Measuring the digital divide at regional level. A spatial analysis of the inequalities in digital development of households and individuals in Europe

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Abstract

The aim of this paper is to identify the spatial inequalities in digital development (digital divide, DD) of households and individuals in Europe at regional level. Digital development is understood as the level of access to and use of Information and Communication Technologies (ICTs) in households and by individuals. This study has been undertaken using the following methodology: 1) factor analysis to identify the key variables of use of and access to ICTs in households and by individuals in European regions on the basis of data provided by Eurostat; 2) construction of a synthetic index, the household and individual digital development index (HIDDI) on the basis of identified factors; 3) analysis of the spatial autocorrelation of digital development to identify, delimit and quantify spatial patterns and clusters in European regions.

The results of this study lead to the conclusion that the digital development of households and individuals in European regions is founded on broadband Internet access. In this context, the level of digital development and the DD of European regions is based on households and individuals' daily use of e-commerce, e-banking and e-government services. However, the use of social networks in households with broadband shows less DD in Europe. The values obtained by using the HIDDI for each European region reveal that the maximum DD between these is 37%, with the spatial autocorrelation analysis identifying a NW-SE pattern in Europe. Thus, a region's level of digital development is directly related to that of its neighbours; and geographical proximity/vicinity is an element to take into account when analysing the disparities of the DD.

Keywords: ICTs, NUTs 2 region, complex index, regional spatial pattern, spatial clusters.

Highlights

- The digital development of households/individuals in European regions is based on broadband Internet access.
- Households'/individuals' daily use of e-commerce, e-banking and e-government services establishes the level of digital development of European regions.
- The maximum DD between European regions is 37% of households/individuals, according to the HIDDI values.
- There is less DD between European regions in the use of social networks in households with broadband.
- The spatial autocorrelation analysis shows a NW-SE spatial pattern of DD among European regions.

1. Introduction.

Digital development is understood as a process by means of which all the households and individuals in a society have access to Information and Communication Technologies (ICTs) and can use them for a wide range of basic public and private services, and also to communicate, interact and relate to each other and their governments. ICTs refer to the set of tools, usually of an electronic nature, used for the collection, storage, processing, dissemination and transmission of information. This set includes both physical devices (computer equipment, telecommunication networks, terminals, handsets, etc.) and the software or computer applications that run on these devices (INE, 2017). ICTs are a vector of social development and transformation (Sujarwoto and Tampubolon, 2016) as they improve citizens' access to basic services (Falch and Henten, 2017) and create new employment opportunities (Van Deursen and Van Dijk, 2013). Thus, several studies have shown (Barzilai-Nahon, 2006; Van Dijk, 2006, Vu, 2011) that the mere provision of ICT infrastructures does not enable the social inequalities existing in the global information society to be redressed (Helsper, 2012; Witte and Mannon, 2010) and thereby achieve sufficient digital development.

The inequalities in digital development are generically known as the digital divide (DD). The OECD (2001) defines DD as the gap between individuals, households, businesses and geographical areas at different socio-economic levels with regard to both their opportunities to access ICTs and their use of the Internet for a wide variety of activities (Van Deursen, et al., 2015; Alizadeh e Farid, 2017; Gonçalves et al., 2018; Jordá-Borrell et al., 2018). Within this context, numerous studies in the last decade have addressed the need to detect measure and understand the differences between a society having accessibility and/or its use of computers and the Internet (Yu, 2006; World Economic Forum, 2017).

From the perspective of a geographical analysis of the DD (geographical areas), the main indicators and indices created by different institutions to measure digital development do not reflect the complexity of this concept and have usually been applied at country level (Ruiz-Rodríguez et al.., 2018). Meanwhile, the study for other territorial levels, such as rural/urban areas is undertaken from the perspective of the digital inclusion of the rural population in view of the lack of access to infrastructures and/or individual ICT skills (Freeman et al, 2016; Salemink et al., 2017). Choosing the country level for geographical analyses of the DD may therefore conceal intra-national differences in access to and use of ICTs (Pick and Nishida, 2015) as states have large socio-economic disparities at regional level (Beugelsdijk et al., 2017 and 2018; Iammarino et al., 2018; Charron et al., 2015). Hence, it is with good reason that the territorial cohesion policies in Europe are fundamentally designed and managed from and for regional political and administrative levels (European Commission, 2010; Asheim, 2018).

Moreover, the scientific literature on DD has focused on the identification of the socio-economic and institutional factors that explain the different levels of digital development of countries/ rural-urban areas (Salemink et al., 2017). Meanwhile, the geographical distance between areas has been less studied as an element of diffusion of ICTs, although some authors have already shown that geographical proximity may exert an influence on the diffusion and scale of digital development and, consequently, on differences in DD (Corrocher and Ordanini, 2002).

Consequently, a shortfall of studies that contribute to measuring and explaining the DD between European regions at household and individual level can be detected. There are still questions to be resolved: 1) What is the magnitude of the DD between European regions? 2) What types of ICTs define this digital divide? 3) Is there a spatial pattern of regional DD? Hence, the main objective of this paper is to identify the spatial inequalities in digital development of households and individuals at regional level in Europe. This objective entails: i) identifying the key variables that define the underlying structure of the digital development of households and individuals in European regions on the basis of data provided by Eurostat; ii) constructing a synthetic index to measure current achievements in digital development by European regions and, moreover, the DD between them; and iii) identifying the spatial patterns and clusters of European regions according to the level of digital development of households and individuals on the basis of the synthetic index in order to show the DD between them.

This paper first addresses the theoretical background of the DD of households and individuals at regional level in Europe. Second, there is a description of the methodology used to measure both the digital development of European regions and the DD existing between them and the resulting spatial pattern. In the following section, the results of the analysis are provided: the dimensions of digital development, the ranking of the level of digital development of European regions and the spatial inequalities between regions in terms of digital development. Finally, there is a discussion of the results obtained, conclusions are drawn, and there is an evaluation of their contribution to the scientific literature and to public policies for ICTs and for reducing regional inequalities.

2. Theoretical background

The first scientific studies on the DD primarily focused on examining the conditions of citizens' access to information (Riggins and Dewan, 2005; Kraemer et al., 2005). The DD was initially understood in a binary fashion and was restricted to distinguishing between having and not having access to ICTs (first level of analysis of the DD, according to Scheeders et al., 2017; Cruz-Jesus et al., 2012; or Eastin et al., 2015). This understanding was useful for describing social and technological inequalities, but it was a reductive, imprecise and inexact classification to apply in some territories with a large amount of ICT infrastructure. However, it is known that the internet and broadband penetration decreases as distance increases. So, it's still an important issue for large territories like the US, Canada or Australia, where access to reliable and fast digital connectivity is a perennial problem (Freeman et al, 2016). This gave rise to a second level of analysis of the divide based on types of use (Scheeders et al. 2017, van Deursen et al. 2015), which was in line with the EU's most recent definition, according to which the DD does not only contemplate the population that has access to the Internet and other digital technologies, but also reflects concerns about the use of commercial and government services, putting emphasis on the groups without digital access that get left behind and are missing opportunities (European Commission, 2010).

Research related to ICT applications and services has a more recent origin (Falch and Henten, 2017) and the issue has become a major policy concern. There is currently talk of a third level of analysis of the DD, which focuses on the beneficial results of Internet use (Wei et al., 2011; Van Deursen et al., 2014), making it clear that inequalities occur when, despite access to and frequent and extensive use of ICTs, this does not lead to beneficial socio-economic results (Van Deursen et al., 2015; Baller et al., 2016)

Even so, there is an ongoing debate on the approach to the DD which focuses exclusively on inequalities in access to the Internet (Fuchs, 2009; Selwyn, 2004; Van Dijk, 2006) especially in those territories (rural areas, less economically advanced regions, geographically isolated populations) where the limited provision of ICT infrastructure and the activities linked to them (online) will be subject to accessibility to infrastructures and the quality of internet connections (Hale et al 2010; Freeman et al, 2016). In fact, although this is not the case in all developed countries such as the US or Australia, in most european countries, a large proportion of the population has a connection to the Internet, and accordingly having a connection is no longer considered to be an element that generates digital inequality, Thus, measuring the DD on the basis of access to Internet in Europe started to be questioned when broadband and digital devices became more commonplace (Scheerder, et al., 2017) and super-fast broadband began to be seen as an essential service to foster economic growth and social development (Broadband Commission, 2016). Therefore, the DD in Europe already goes beyond physical access or the economic possibility of offering a high-speed Internet connection, and is actually a complex and dynamic concept.

