to assess the performance of each country in each dimension, factor scores can be computed. These scores are obtained as the product between the standardized factor score coefficients and the corresponding standardized values of the original set of variables.

Figure 6.1 shows countries' scores in the two factors/dimensions identified. The first factor, *general ICT adoption by individuals*, is plotted in the horizontal axis, where the right side indicates that a country scores higher than the European average and correspondingly, the left side shows that it is below it. The second factor, eLearning, cross-border eCom, and civic participation, is represented on the vertical axis, where the top and bottom sides mean that a country is over or beneath the mean, respectively. Hence, the upper-right quadrant includes those countries that score higher than the European average on both dimensions (+/+). The lower-left quadrant shows just the opposite situation, countries below the mean in both dimensions (-/-).

As one can see, the best-ranked countries in the first dimension, *general ICT adoption by individuals*, are the Netherlands, Sweden, Denmark, and Finland, while Romania and Bulgaria present the lowest levels in this dimension. In the second dimension eLearning, cross-border eCom, and civic participation, Luxembourg is far ahead among the member states, followed by Malta and Spain, while the Czech Republic and Poland are at the other end of the spectrum. Looking at upper-right and lower-left quadrants, it is possible to identify the best and worst performers in the two dimensions, respectively. The first group is composed of Northern and Central European Countries, while the second one includes Western and Southern states. This confirms the idea that the digital divide mirrors, at least to some extent, the traditional socio-economic divides between nations, a finding in line with earlier research (e.g., Çilan et al., 2009; Frederico Cruz-Jesus et al., 2012). Among the countries in the other quadrants, it is interesting to note that Dutch position: while it is the best-positioned country in the first dimension, it scores negatively in the second one. A similar case is that of its geographic neighbour, Belgium, which also scores negatively in the second dimension, while showing a positive score in the first, although not as good as the Dutch. Both countries are thus lagging behind regarding the use of eLearning, cross-border eCom, and civic participation. The countries closest to the European average are Ireland, Estonia, Slovakia, and Slovenia.

Fig. 6.1 - Countries' projections



6.4.3 The education-related digital divide across European member states

As the global position of European member states in the information society has been analyzed, we turn our attention to whether this position changes when educational attainment is taken into account, and if so, in what manner.

With that aim, education-related factor scores are obtained for each country. These scores are computed by multiplying the previously obtained factor score coefficients and the standardized values of the ICT variables, by the averages and standard deviations of the aggregated data, "*drilled*-down" by the educational classes specified above. With this approach we assure that both the aggregated and disaggregated countries are represented in the same space. The units of analysis are 84, i.e., the 28 European member states multiplied by the three educational classes (low, medium and high).

Figure 6.2 shows countries' positions in the two dimensions once education has been taken into account. The meaning of the axes is the same as in Figure 6.1. The quadrant in the top-right corner comprises those educational groups that are above the European average in both dimensions; conversely, the quadrant in the lower-left includes those that are below the mean. As one can see, the highly educated individuals of most member states are situated in the upper-right quadrant, with the exceptions of Malta, Spain, Italy, and Romania, which are in the upper-left quadrant; and Poland and the Czech Republic in the lower-right quadrant. Note that, therefore, no higher educated nationals are in the lower-left quadrant, the one with the lowest levels on both dimensions. It is also worth noticing that the Finish population, regardless of its education level, is above the European average in the two dimensions of ICT use. The upper-right quadrant also shows that, exceptionally, the low-educated populations of some Northern countries are using ICT more than the average, those being the less educated Swedish and Danish. The same happens with the Austrians, with medium educational attainment. The remaining low-educated Europeans are below the European average in the two identified dimensions and are situated in the lower-left corner, except for those in Luxembourg, who show a negative score in the first dimension and positive in the second, and the Dutch with just the opposite situation, positive score in the first dimension and negative in the second. Medium-educated Europeans are scattered over the two left quadrants and the lower-right quadrant.