Thus, the European Digital Agenda 2010 focused, to a large extent, on developing ICT applications and services for citizens, which promote and facilitate their commercial, institutional and social relations. On the one hand, the Nordic countries prioritised the implementation of e-government applications, in order for citizens and businesses to request information, relate to the public authorities and apply for public services, which has led to the massive deployment of broadband (Falch and Henten, 2017). On the contrary, other countries, especially in South-Eastern Europe, have given priority to developing the broadband network prior to the diversification of applications and Internet use.

Currently, inequalities or the DD are created by the types of Internet use. Studies on Internet use have generally focused on frequency and type of activities (Purcell, 2011; Scheerder et al., 2017). Brandtzæg et al., 2011 explain the DD by identifying the variety of ways in which people in Europe use the Internet (non-users, occasional users, utility users, entertainment users and advanced users). At present, social networks have popularised Internet use by individuals seeking greater social interaction (Van Deursen et al., 2015). This trend has also increased due to the facilities provided by mobile Internet access via tablets and smartphones (Van Deursen and Van Dijk, 2013). In fact, recent research affirms that people in western countries tend to use the Internet and ICTs mainly for recreational purposes (Pearce and Rice, 2013; Van Deursen and Van Dijk, 2013; Zillien and Hargittai, 2009, Feijóo et al., 2017), and to a lesser extent for social, technical and commercial services, leisure, etc. (Kalmus et al., 2011; Amichai-Hamburger and Ben-Artzi, 2003). Hence, gaining greater knowledge of the types of use is also a means to understanding the DD, providing a more nuanced perspective on the unequal use of the Internet and participation in an increasingly digital society.

As well as the advances in the conceptualisation of the uses of ICTs and of the DD between individuals, it is also necessary to know the extent and importance of differences between countries or geographical areas (Novo-Corti and Barreiro-Gen, 2015; Schlichter and Danylchenko, 2014). Methodologies have been developed to measure the levels of access to and use of ICTs and the DD. However, the main indicators and indices created by different institutions to measure the DD have mainly been applied at country level: the "ICT Development Index" published by the International Telecommunication Union (ITU, 2017), the World Economic Forum's "Networked Readiness Index" (World Economic Forum, 2017) and the "Digital Economy and Society Index (DESI- European Commission, 2017), which has been published annually by the European Commission since 2014, among others. To date, these indices have been used by different studies to explain the DD in connection to socio-demographic factors and other economic characteristics of ICT users (Vehovar et al., 2006; Barzilai-Nahon, 2006; Mason and Hacker, 2003; Zoroja, 2011).

However, recent studies (Ruiz-Rodriguez et al., 2018) have shown that, to measure regional differences in access to and use of ICTs and the DD, these national indices have a number of limitations. It is worth noting, for example, a simplification of the complex interrelations between the ICT variables (Vehovar et al., 2006); the inappropriate selection of variables related to ICT technologies; or the random weight assigned to each indicator or variable in calculating the indices (OECD, 2008, Bruno et al., 2010). In this respect, European regional data (at NUTS 2 level) may be viewed via the Digital Economy and Digital Society Statistics at Regional Level (Eurostat, 2017), but the conclusions drawn refer to the variables analysed in a univariate manner, without talking into consideration the interrelationships produced between them (European Commission, 2017). Despite these limitations, the national indicators developed to measure ICT deployment and usage revealed the existence of different levels of DD between geographical areas, such as the north-south divide at global/worldwide level, or that which exists between EU Member States (Moroz, 2017; Cruz-Jesus et al., 2012; Schlichter and Danylchenko, 2014; Corrocher and Ordanini, 2002). Specifically, Billon et al. (2009 and 2016) define a spatial pattern of DD for Europe between Northern, Southern and Eastern Europe.

A line of research on the DD is accordingly opened that incorporates a new component to take into account in the analysis of the differences of level of digital development: the role of geographical space and the identification of spatial patterns of DD. The levels of technology and ICT usage of countries and geographical areas do not only depend on social, economic and governmental factors and social openness, as geographical proximity may also exert an influence on the diffusion and scale of digital development (Pick and Nishida, 2015).

With this argument, some studies have addressed the DD by using spatial analysis techniques (spatial autocorrelation) at national level in Europe (Van Dijk, 2006), the United States, Japan, China, Indonesia, etc. (Nishida et al., 2014; Pick et al., 2015; Grubesic, 2010). All of these demonstrated that geographical space is of great importance to explain the diffusion of similar ICT levels, virtual space and the DD (Grubesic and Murray, 2005; Pick et al., 2015). Hence, geographical proximity plays a relevant role in ICT usage and differences in the DD. These conclusions therefore reinforce Tobler's first law of geography (2004), which states that "everything is related to everything else, but near things are more related than distant things"; and are contrary to the theory of the death of distance (Cairncross, 1995), which defends that geographical space would cease to have importance with the development and diffusion of ICTs (Grubesic and Murray, 2005; Sujarwoto and Tampubolon, 2016).

3. Methodology

3.1. Data used: sources, variables and unit of analysis.

The data used in this research come from the Eurostat survey "ICT usage in households and by individuals" (isoc_i)[1] for 2017. The main reason for using Eurostat statistics is that these data are available and standardised at international level, which ensures that the results of the analysis have a high degree of reliability. This survey provides data on access to and use of ICTs for two statistical units: households (all private households having at least one member in the age group 16 to 74 years); and individuals (individuals aged 16 to 74). The databases of the survey cover different areas or topics, such as "Access to IC technologies", "use of the Internet and other electronic networks for different purposes", "use of ICT by individuals to exchange information and services with governments and public administrations (e-government)", etc.

Table 1. Variables used in the analysis

ÁREAS	VARIABLE AND UNIT OF MEASUREMENT	ABBREVIATION
ACCESS TO THE INTERNET AT HOME	1. Percentage of households with access to the Internet at home 2. Percentage of households with broadband access 3. Percentage of households with broadband Internet access at home	a) H_ACCESS home b) H_ACCESS broadband c) H_ACCESS internet by broadband
USE OF THE INTERNET BY INDIVIDUALS	4. Percentage of individuals who use the Internet daily 5. Percentage of individuals participating in social networks (creating user profile, posting messages or other contributions to Facebook, Twitter, etc.) 6. Percentage of individuals using Internet banking 7. Percentage of individuals selling goods or services 8. Percentage of individuals who never use the Internet 9. Percentage of individuals who access the Internet away from home or work	d) IND_USE_daily e) IND_USE_social_networks f) IND_USE_banking g) IND_USE_selling h) IND_USE_never i) IND_ACCESS_away from home or work
INTERACTIÓN WITH PUBLIC AUTHORITIES VIA E-GOVERNMENT	10. Percentage of individuals interaction with public authorities (last 12 months) 11. Percentage of individuals submitting completed forms (last 12 months)	j) IND_INTER_public authorities k) IND_INTER_submitting forms last 12m
E-COMMERCE:	12. Percentage of individuals whose last online purchase was in the last 3 months 13. Percentage of individuals whose last online purchase was more than a year ago	l) IND_BUY_online purchase last 3m m) IND_BUY_did not online purchase in the last year

[1] http://ec.europa.eu/eurostat/web/digital-economy-and-society/data/database

	14. Percentage of individuals who ordered goods or services, over the Internet, for private use, more than a year ago or have never ordered	n)	IND_BUY_did not order goods or services in the last year or never
	15. Percentage of individuals online purchases travel and holiday accommodation	o)	IND_BUY_purchases travel
	16. Percentage of individuals online purchases from sellers from other EU countries	p)	IND_BUY_otherEUcountries

Source: own preparation.

The survey used provides data at country level for EU Member States, candidate countries, and Iceland and Norway. However, this scale often conceals intra-national differences (Corrocher and Ordanini, 2002; Pick and Nishida, 2015). In this respect, it was decided to measure the DD at regional level in this study, making use of data disaggregated by region of residence (NUTS[2], "isoc_reg" section), specifically, at NUTS 1 and NUTS 2 levels.

This paper studies access to and use of ICTs in households and by individuals in the regions of the 28 countries of the EU and Republic of Macedonia, Norway, Iceland, Switzerland and Turkey. The reference area chosen for the regional analysis of digital development of households and individuals in Europe is the NUTS 2 level. However, the variables of the Eurostat survey "ICT usage in households and by individuals" listed in Table 1 are disaggregated at NUTS 2 level for all the countries indicated above except for Germany, Greece, Poland, United Kingdom and Turkey. To address the lack of data at regional level for these countries and, therefore, avoid conducting an incomplete regional analysis, the NUTS 1 regions of these countries have been included in this study, for which Eurostat does offer data on the variables selected in Table 1. Consequently, in order to undertake this research, a database was developed with 16 variables of ICT usage in households and by individuals (Table 1) for 242 European regions (190 NUTS 2 and 52 NUTS 1[3]).

The exploratory data analysis (Table 2) of access to and use of ICTs in households and by individuals enables differences to be observed in the behaviour of European regions for certain variables. On the one hand, the variable *H_ACCESS internet by broadband* has the highest average, with 97% of households in European regions having this type of connection. On the other hand, there is a set of variables that provide data with large standard deviations (over 16% of households and individuals), such as *IND_USE_banking, IND_INTER_public authorities*, *IND_INTER_submitting forms last 12m, IND_BUY_online purchase last 3m, IND_BUY_purchases travel* and *IND_ACCESS_away from home or work*. This indicates a high variability and differentiation between households and individuals in European regions for these ICTs. On the contrary, there is another set of variables with low variability (standard deviations close to 0% of households and individuals), such as the aforementioned

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[2] The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU. Source: http://ec.europa.eu/eurostat/web/nuts. See the Appendix A.

[3] In the final analysis, 7 NUTS 2 and 2 NUTS 1 were omitted due to lack of data, hence in the end 233 European regions were analysed.

H_ACCESS internet by broadband and *IND_BUY_did not online purchase in the last year*, with very similar values for households and individuals across European regions.

Furthermore, the descriptive statistical analysis showed that there are two items, *IND_BUY_did not order goods or services in the last year* and *IND_USE_never,* that behave in the opposite fashion to the other variables. Indeed, whereas European regions have low percentage values for these two variables, percentages are high for all other items, and the opposite. Thus, for the sake of statistical analyses[4], the values of these variables were transformed by inverting the ranking of the same in the following manner: the percentage values of these two variables was subtracted from 100 (%) for each region. As a result, in the following statistical analyses, the two variables in question were changed to *IND_BUY_ordered goods or services in the last year* and *IND_USE_ever*.

Table 2. Descriptive statistics of the variables analysed.

VARIABLES	Mean	SD	Min.	Max.
H_ACCESS home	85	8.4	58	100
H_ACCESS broadband	83	8.9	55	100
H_ACCESS internet by broadband	97	3.3	84	100
IND_ACCESS_away from home or work	66	**16.6**	**26**	**95**
IND_BUY_did not online purchase in the last year	6	2.7	0	15
IND_BUY_online purchase last 3m	43	**18.8**	**8**	**75**
IND_BUY_did not order goods/services in last year	32	12.5	11	66
IND_BUY_public authorities	22	12.3	1	77
IND_BUY_purchases travel	30	**17.9**	**1**	**69**
IND_INTER_submitting forms last 12m	36	**19.9**	**2**	**77**
IND_INTER_public authorities	54	**22.1**	**6**	**91**
IND_USE_banking	54	**24.7**	**2**	**96**
IND_USE_daily	72	12.3	40	96
IND_USE_never	13	8.8	0	35
IND_USE_selling	17	10.1	1	44
IND_USE_social_networks	56	12.2	34	89

Source: own preparation.

3.2 Statistical analysis.

3.2.1 Factor analysis.

To study the differences in digital development between European regions, the univariate statistical analysis of the ICT variables is insufficient, as it does not enable the interrelationships that make up the underlying structure that defines digital development to be known. Measuring digital development should include the interrelationships of the multiple aspects related to the access to and use of ICTs in

[4] In fact, this was confirmed subsequently on performing the factor analyses, where inverse correlations were noted between these two variables and the rest. This affected the interpretation of the factors as, in the rotated component matrix, the two variables in question appeared with a minus sign, which indicated this inverse behaviour. The above-mentioned transformation of the variables did not alter either their association with their factor, or the value of the correlation coefficients with the same, it only changed their sign. Hence the new names of these two variables.

households and by individuals in European regions, such as: the availability of infrastructures that enable access to the Internet; and the different types and frequency of uses of the Internet (e-commerce, public administration, social networks, etc.).

Factor analysis (FA) has been used in order to identify the interdependences between all the ICT variables. FA is a multivariate statistical technique that enables the interdependences between a broad set of variables to be analysed and identified, by aggregating them by means of common and unique factors that are not directly observable (Pérez Gil et al., 2000; Uriel, 1995; Martínez Arias, 1999). Authors such as Cruz-Jesus et al. (2012, 2016) or Corrocher and Ordanini (2002) consider FA to be an especially appropriate statistical technique for the analysis of digital development, given the omnipresence of ICTs in society and in the economy. In this respect, an exploratory factor analysis was performed using the main components method. The purpose of the exploratory analysis is to obtain an optimum number of factors and the factor structure underlying digital development in households and by individuals in European regions. The main components method, for its part, is the most appropriate when it is intended to initially establish a theory or model as it seeks to find the minimum number of factors that explain the largest possible amount of variance or information (Frías-Navarro and Pascual-Soler, 2012). To this end, it was decided to obtain a factor matrix rotated by the Varimax method.

3.2.2 Construction of a synthetic index of access to and use of ICTs in households and by individuals.

A synthetic[5], objective and quantifiable index was developed to measure the average level of access to and use of ICTs in households and by individuals in each region. This index is composite as it takes into consideration the existence of the interrelationships between the variables provided by Eurostat (shown in Table 1). This index has been named the Household and Individual Digital Development Index (HIDDI) for European regions. Synthetic or complex indices allow the degree/level that these subjects reach with respect to the index developed, and to each other, to be measured and compared (Quintero, 2008). As indicated in the previous section, the use of complex indices that address the measurement of digital development and the DD of individuals and households at regional level is rare, and thus the methodology developed in a previous work was based on to develop the HIDDI (Ruiz-Rodríguez et al., 2018).

In order to develop complex indices, authors such as Poza and Fernández (2010), Castro (2009), Castaño (2011), Nunnally (1978), Stapleton (1997) and Nardo et al. (2005) recommend using multivariate statistical analysis procedures that, as well as reflecting the underlying relationships between the variables used, allow the aggregation and weighting of the same in the final index. Moreover, using these statistical methods enables some methodological problems related to the construction of the synthetic index to be addressed, namely: which aspects to be considered are relevant for adequate measurement; how to reduce the subjectivity associated with the index; how to integrate the different elements and/or criteria to be assessed; and

[5] In accordance with the OECD's glossary of statistical terms, we understand a synthetic index to be that mathematical combination (or aggregation) of the indicators that represent the different components of the concept to be assessed on the basis of an underlying model, providing a multi-dimensional assessment of the same (Saisana and Tarantola, 2002)

how to evaluate or weigh the importance of these components (Barredo Cano, 1996; Corrocher and Ordanini, 2002; Galacho and Ocaña, 2006; Domínguez Serrano et al., 2011). From among the different statistical procedures for developing synthetic indices indicated by international organisations such as the OECD (2008) and the ECLAC, (developed by Schuschny and Soto, 2009), the one followed is a compensatory model (Jankowski, 1995) as the index that it is intended to develop should: i) integrate the information on all the variables relating to access to and use of ICTs in households and by individuals in European regions into one single value, paying attention to the relationships or structure underlying these data; and ii) consider the possible compensation or weighting of the criteria, that is, taking into account the weight or relative importance that each variable has in the set as a whole.

One of the most recommended multivariate statistical techniques (OECD, 2008; Schuschny and Soto, 2009) for obtaining a complex index is factor analysis (FA), as in the case of the HIDDI it is possible to know:

i) how the variables of access to and use of ICTs in households and by individuals that are going to form part of the composite indicator interrelate statistically. Indeed, the factors of the FA show the underlying or latent dimensions (not directly observable) existing between the variables based on the correlations.

ii) the weight of each variable of access to and use of ICTs according to the value of its correlation with each component (factor loading or saturation); and the relative importance of each factor or dimension within the aggregate indicator, which derives from its eigenvalue or total variance explained (Corrocher and Ordanini, 2002).

In this way, and following a bottom-up procedure, the variables on access to and use of ICTs in households and by individuals are grouped forming different factors; each factor is a dimension of the HIDDI according to its weight in the factor model; and, finally, all dimensions will be aggregated to form a single measurement, the HIDDI, of each region by calculating the weighted arithmetic mean according to the weight of each dimension (the value of the variance explained by each factor). All of this is expressed in the following equation to weight the factors by adapting the weighted linear summation (Galacho and Ocaña, 2006):

$$\textbf{\textit{HIDDI}} = (A_{fi} * D_{fi}) / 100 \qquad [1]$$

Where:

HIDDI Index of ICT Usage in Households and by Individuals

Af_i Weight of each dimension. It´s the eigenvalue of each factor (*fi*) as % of total variance explained.