Comparing Figures 6.1 and 6.2 leads to some interesting insights. For example, when aggregated figures are considered, factor analysis shows that Latvia is positioned in the lower-left quadrant, meaning that it is below the European average in both dimensions (Figure 6.1). However, when ICT figures are disaggregated by educational level, we see that Latvians with higher education score positively in both dimensions compared to the rest of educational groups, which score negatively (Figure 6.2). In the case of the United Kingdom, the aggregated results show that it is above the average regarding *general ICT adoption by individuals*, whereas it is below average for eLearning, cross-border eCom, and civic participation (Figure 6.1). By educational level, the United Kingdom shows some important gaps: the higher educated British perform positively in both dimensions, in contrast to the lower educated who score negatively and those with medium level education, who are good in terms of adoption but still lag behind in the take up of some online activities, i.e., e-learning, e-commerce, and e-participation (Figure 6.2).

Fig. 6.2 - Countries’ projections by citizens´ educational attainment

Table 6.5 summarizes the results of each country on each dimension when the analysis is performed with the population taken as a whole and when figures are disaggregated by educational level. This table clearly shows how the analyses performed on aggregated data can mask important internal divides within countries. In addition to the above-mentioned cases of Latvia and the United Kingdom, it is also worth mentioning what happens with Austria, Ireland, and Luxembourg. These three countries score positively on an aggregated level, meaning that their populations are above the European average in the two dimensions identified. However, when educational level is taken into account, it is possible to observe some problems with the low-educated Luxembourg population (negative score in the first dimension) and Austrians (negative score in both dimensions) and with the low and medium-educated Irish (the former with negative scores in both dimensions and the latter scoring negatively in the second dimension).

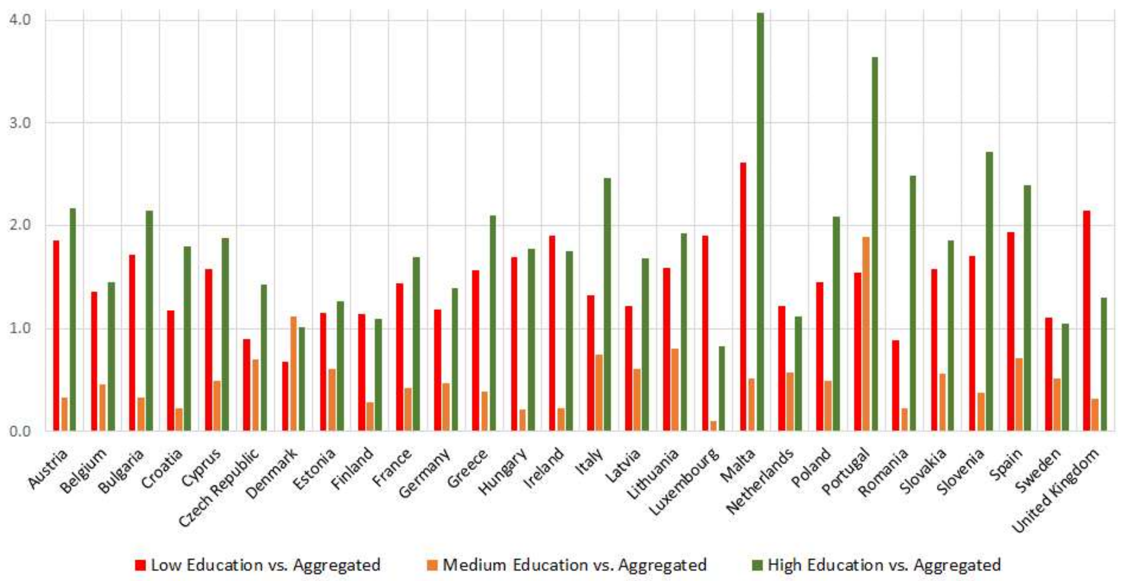
Table 6.5 - Countries' scores in each dimension