D_{fi} Value of each Dimension or variable (*fi*) of the % of Households and Individuals. It is calculating as the mean or average of: C_{fi} (the factor loading for each variable *fi* included in each dimension in the Table 6 Rotated component matrix); and V_{fi} (the value of each ICT variable *fi*).

Therefore, based on this statistical procedure, the HIDDI shows the aggregate value (average) for each European region, that is, of all the variables of ICT usage analysed (Table 1). As these variables have the same unit of measurement (percentage), the HIDDI does not need standardisation and, as a result, the value of the index will be the average percentage of digital development of households and individuals in each European region. The proposed method makes it possible to explain the differences in levels of digital development between European regions on the basis of the factors identified. Thus, the greater the value of the HIDDI, the greater the digital development of a region, and the opposite.

The development of the HIDDI enables advances in the access to and use of ICTs in households and by individuals in different European regions to be measured jointly. The HIDDI is, therefore, a comparative measurement of digital development for all the regions of Europe. If we compare the value of the index for each European region with that which has the highest value in the HIDDI, the result shows the differences in digital development between them, that is, the DD.

3.3 Spatial autocorrelation analysis.

The analysis of the spatial distribution of the HIDDI makes it possible to know whether spatial patterns of digital development exist in European regions. Spatial pattern is understood to mean the way in which regions with similar values of digital development are distributed geographically. When these regions are close or adjacent they form a spatial cluster. A spatial cluster of regions implies the presence of a spatial association or autocorrelation between them. The spatial autocorrelation is based on Tobler's first law of geography (2004) which states that, in geographical space, everything is related to everything else, but near things are more related than distant things. Although it is possible to identify a spatial pattern through the cartographic representation of the HIDDI of European regions, it is essential to verify this pattern by using spatial statistical techniques. Geographical information systems (GIS) enable the analysis of spatial autocorrelation with a wide array of spatial statistical techniques.

To this end, a GIS was created with ArcGis v10.3 software by ESRI georeferencing the thematic database (prepared in this study with the 233 regions and the variables of access to and use of ICTs in households and by individuals) with vector coverage of the GISCO NUTS 2013 spatial database from Eurostat, which contains the shapefile of European NUTS. This GIS was used to examine whether there is a spatial pattern by calculating local and global indices of spatial autocorrelation since, according to Moreno and Vayá (2000), the information provided by both types of global indices is complementary. Specifically, the following analyses were performed:

a) Calculation of the global or general indices. These make it possible to confirm the existence of spatial patterns. These techniques measure, by means of calculating the indices indicated below, the degree of spatial autocorrelation, highlighting the contrasts in the geographical distribution of the regions (clustering-randomness, dependence-independence). These indices allow testing of the null hypothesis of no spatial autocorrelation, that is, of the existence of a random distribution of the variable throughout the territory.

    - Moran's I index (Moran, 1948). This index is, essentially, Pearson's correlation coefficient, which maintains the range between -1 and 1. The result of Moran's I index may be positive (the regions have values similar to their neighbours, which shows that there is a tendency of the same to cluster); negative (the opposite, very different values among neighbouring regions, indicating a dispersion of values); or without autocorrelation (the values of neighbouring regions have randomly produced values).

- Getis-Ord General G Index (Getis and Ord, 1992) or high/low clustering tool. Having confirmed the existence of spatial autocorrelation, it measures the clustering of high or low values of the regional index. A positive z score indicates that there is clustering or a concentration of high values, whereas a negative z score indicates the opposite. If the z score is close to zero it means that there is no clustering. The higher (or lower) the z score, the greater the intensity of clustering.

b) Calculation of the local indices. These tools are based on the previous global statistics with the aim of verifying whether the structure of spatial dependence detected at global level is maintained at this level (Ramírez and Falcón, 2015). With these indicators, an index is obtained for each geographical unit analysed (regions) that shows the individual degree of dependence of each region with respect to the rest. It makes it possible to see, through the production of maps, any existing spatial clusters, that is, areas of high occurrence or spatial concentration of a phenomenon as opposed to areas of low occurrence.

- The Anselin Local Moran's I (LISA or cluster and outlier value analysis) identifies the spatial clusters or groups of regions that have similar values and spatial outlier values. This index calculates a value that represents the type of cluster for each entity: high-high (HH), low-low (LL), high-low (HL) and low-high (LH), as well as those not statistically significant.

- The Getis-Ord (Gi*) or optimized analysis of hot points. Getis and Ord's analysis of hot/cold spots makes it possible to see, through the production of maps, the groups or clustering of regions with high (hot spots) or low (cold spots) statistically significant values. For a region with a high/low value to be statistically significant, it must be surrounded by other entities with high/low values. Regions receive a value (± 0, 1, 2 and 3) according to the statistical confidence level (which corresponds to reliability levels of 0%, 90%, 95% and 99%, respectively), giving rise to spatial clusters.

In the calculations of these indices and maps for the analysis of the spatial autocorrelation, it is necessary to define the spatial relationships that assess each region within the context of neighbouring regions. In this study, only the European regions that are adjacent to a region are considered as its neighbours, following the "nearest neighbour rule" ("Contiguity_Edges_Only"). This threshold distance value was applied in the calculation of the indices and maps of spatial autocorrelation undertaken with the ArcGis v10.3 program, considering that the spatial relationships between European regions are defined by Euclidean distance. There are two reasons for choosing Euclidean distance: first, because the variable used to calculate the spatial autocorrelation between European regions is continuous (the value of HIDDI and of its dimensions); and, second, because the contagion effect diminishes with distance (inverse effect or impedance) as all regions affect/influence all others, but the further they are, the less the effect.

4. Results

4.1 Factors that determine access to and use of ICTs in households/by individuals in European regions (FA)

Using IMB's SPSS v23 statistical software package, a first exploratory FA was performed with the 16 variables of ICT usage in households and by individuals in European regions. The results showed that two of the original variables were not appropriate for obtaining an optimum FA. On the one hand, according to the communality values (amount of variance that each variable shares with the rest), the *"IND_BUY_no online purchase in the last year"* variable was not valid for the FA because it had a low value (of only 0.363), less than the minimum value of 0.50, criterion established by Hair et al.. (2004) to accept a variable according to its communality. The conjunction of very little relationship with other variables (low communality) coincides with the fact that this item is also the one with the least variance (Table 3) which, overall, indicates that it must be a variable that is not sufficiently related with the resulting components, and thus it was excluded from subsequent factor analyses.

Table 3. Final Communalities.

	Initial	Extraction
H_ACCESS home	1.000	0.844
H_ACCESS internet by broadband	1.000	0.851
IND_USE_daily	1.000	0.889
IND_USE_social_networks	1.000	0.622
IND_USE_banking	1.000	0.924
IND_USE_selling	1.000	0.718
IND_USE_ever	1.000	0.852
IND_INTER_public authorities	1.000	0.839
IND_INTER_submitting forms last 12m	1.000	0.691
IND_BUY_online purchase last 3m	1.000	0.878
IND_BUY_ordered goods or services in the last year	1.000	0.821
IND_BUY_purchases travel	1.000	0.890
IND_BUY_public authorities	1.000	0.560
IND_ACCESS_away from home or work	1.000	0.711
*IND_BUY_*did not online purchase in the last year	1.000	*0.398*

Source: own preparation

On the other hand, according to the rotated component matrix of the first FA, 2 factors were obtained. All the original variables show high weights or saturations in one factor and low in the other, except the *H_ACCESS broadband* variable that showed high correlations with both factors. Therefore, by behaving like a complex variable, it is not appropriate to identify the nature of the factors and, consequently, it was also excluded from the model and from subsequent analyses.

After eliminating these two variables, a second FA was performed with only 14 original variables. The results of the adequacy measures (determinant, KMO test and Bartlett's sphericity test, Table 4) indicate that the variables are highly correlated with each other and, hence, the result of the FA is correct. Indeed, the determinant of the correlation matrix is very low (1.89E-012); Bartlett's test makes it possible to test the null hypothesis of absence of correlation between the variables; and the value of the KMO sampling adequacy index is equal to or more than 0.80 (specifically 0.847), as recommended by Kaiser (1970).