Country / Education	Aggregated		Low		Medium		High	
	Factor	Factor	Factor	Factor	Factor	Factor	Factor	Factor
Austria	+	+	-	-	+	+	+	+
Belgium	+	-	-	-	+	-	+	+
Bulgaria	-	-	-	+	-	-	-	+
Croatia	-	+	-	-	-	+	-	+
Cyprus	-	-	-	-	-	-	+	+
Czech	+	-	-	-	+	-	+	-
Denmark	+	+	+	+	+	-	+	+
Estonia	+	-	-	-	+	-	+	+
Finland	+	+	+	+	+	+	+	+
France	+	-	-	-	+	-	+	+
Germany	+	+	-	-	+	-	+	+
Greece	-	-	-	-	-	-	+	+
Hungary	-	-	-	-	-	-	+	+
Ireland	+	+	-	-	+	-	+	+
Italy	-	-	-	-	-	+	-	+
Latvia	-	-	-	-	-	-	+	+
Lithuania	-	-	-	-	-	-	+	+
Luxembourg	+	+	-	+	+	+	+	+
Malta	-	+	-	-	-	+	-	+
Netherlands	+	-	+	-	+	-	+	+
Poland	-	-	-	-	-	-	+	-
Portugal	-	+	-	-	+	+	+	+
Romania	-	-	-	-	-	-	-	+
Slovakia	+	-	-	-	-	-	+	+
Slovenia	-	+	-	-	+	-	+	+
Spain	-	+	-	-	-	+	-	+
Sweden	+	+	+	+	+	-	+	+
U.K.	+	-	-	-	+	-	+	+

Note: + indicates a positive score, that is, the country is above the European average in that dimension; conversely, - indicates a negative score, that is, the country is below the European average in that dimension

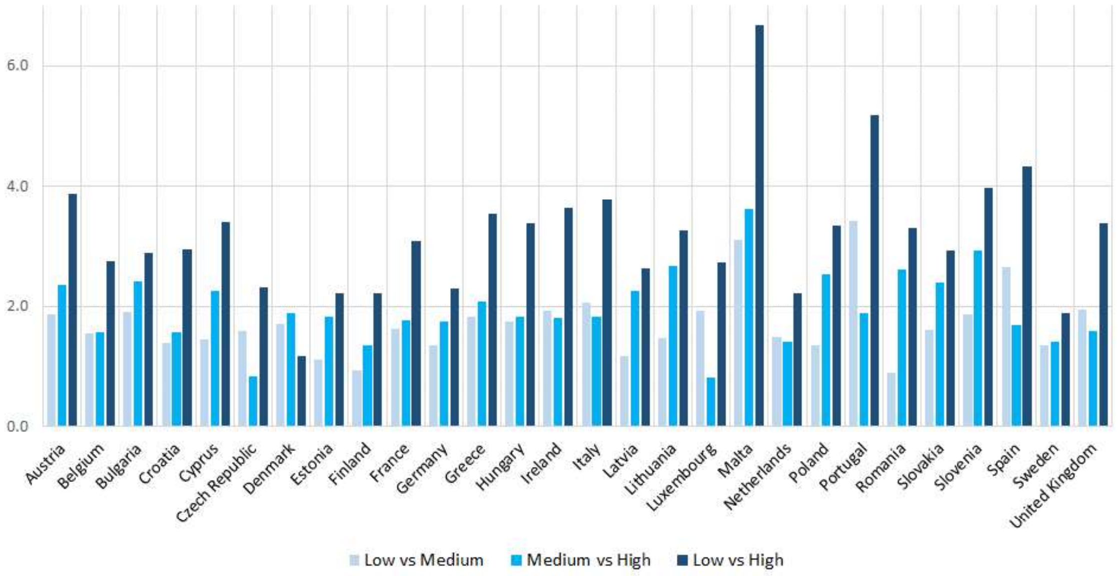
In order to gain some more insights on the internal digital divides described by education, we have measured the distances between factor scores using two different perspectives. In both, these distances correspond to the definition of the Euclidean distance between two points, where the scores in the first and second dimensions define the first and second elements of the coordinate, respectively. The first perspective involves calculating the distance between nationals of each of the three education classes to the national average (see Figure 6.3), and the second is calculating the combination of distances between the three (Figure 6.4). These two approaches are thus complementary.

Fig. 6.3 - The education-related digital divides – Education class vs. National average



When analyzing the differences between each educational class with the respective country, as seen in Figure 6.3, not surprisingly the medium educated individuals are those who best represent the aggregated national average. Hence, the main differences lies between those with low and high educations. However, the latter seems to distance themselves in a more intensive manner that the former. In other words, the gap between the higher educated citizens, with respect to the national average, is stronger than the lower educated when it comes to ICT use in 22 of the 28 member states.

Fig. 6.4 - The education-related digital divides – Education classes´ distances



Concerning the relative position between education classes, it is clear that, naturally, the largest divides are between the highest and lowest educated people, with Malta, Portugal, and Spain showing the biggest gaps. These three countries also show the largest divides between the medium and low levels of education, although Portugal and Malta interchange their positions. Note that the distance from low to medium educated, and from medium to high educated people, in terms of digital development, is somehow similar. At the other end of the spectrum, Denmark and Sweden have the smallest digital divides between the highest and lowest educated. Regarding the divide between medium and low education levels, Finland and Romania show the smallest. Nonetheless, the situation of these two countries is radically different, since the former has very high levels of ICT penetration and use compared to the low levels of the latter. This figure also reveals a quite unexpected result: in Denmark it seems that there is a larger gap between medium and low educated people compared to the gap between the high and low educated. The reason for this result can be found in Figure 6.2 and Table 6.6. They both show that while high and low educated Danish have positive scores on both dimensions, Danish with medium level of education score negatively in dimension 2. Overall, the factor scores obtained by educational level and the calculation of the above-mentioned distances allow us to better assess the internal digital divides that exist within a country.

6.5 Concluding remarks

Our paper has analyzed the digital divide across and within the EU-28, combining as units of analysis, both aggregated countries and individuals according to their educational levels. Since most earlier studies have focused on identifying digital divides, whether across countries or, for a particular country, within its population, we consider our study as a necessary advance to the general approach that takes account of the international digital divides but not of the internal gaps. Doing so is especially important since, as demonstrated, within a country some segments of the population might be lagging behind in the take up of ICT. Our analysis suggests that if we work only with aggregate levels, we might lose some important insights about the digital divide and fail to design appropriate policies as a result. Even in countries such as Finland, which is performing very well, there are some gaps to address within the population. In other countries such as Malta, Spain, and Portugal the big gaps are a concern. Hence, our analysis reveals that aggregated analysis can lead to false conclusions. Aggregated analysis shows only a part of the picture. This analysis should therefore complement traditional cross-country analysis.

Despite our best efforts to develop a complete and multidimensional analysis of the digital divide between and within countries of the European Union emphasizing the role of education asymmetries, some limitations must be acknowledged. First, our empirical application consists of just 10 variables, and, consequently, some features of the information society may very well not be covered by or data. Second, although we have analysed the digital divide within EU countries, this analysis covered only educational imbalances between individuals, which implies that other domestic divide gaps were not be covered, such as those regarding income or age of individuals. Finally, in third place, our analysis refers to the digital divide at a specific point in time, the year of 2013. Changes in this context are likely to occur with some speed, and our findings may become out-dated in the medium term.

Chapter VII

7. Conclusions

7.1 Summary of findings

Information and Communication Technologies (ICT) are today deeply integrated in virtually every aspect of economic and social activities, and they continue to hold the promise of tremendous innovation and development opportunities, provided that the right enabling conditions are put into place (European Commission, 2013). Thus, the conviction that greater adoption and use of ICT will foster growth and development, trumping the present socioeconomic difficulties, has been supported by some leading entities (e.g., European Commission, 2010a, 2010b, 2013; International Telecommunication Union, 2013; OECD, 2011; World Bank, 2016; World Economic Forum & INSEAD, 2013). Our research seems to indicate that this assumption is, however, far from being fulfilled, as strong digital disparities still exist across the World. In the European context (chapters three and six), and strong digital disparities were found across the European Union´s member states. Besides ICT asymmetries across countries, these are also detected within themselves. Europeans with different educational levels were found to have very different ICT adoption patterns. Other drivers, such as income and age, are also very likely to lead to domestic digital divides. As for countries not belonging to the EU, we also found important digital inequalities (chapters four and five). From a theoretical perspective (chapters two and four) in the root of digital inequalities there are economic, educational, and socio-demographic characteristics of countries, with their impact being dependent upon the context.