Table 4. KMO and Bartlett's test

Kaiser-Meyer-Olkin sampling adequacy measure	0.870

Bartlett's sphericity test	Approximate chi-square	6105.11
	Gl	105
	Sig.	0.000

Determinant of the correlation matrix = 1.89E-012
Source; own preparation

The choice of the final number of factors was made in accordance with total variance explained and the Kaiser method, as can be seen in Table 5. 2 factors were obtained that accumulate the largest possible amount of information (the accumulated total variance explained is almost 80%, in accordance with Pearson's criterion) and moreover they are the 2 components with an eigenvalue over 1 (in accordance with Kaiser's method). Table 6 shows the factor matrix of components rotated by the Varimax method, in which the correlations between the variables and the 2 factors obtained can be seen. The interpretation of the same is as follows:

Table 5. Total variance explained

	Initial eigenvalues		
Component	Total	% variance	% accumulated
1	9.678	69.130	69.130
2	1.438	10.274	79.404
3	0.764	5.454	84.858
4	0.515	3.682	88.540
5	0.374	2.673	91.213
6	0.360	2.572	93.785
7	0.294	2.099	95.883
8	0.213	1.524	97.407
9	0.129	0.924	98.330
10	0.078	0.556	98.886
11	0.064	0.459	99.345
12	0.044	0.312	99.657
13	0.036	0.261	99.918
14	0.011	0.082	100.000

Extraction method: Principal component analysis.
Source: own preparation

Factor 1 accounts for 69.13% of the variance. It is made up of 12 variables related positively to:

i) Access to the Internet at home (H_ACCESS home).

ii) Daily use of the Internet (IND_USE_daily and IND_USE_ever).

iii) Activities carried out for particular reasons such as: online banking (IND_USE_banking), sale of goods or services (direct selling, via auctions, eBay, etc. (IND_USE_selling); online purchases in recent months, specifically some product or service (IND_BUY_online purchase last 3m and IND_BUY_ordered goods or services in the last year), holiday accommodation services (hotel, apartment, etc., IND_BUY_purchases travel) or from sellers in other European Union countries (IND_BUY_otherEUcountries); contact or interaction with public administrations or services via the Internet for particular reasons (IND_INTER_public authorities) and/or to send completed forms (such as the income tax declaration or other taxes (IND_INTER_submitting forms last 12m) and,

iv) Persons who accessed the Internet away from home or work (IND_ACCESS_away from home or work).

Factor 2 only accounts for 10.27% of the variance, and establishes a relationship between two variables: use of the broadband connection to the Internet in households (H_ACCESS internet by broadband) and the use of social networks (IND_USE_social_networks).

Table 6. Rotated component matrix.

	Component	
	1	2
IND_USE_banking	0.941	
IND_BUY_online purchase last 3m	0.918	
IND_BUY_purchases travel	0.914	
IND_INTER_public authorities	0.914	
IND_BUY_ordered goods or services in the last year	0.905	
IND_USE_EVER	0.861	
IND_USE_selling	0.847	
H_ACCESS home	0.835	
IND_INTER_submitting forms last 12m	0.831	
IND_USE_daily	0.822	
IND_ACCESS_away from home or work	0.749	
IND_BUY_otherEUcountries	0.663	
H_ACCESS internet by broadband		0.899
IND_USE_social_networks		0.654

Extraction method: Principal component analysis.
Rotation Method: Varimax with Kaiser Normalization.

4.2 The HIDDI and its dimensions.

The two factors extracted from the FA show the theoretical components that underlie the behaviour of access to and use of ICTs in households and by individuals in European regions. These two components of the factor model will constitute the two dimensions of the HIDDI, which will serve to develop the index itself.

Thus, Dimension 1 (DIM1), named “daily use of e-commerce, e-banking and e-government services”, is composed of factor 1. This first component of the HIDDI means that, in European regions, access to the Internet in households and by individuals is associated with daily use of the Internet for particular reasons for e-commerce, e-banking and to relate to the public authorities via e-government whether from their own homes or away from home.

For its part, Dimension 2 (DIM2) corresponds to the “Use of social networks in households with broadband” as it is defined by the second factor that associates these two ICT variables. This component of the HIDDI shows that the use of social networks by individuals in European regions is associated with households that have broadband access to the Internet.

As mentioned above, the HIDDI is the weighted mean of the 2 dimensions, taking into account that each has a different weight depending on the eigenvalue of its factor (Table 5). Consequently, according to the value of these weights, the equation [1] for calculating the HIDDI for European regions has the following mathematical expression:

HIDDI (%) = (69.48*DIM1 + 10.34*DIM2) / 2 [3]

While the equation [2] for calculating the value of (the) DIM1 for European regions would be expressed thus:

(DIM1) Dimension 1 = (0.941*IND_USE_banking) + (0.918*IND_BUY_online purchase last 3m) + (0.914*IND_BUY_purchases travel) + (0.914*IND_INTER_public authorities) + (0.905*IND_BUY_ordered goods or services in the last year) + (0.861*IND_USE_ever) + (0.847IND_USE_selling) + (0.835*H_ACCESS home) + (0.831*IND_INTER_submitting forms last 12m) + (0.822*IND_USE_daily) + (0.749*IND_ACCESS_away_from home or work) + (0.663*IND_BUY_otherEUcountries) + Rest f_i [4]

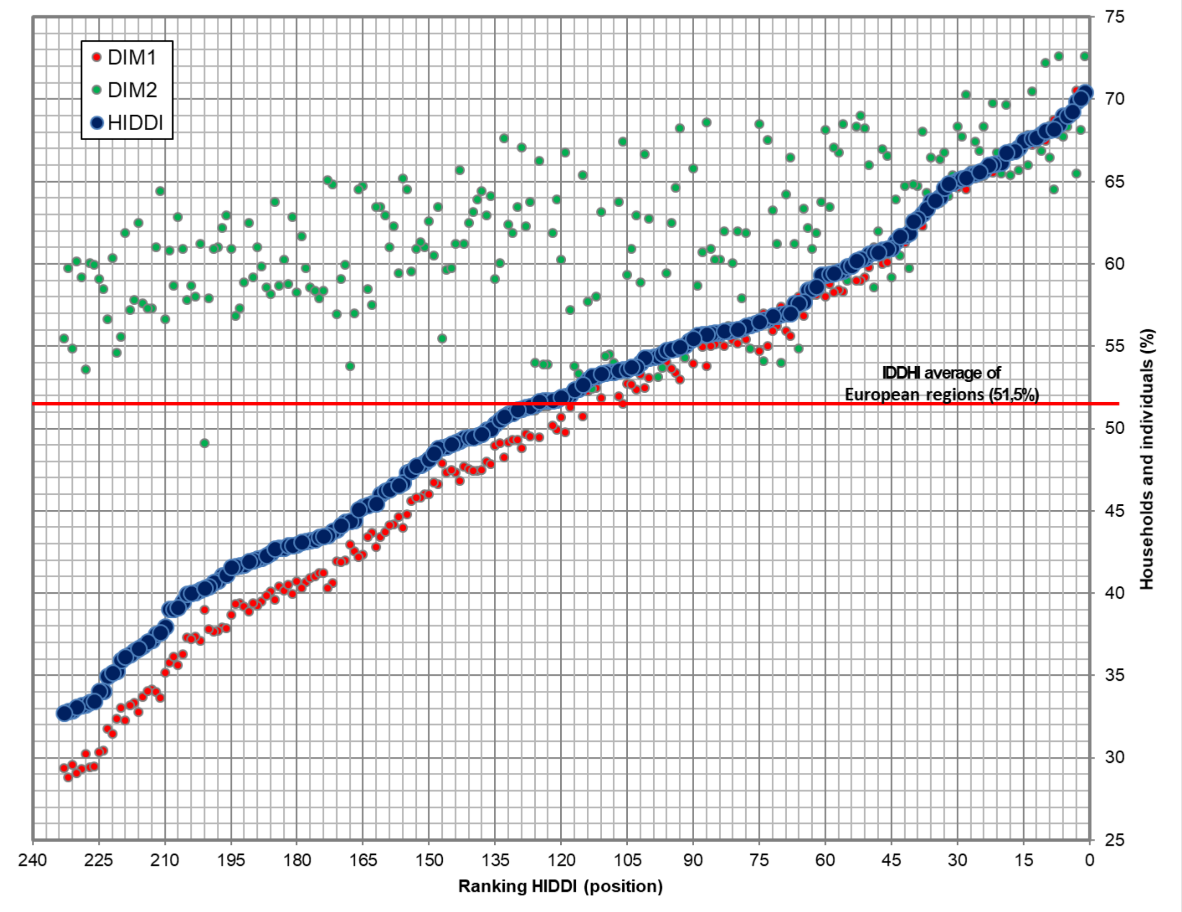
And the value of (the) DIM2 would be calculated in a similar fashion. The HIDDI of European regions is obtained with the two dimensions, and based on this a ranking of regions is made (Appendix B).