Based on our comprehensive literature review of the digital divide´s main drivers (chapter two), we were led to conclude that these are mainly related with the economic performance of countries, their education attainment, as well as ICT infrastructure and demographic factors (such as age of individuals). Additionally, there is some evidence that geography, gender, and ethnicity may also play a role in digital disparities across or within countries. One of the most important conclusions arising from the literature review, which influenced the path of this dissertation, was that research is usually conducted between or within countries, providing, in any case, an incomplete picture of the digital divide.

Our first study, which was focused on the European digital divide (chapter three), allowed us to identify two latent dimensions and five profiles of countries in terms of digital development. Our substantive findings demonstrate that a digital divide still exists within the EU, despite all the efforts to narrow it, specifically those from the European Commission. Results from chapter three seem to unveil a correlation between the European digital divide with economic asymmetries together with the entrance year to the Union. On the other hand, it was with some surprise that differences in education attainment at country-level does not appear to have a significant effect on the digital divide, which goes against what some studies have reported in the past. Finally, using data from 2008 to 2010 we were also able to track path movement of each country in the two dimensions identified. We were led to conclude that in one dimension there is evidence that the European digital divide is narrowing, while in the other it appears to be widening.

Our second research project, which was confined to the European context (chapter six) revealed what, at a first sight, may appear to be a contradiction with the first one (chapter three) – the fact that education is not a European digital divide driver. However, in our opinion, these two studies together serve as an (almost perfect) example of what we found as a gap in the digital divide literature review (chapter two). In chapter three we were limited to country-level data; whereas in chapter six we were not. In the EU, eastern countries are known to have, despite their lower levels of economic and digital developments, very good education systems and, therefore, well-educated individuals. Looking just at cross-country differences, it is therefore natural that education attainment does not emerge as a digital divide driver. However as soon as we were able to analyse domestic groups, strong asymmetries were unveiled across Europeans with different educational levels, regardless of their country. Results from chapter six also confirmed that the cross-country European digital divide still exists, as the results were in line with those obtained in chapter three, although data are from three years later (2013). This chapter was especially important since it demonstrated that even within a country with high levels of digital development some segments of the population might be lagging behind. If we work only with aggregate levels, we might lose some important insights about the digital divide and fail to design appropriate policies as a result. This conclusion is, we believe, valid for many other contexts than just the European one.

Outside the European context (chapter four), we analysed the digital divide and some of its potential drivers, between the countries of the EU, OECD, together with Brazil, Russia, India, and China (BRIC). Using multivariate statistical methods, we found a strong digital divide between these 45 countries. The most digitally developed countries are mainly located in Europe and North America, whereas the BRIC and eastern EU members are those lagging behind in terms of ICT adoption. In this chapter we developed a conceptual model for the global digital divide, which seems to indicate that the cross-country digital divide appears to be a direct consequence of economic and educational asymmetries between countries, whereas the size (area) of countries also has a word to say in this matter. Moreover, there is some evidence that domestic digital divides, specifically the differences between urban and rural areas, also appear to influence the digital development of a country.

As economic disparities, using the gross domestic product per Capita (GDP) as proxy, were found to be the most important, in chapter five, we analysed in detail the relationship between economic and digital development in a large-scale of countries – 110. As our aim was to explore the link between economic and digital developments, we assessed the pattern between the score of a factor analysis based on seven ICT-related indicators of countries, with their GDP. We also made use of cluster analysis to, as in chapters three and six, profile each country's economic and digital development, and georeferenced them on a world map. The less "economically-digital" groups are located in Africa and Southeast Asia. Progressively, countries with higher "economically-digital" development are located in South America, Europe, North America, and Oceania. The main conclusion of this study is that, although the correlation between economic and digital development of countries is very high, it appears to be even stronger in developing countries. In other words, it is non-linear, perhaps meaning that for those countries with the conditions to acquire ICT, other factors emerge regarding the actual use of these technologies. This chapter is very important in the sense that most methods used to assess the digital divide´s drivers have as assumption the linear relationship between economic and digital development.