4.3 Analysis of the spatial inequalities in digital development between European regions according to the el HIDDI.

The statistical analysis of the HIDDI shows that on average 51.9% of households and individuals in European regions access and use ICTs. The region with the highest HIDDI in Europe is the Norwegian region of Oslo og Akershus, with 70.4% of households and individuals, while the region with the least digital development is the Romanian region of Sud-Vest Oltenia, with only 32.7% of households and individuals accessing and using ICTs. Consequently, the DD between European regions is 37.7% of households and individuals, which indicates that the most-developed region has double the percentage of households and individuals that access and use ICTs that the region with the lowest index has. Figure 1 shows the ranking of the HIDDI of European regions graphically and makes it possible to see contrasts between the same and the DD based on the calculated HIDDI.

Analysing the relationship between the index and its dimensions, two significant points can be concluded in relation to digital development and the DD (Figure 1): i) the line described by the HIDDI is very similar to that of DIM1, since the digital development of European regions is defined by DIM1; and ii) European regions behave differently according to the two dimensions of the IDHHI, which implies regional inequalities in digital development.

Figure 1. Ranking of European regions by HIDDI and dimensions.



Source: own preparation

With regard to the first point, the level of digital development of European regions is fundamentally based on the daily use of ICTs for e-commerce, e-banking and e-government (DIM1); while the use of social networks (DIM2) accounts for less in terms of the level of digital development. This is because the two dimensions have a very different weight in the final HIDDI, since this is due to the percentage of total variance explained for each of them in the factor model. If the accumulated percentage of total variance explained by the two factors is 79.8%, DIM1 accounts for 87% of the HIDDI, and DIM2 accounts for the remaining 13%.

On the other hand, European regions show unequal behaviour in each of the dimensions of digital development (Figure 1). Indeed, there are large contrasts between regional values in the daily use of ICTs for e-commerce, e-banking and e-government (the coefficient of variation of DIM1 is 21.8%). Meanwhile, the values of the use of social networks (DIM2) show very similar percentages between regions (due to a coefficient of variation of 7.2%). This implies:

i) the use of social networks (DIM2) in European regions is more widespread than the online activities included in DIM1 (on average, 61.8% and 50.4% of households and individuals, respectively). This implies that there is a greater DD in DIM1, with a maximum difference of 41.8% of households and individuals between regions (more than double digital development between regions with the highest and lowest index). Meanwhile, DIM2 behaves in a much more egalitarian manner for European regions, with a maximum divide of 23.5% of households and individuals

ii) there are European regions that have a higher HIDDI value than others (better position in the ranking) because they have high DIM2 values. Indeed, although the HIDDI is fundamentally determined by DIM1, as seen above, this only occurs in 60% of regions. Of these, only 12.2% are due to the regions having higher values in both dimensions; while in the rest (in 47.8% of the same), the position in the ranking is due to the fact that the DIM1 is higher. Therefore, in the remaining 40% of European regions, a region has a better position in the HIDDI ranking because it has a higher DIM2 value, even though it has a lower DIM1.

Likewise, if the spatial distribution of the HIDDI of European regions is analysed, as displayed in Fig. C.2.A , one may discern the existence of a differentiated geographical distribution of the levels of digital development in Europe. In effect, it can be seen in this map that both regions with high and those with low HIDDI values tend to be spatially concentrated, which seems to indicate the presence of spatial autocorrelation. This fact is confirmed with the result obtained with Moran's Global Index (Fig. C.1) which, first of all, rejects the null hypothesis that this spatial distribution is due to a random process (P is equal to 0). Moreover, second, it confirms that there is an aggregate spatial distribution pattern, since Moran's index is positive (0.769). All of this shows that the distribution of the HIDDI of European regions reveals the existence of a spatial pattern of digital development in Europe at regional level. As a result, it can be affirmed that European regions with high HIDDI values have other regions with high levels of digital development as neighbours, and the opposite. For their part, the results of the Getis-Ord general index (Fig. C.1) support the existence of this spatial distribution pattern as they reject the null hypothesis that HIDDI values are randomly distributed (the P value is very low); and furthermore there is a cluster or concentration within the space of European regions with high HIDDI values (Z is equal to 5.045).

This pattern follows a NW-SE gradient from greater to lesser digital development in European regions and, consequently, of DD (Fig. C.2.A). Indeed, the highest levels of HIDDI are registered in the Nordic and Baltic regions along with the regions of the United Kingdom, Netherlands, Luxembourg and Switzerland (values over 57.8% of the HIDDI with access to and use of ICTs and barely 6.3% of DD).The intermediate values of digital development (between 57.8% and 46.4%) and divide (between 12% and 23.9%) for households and individuals are registered in the European regions located in the central European zone, from the west to the east of the continent: Spain, Ireland, France, Germany, Belgium, Austria, Slovakia, Slovenia, Latvia, Lithuania, and some western regions of Hungary. Finally, the lowest values of digital development (less than 46.4% of households/individuals) and a great DD (more than 23.9%), are in south-east Europe, and also in regions of Portugal: Turkey, Greece, Poland, Italy, Romania, Hungary and Bulgaria (in decreasing order of HIDDI).

The local indices of the Anselin Local Moran's I (LISA) and the Getis-Ord Gi* also confirm the existence of this NW-SE spatial gradient of European regions according to the HIDDI. The LISA shows three large spatial clusters (Fig. C.2.B):

i) A High-High (HH) group comprising regions with high HIDDI values. It groups together the NUTS with the highest levels of digital development contiguous with other regions with high values (average HIDDI of 62.7% and HIDDI values over 55%). This group is made up of northern European regions (76 NUTS). They are the Scandinavian regions of Finland, Norway and Sweden; plus all regions of

Denmark, Netherlands, United Kingdom and Switzerland; and some of northern Germany, Ireland and France.

ii) A Low-Low (LL) group comprising European regions with low HIDDI values. It groups the European regions with the lowest HIDDI levels (an average of 38.8%). They are 50 NUTS from eastern and south-eastern Europe: eastern Poland, central and southern Italy and Hungary, and all of Croatia, Greece, Macedonia, Romania, Bulgaria, Cyprus and Turkey.

iii) A Low-High (LH) group that includes the regions with low-medium outlier HIDDI values. They are 4 NUTs with low HIDDI values (an average of 42.7%) surrounded by regions with high values. Two of them are in Poland (Pólnocny and Pólnocno-Zachodni), one in the Czech Republic (Severozápad) and the other in Italy (Valle d'Aosta)

On the other hand, the local index of Getis-Ord (Gi*) (Fig. C.2.C) shows 2 large groups of regions according to the HIDDI:

i) A hot spot formed by the concentration of regions with very high HIDDI values (in red on the map, with a 99% confidence level). They are 26 NUTS that correspond to European regions in the north of the continent.

ii) A cold spot that groups together European regions with the lowest HIDDI values (in blue on the map at a 99% confidence level). There are 26 NUTS in this cluster that are located in the south-east of the continent.

The clusters identified by the LISA and the Gi* make it possible to show the DD in European regions. Thus, the regions of the HH and hot spot clusters (with an average HIDDI of almost 66.3%) almost double the digital development of the regions of the LL and cold spot clusters (with an average HIDDI of only 36.2%).

As regards the results of the analysis of the spatial distribution of the two dimensions of the HIDDI of European regions, DIM1 “Daily use of e-commerce, e-banking and e-government” has very similar results to those of the HIDDI. This is a result of the fact that the index is determined by DIM1 since, as commented above, this dimension accounts for 87% of the HIDDI. This is corroborated by the values of the spatial autocorrelation indices (Fig.C.1) Moran’s Global Index (0.339, with a Z-score of 54.4%) and the Getis-Ord General G (with a G of 0.454 and a Z-score of 5.46%). Similarly, the local indices of the Anselin Local Moran's I (LISA) and of the Getis-Ord Gi* indicate a very similar spatial distribution both for the HH and LL clusters (Fig. C.3.B), and for the hot and cold spot clusters (Fig. C.3.C) of European regions in DIM1. Hence, the greatest differences in DD for households and individuals between European regions appear in relation to “Daily use of e-commerce, e-banking and e-government”.

Contrary to the HIDDI and DIM1, the analysis of the spatial distribution of DIM2, “Use of social networks by broadband”, does not follow a clear NW-SE spatial gradient of digital development, its spatial distribution being more heterogeneous or, a priori, disperse (Fig. C.4.A). Thus, on the one hand, it highlights European regions with a high level of use of social networks (NUTS with more than 64% of households and individuals) that once again are basically located in the north of the continent (Norway, Finland, Denmark, Sweden, United Kingdom, Netherlands, Belgium and Luxembourg) along with a few disperse regions (Cyprus, almost all of Hungary and Istanbul in Turkey). On the other hand, a group of regions can be seen on the map in Fig. C.4.A with medium-high levels of use of social networks (around 60% of households and individuals) scattered throughout Europe: part of these are located in the central European corridor (Germany, Switzerland, Austria, Czech Republic, Slovakia, Hungary and Romania); others on the western (Ireland, Spain and part of Portugal) and eastern (regions of Greece, Bulgaria and Turkey) peripheries; and also in the NE of the continent (Latvia, Lithuania and Estonia). Finally, it can be observed that almost all the regions with lower levels of social network usage (under 55% of households and individuals) are located in France and central and southern Italy, as well as others in the east of Germany and Poland, Croatia and the easternmost regions of Turkey and southern Greece.

Hence, a priori, this could suggest that there is no spatial pattern of the use of social networks in European regions. This is only partly the case, according to the results of Moran's Global Index and the Getis-Ord G index (Fig.C.1). On the one hand, according to Moran's index (with a P value of 0.105 and a Z-score of 17.4) a certain degree of spatial autocorrelation exists. However, on the contrary, the Getis-Ord index has a Z-score of 0.744, which means that the patterns of spatial association could be due to a random distribution.

The results of the local indices of spatial autocorrelation of DIM2 indicate a geographical distribution of European regions different to the NW-SE gradient of European digital development according to the HIDDI and DIM1. Thus, the map of the Anselin local Moran's I (Fig.C.4.B) reflects the fact that the cluster with the highest percentages of households and individuals that use social networks by broadband (HH) is once again concentrated in the north of Europe (16% of regions with an average of 67.1% of DIM2). This cluster is located in Norway and the United Kingdom (except East of England), along with a few Swedish regions (Norra Mellansverige and Västsverige) and in the centre of Belgium. Meanwhile, the cluster made up of the European regions with the lowest percentages (LL) of households and individuals that use social networks by broadband (15% of the NUTS with a DIM2 below the average of 59.2%) is concentrated almost exclusively in France (except the regions of Champagne-Ardenne, Nord-Pas-de-Calais, Lorraine and Corse), as well as in two regions in eastern Turkey (Ortadogu Anadolu and Kuzeydogu Anadolu).

The differing spatial behaviour of DIM2 with respect to DIM1 is also evident in the results shown by the map of the Getis-Ord-Gi* index (Fig. C.4.C). The spatial clusters signifying high percentages (hot spots with confidence levels over 90%) of households and individuals that use social networks in Europe comprise 40 NUTS (with average DIM2 over 67%). These regions are also located in the north of Europe, especially in Sweden, Norway, United Kingdom, Belgium, Netherlands, Denmark and Iceland. Meanwhile, the clusters of European regions with the lowest percentages of households and individuals that use social networks (cold spots with confidence levels over 99% with an average DIM2 value below 54%) are mainly concentrated in France (except Nord-Pas-de-Calais and Lorraine). Meanwhile, the regions of central and southern Italy (and Piedmont), eastern Turkey (Ortadogu Anadolu and Kuzeydogu Anadolu), Région lémanique (Switzerland), Sachsen (Germany) and the macro-region of Pólnocno-Zachodni (Poland) form a second cold spot cluster (with a confidence level over 95% and an average DIM2 of 57%).

The spatial clusters identified by the LISA and the Gi* reveal that the DD between the European regions with the highest and lowest percentages of participation of individuals in social networks by broadband is small, as it does not reach 8 percentage points (an average of 67.1% in the HH and hot spot groups and an average of 59.2% in the LL and cold spot groups). It can therefore be affirmed that, unlike the DIM1 dimension, the values of DIM2 are more equal or similar between regions.

5. Discussion and conclusions

The results of this study conclude that the digital development of households and individuals in European regions is based on broadband Internet access. As pointed out above, the *H_ACCESS_broadband* variable is correlated with the two factors that define the dimensions of digital development ("Daily use of e-commerce, e-banking and e-government services" and "Use of social networks in households with broadband"). This confirms what other studies had already envisaged in relation to the constant evolution of the Internet and its association with broadband. This technology is necessary for most websites that contain applications requiring a high capacity for data transfer (Cruz-Jesus et al., 2016). Moreover, broadband enables individuals to be better informed online (Gijón, C., et al., 2016), benefit financially, buy and sell goods and services, and also reduce the travelling time to complete any administrative procedure, among other things (Stocker and Whalley, 2017).

Furthermore, this work provides a complex index (HIDDI) to measure the level of digital development of households and individuals in European regions and to quantify the differences or DD between them. "Unlike other indicators such as "ICT Development" of the International Telecommunications Union (ITU, 2017); "Networked Readiness Index" of the World Economic Forum (World Economic Forum, 2017); and the "Digital Economy and Society Index (DESI)" created by the European Commission to measure the Digital Society in Europe; HIDDI measures the access and use of ICTs at a subnational level (when data is available). For this reason, the HIDDI is a complementary indicator to the existing ones because it analyses the DD at a greater level of spatial detail, especially in large countries and/or countries with regional differences. In addition, the DESI is a composite index that summarises some 30 relevant indicators on Europe's digital performance and tracks the evolution of EU Member States, across five main dimensions that, unlike those of HIDDI, are not calculated with statistical criteria (Connectivity, Human Capital, Use of Internet, Integration of Digital Technology, Digital Public Services)"

It demonstrates that the level of digital development attained by European regions is due to the types of use that these make of ICTs, more specifically the daily use of e-commerce, e-banking and e-government services (DIM1). This is the differentiating factor between the level of development in European regions, and the one that establishes the levels of DD between them. This suggests that, in the context of developed economies, regional DD is associated with the more advanced uses that households and individuals make of ICTs. Consequently, this study confirms that the DD of households and individuals in European regions is "second-level" (Scheeders et al. 2017) and it is, therefore, these uses that create regional inequalities.

The values obtained by calculating the HIDDI for each European region show that the maximum DD between these is 37% of households/individuals that access and use ICTs. This confirms that, in 2017, in Europe, the DD of households and individuals already identified at country level for the 2008-10 period by Cruz-Jesus et al. (2012)

remains the same, which implies the consolidation of spatial inequality in terms of digital development. These inequalities in the use of ICTs will continue to change over time in line with users' different needs and technological advances (Kyriakidou, et al., 2011). In Europe, households/individuals have already adopted the basic ICTs and are currently in the process of acquiring and using more advanced and productive applications that are becoming available with new ICT infrastructures (Cruz-Jesus, et al., 2016).

In this regard, studies undertaken in the USA (Howard et al., 2010; Selwyn et al., 2003), the United Kingdom, (Helsper and Galácz,2009) and the Netherlands (Van Deursen and Van Dijk, 2013; Van Deursen, et al. (2015) show that the most advanced uses of ICTs (health information, financial transactions, research, news, work , travel and product information) are used by persons with higher levels of education and employed (Van Deursen, et al., 2015). It can consequently be deduced, following Helsper (2012, Helsper, and Reisdorf, (2017).,Van Dijk (2005), Witte and Mannon (2010) and Pick and Nishida (2015), that regions and countries with a high socio-economic level reinforce their level of digital development in comparison with regions and countries with lower levels of per capita income, thus suggesting, as a hypothesis for future studies, that the spatial distribution of digital development at regional level follows in the wake of, and is a direct result of, the socio-economic development of these geographical areas.

As mentioned above, this idea is corroborated by the existence of the NW-SE spatial pattern of digital development according to the HIDDI and DIM1 of European regions. The maps of the spatial distribution and the spatial autocorrelation indicators detected express a similar pattern to that of overall or socio-economic development. This pattern shows a gradient from greater to lesser digital development (and consequently of digital divide) which is associated with "Daily use of ICTs for e-commerce, e-banking and e-government services by households/individuals" (DIM1). Hence, this indicates that the degree of digital development and DD of European regions for households and individuals is affected by a phenomenon of dependence or spatial autocorrelation. Thus, the level of digital development of a region is directly related to that of its neighbours and, therefore, geographical proximity/vicinity is an element to take into account in the analysis of the disparities in the DD (Pick and Nishida, 2015). This is in line with Tobler's First Law of Geography (Tobler 2004) "nearby things are more similar than distant things" (Waters, 2016; Goodchild, 2018). In this respect, the three spatial clusters of European regions identified with the HIDDI follow this principle of spatial autocorrelation, as each is associated with different levels of digital development. Thus, the conglomerate of regions with the highest HIDDI is located in north-west Europe; while the cluster of regions with the lowest HIDDI values is located in the south-east of the continent; and a last set of regions with relatively intermediate HIDDI values is located in a SW-NE transcontinental strip.