7.2 Contributions

In Chapter two we conducted a literature review on the global digital divide, focusing on the evolution of this phenomenon as a research subject, and also its main drivers. The main contribution lies in the fact that, to the best of our knowledge, a research specifically focused on the cross-country digital divide has not yet been undertaken, thus bridging a gap in the literature. From this chapter, a main contribution to researchers should be the idea that cross-country analysis should also include domestic data.

In chapter three a European digital divide analysis was conducted, using a multivariate framework. The main contribution of this chapter is that different profiles of digitalization were found and, for each of them, a recommended path toward digital development was drawn. Also, European policy-makers should be aware that there is a strong European digital divide, grounded not only on economic imbalances, but apparently also based on the European entrance date. The digital divide is significant in the sense that the European "digital leaders" have at least a three-year head start on to their counterparts. Hence, bridging this divide is not an easy task.

Chapter four develops a conceptual model for the cross-country digital divide, in which different would-be drivers are empirically tested in a set of 45 developed and developing countries. To the best of our knowledge, this is one of the first attempts to develop a theoretical model for understanding the digital development at country level. Using different theories as lenses to understand the digital divide, our findings suggest that economic, educational, and to some extent geographic factors, help explain the existence of digital asymmetries at country level.

In chapter five, we analyze in detail the relationship between economic and digital development of a comprehensive sample of countries – 110. This chapter comes as a result of our findings in the previous one. The main contribution of this chapter, both to academics and policy-makers, is that this relationship is not linear, as it is widely assumed to be in other research projects. Economic and digital development are highly correlated where economic levels are low. From a certain point, this relationship fades out or, at least, decreases significantly. Hence, it seems that once the ability to acquire

ICT is achieved, other factors come into play to influence ICT adoption and use. Future studies should include this non-linear relationship as an assumption, which clearly does not occur by default.

Finally, chapter six analyzes the European education-related digital divide both at country-level (across the 28 member states) and also within the countries. Hence, as suggested in chapter two, we included cross-country and domestic digital divide analysis together. The main implication of this chapter is that, effectively, only cross-country analysis may hide relevant domestic asymmetries. Even the most digitally developed European countries presented, in some cases, important educational-related domestic divides. Hence, researchers should definitely take into account domestic analysis when analyzing country-level data. For policy-makers it is suggested that in addition to national (aggregated) data, those from individuals that are more likely to be digitally excluded also be used.

7.3 Limitations and future research

As in most empirical studies, our work is limited in some ways. Firstly, the cross-sectional nature of the studies conducted does not allow knowing how the digital divide and its drivers will change over time. Hence, future research should involve panel data, although that may not be as easy as it seems given the very dynamic evolution of ICT. Another limitation, and perhaps the most important one, has to do with the trade-off between the number of indications we include with the number of countries under study. In other words, despite the high number of indicators we use in order to cover all aspects of the information society, the fewer are the countries that could be included. It should be kept in mind that if the data collected are scarce in terms of number of countries and/or drill-downs, the conclusions will be limited. On the other hand, if the data are scarce in terms of number of variables, conclusions may be misleading. In order to minimize this constraint, primary (individual) data should be included in future works.

Finally, the most important suggestion for future research, which we have endeavoured to address in chapter six, is that studies begin to consider, simultaneously, both international and domestic differences. As was referred to in the literature review, and confirmed in the previous chapter, neglecting this choice may lead to misleading results. Hence, other studies following this path should be conducted, especially those including income-, age-, ethnic-, and gender-related digital divides.

Chapter VIII

8. References

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