However, the same does not apply to the use of social networks with broadband (DIM2). The results of this study reaffirm that the participation of individuals in social networks (creating user profiles, sending messages or other contributions to Facebook, Twitter, YouTube, etc.) is more widespread and more equal between European regions. Thus, the region with the least use of social networks has a DIM2 of almost 50% of individuals, that is, half of the population use this type of technology. While the region with the highest percentage of individuals who use social networks only exceeds that which has the least by 23% (compared with almost 42% difference in DIM1). This spread in the use of social networks in households and by individuals in European regions coincides with the results of different studies such as those undertaken at state level in the United States (Pick, et al., 2015) and in the prefectures of Japan (Nishida et al.. 2014). In these works, it is clear that this phenomenon may be due to the attraction that social networks have for groups of younger users/consumers; and this suggests that the use of applications is not limited to regions with a considerable deployment and use of ITCs. There are many types of social networks and they are open to all kinds of people, ages, situations and all types of use. In this respect, it has been found that in regions with a high level of access to the Internet (such as the Netherlands) the use of social networks as a means of social interaction and for games is more popular with people with lower levels of education and those with below-average income (Van Deursen, et al., 2015). Consequently, it seems to suggest that there is no limit to people's use of social networks due to age and/or level of education or income. On the contrary, in European western, the lower social classes tend to use the Internet in a more recreational and less productive manner (Hargittai and Hinnant, 2008; Livingstone and Helsper, 2007; Pearce and Rice, 2013; Van Deursen and Van Dijk, 2013; Zillien and Hargittai, 2009).

Therefore, the similar levels of individuals' use of and participation in social networks in households with broadband in European regions seem to show, according to the results obtained, a reduction in the spatial inequalities in digital development in Europe. Thus, on the one hand, the levels of spatial dependence and autocorrelation of European regions in DIM2 are less than in DIM1 (in the case of the Getis-Ord G index). And, on the other, the spatial clusters of European regions with respect to DIM2 reveal closer values of digital development and, consequently, less DD. Hence, the use of social networks by broadband has a more random distribution of spatial clusters in European regions and, therefore, a random spatial pattern. Consequently, geographical vicinity has less influence on the spatial distribution of European regions with similar levels of use of social networks by broadband. As pointed out by Shelton et al. (2015), it seems that social processes are increasingly similar from a spatial point of view due to the progressive increase in the deployment and use of ICTs, as they favour social relations regardless of the locations where these take place. Somehow or other, social networks, by going beyond borders or political boundaries, reduce space and distance and, therefore, the effect of absolute geographical proximity. As a result, according to Amin (2004), we can start to see a tenuous overlapping of the distant and the near.

The results obtained in this study are a novel contribution and increase the regional literature on the access to and use of ICTs in households and by individuals in Europe. The study contributes: 1) a methodology to measure the level of digital development and spatial inequalities that could be adopted for the analysis of different countries or geographical areas provided that they have regionalised data on ICTs; 2) a synthetic index for European regions at the level of households/individuals (HIDDI) that incorporates the multidimensionality of the phenomenon, as it has been developed on the basis of multivariate statistical methods that make it possible to: a) measure the digital development of European regions with an index adjusted to the European digital society; b) compare the level of digital development of European regions from the perspective of access to and use of ICTs in households and by individuals; c) analyse the resulting DD between European regions; and d) benefit from a dependent variable (HIDDI) obtained via statistical procedures, available for future regression models for the European regional level; and 3) a spatial pattern of digital development in European regions, analysing the weight that the phenomena of spatial dependence or autocorrelation have on a region's level of digital development. In short, the study highlights the importance of the proximity/vicinity of regions in the use of ICTs by households/individuals in European regions.

However, this research also has a number of limitations: 1) the number of variables included in the analysis (16) is very small. The statistical analysis of the digital development of European regions on the basis of the access and use of households/individuals would be more precise and robust (factor analysis, dimensions of the index and results of the spatial analysis) if Eurostat published more variables/indicators at NUTS 2 level; 2) Changes are produced in the statistical series on access to and use of ICTs that do not allow the use of temporal analyses. It must be borne in mind that ICTs are very dynamic technologies, and the statistics themselves need to adapt, and in fact they do, to rapid technological change. Nevertheless, it is apparent that the questionnaires include questions referring to technologies that are already obsolete or outdated in market terms; 3) there are very few conceptual models on spatial autocorrelation in digital development, and most of the research carried out is basically at country level.

Despite the limitations indicated above, the results of this research could be used for digital policy planning, and decision-making at regional level (NUTS 2). The method could also be applied (if data is available) for the geographical analysis of digital development at other spatial scales or levels. Moreover, and depending on the results obtained, future lines of research could be proposed for further or more detailed study of digital development and the DD with respect to households/individuals at regional level in Europe. For example, to determine the causes of the DD by applying spatial regression techniques that make it possible to ascertain how the spatial variable affects regional differences. This would entail closer examination not only of the impact of different elements, such as socio-economic, cultural, political and institutional aspects etc., on DD, but also of geographical variables such as the spatial proximity of regions as a mechanism for disseminating the most advanced and emerging ICTs in European regions.

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APPENDIX A. The NUTS classification (Nomenclature of Territorial Units for Statistics).

The European Commission and Eurostat explain because nuts classification is necessary: “National figures alone cannot reveal the full and sometimes complex picture of what is happening at a more detailed level within the European Union (EU). In this respect, statistical information at a **subnational level** is an important tool for highlighting specific regional and territorial aspects. It helps in analysing changing patterns and the impact that policy decisions can have on our daily life.”

“The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU for the purpose of:

- The collection, development and harmonisation of EU regional statistics.
- Socio-economic analyses of the regions.
  - NUTS 1: major socio-economic regions.
  - NUTS 2: basic regions for the application of regional policies.
  - NUTS 3: small regions for specific diagnoses.
- Framing of EU regional policies.
  - Regions eligible for support from cohesion policy have been defined at NUTS 2 level
  - The Cohesion report has so far mainly been prepared at NUTS 2 level

Source: Eurostat (2019): http://ec.europa.eu/eurostat/web/nuts:

APPENDIX B. Ranking of Regions by HIDDI

R	CODE*	REGION**	DIM1	DIM2	HIDDI
1	NO	Oslo og Akershus	70.1	72.6	**70.4**
2	DK	Hovedstaden	70.4	68.2	**70.1**
3	NL	Flevoland	70.5	65.5	**69.9**
4	SE	Stockholm	69.3	68.9	**69.3**
5	FI	Helsinki-Uusimaa	69.1	68.4	**69.0**
6	NL	Noord-Holland	69.2	67.7	**69.0**
7	IS	Ísland	67.9	72.6	**68.5**
8	SE	Övre Norrland	68.7	64.5	**68.2**
9	NL	Utrecht	68.4	66.4	**68.1**
10	SE	Mellersta Norrland	67.5	72.2	**68.1**
11	DK	Syddanmark	68.0	66.9	**67.9**
12	DK	Midtjylland	67.7	67.3	**67.7**
13	NO	Vestlandet	67.2	70.5	**67.6**
14	NL	Groningen	67.8	66.0	**67.6**
15	NL	Drenthe	67.5	67.1	**67.5**
16	NL	Zeeland	67.3	65.7	**67.1**
17	SE	Västsverige	66.9	66.9	**66.9**
18	NL	Zuid-Holland	67.0	65.4	**66.8**
19	NO	Nord-Norge	66.4	69.6	**66.8**
20	NL	Noord-Brabant	66.2	65.5	**66.1**
21	LU	Luxembourg	66.0	66.8	**66.1**
22	NO	Agder og Rogaland	65.5	69.8	**66.1**
23	SE	Sydsverige	66.0	65.9	**66.0**
24	NO	Sør-Østlandet	65.3	68.4	**65.7**
25	SE	Östra Mellansverige	65.4	66.9	**65.6**
26	DK	Nordjylland	65.2	67.4	**65.5**
27	NL	Limburg (NL)	65.4	65.7	**65.4**
28	NO	Trøndelag	64.5	70.3	**65.3**
29	NO	Hedmark og Oppland	64.8	67.7	**65.2**
30	UK	London	64.6	68.4	**65.1**
31	NL	Gelderland	64.9	65.4	**65.0**
32	DK	Sjælland	65.0	64.1	**64.9**
33	NL	Overijssel	64.3	66.8	**64.6**
34	UK	South East (UK)	63.7	66.3	**64.1**
35	SE	Småland med öarna	63.9	63.9	**63.9**
36	NL	Friesland (NL)	63.4	66.4	**63.8**
37	FI	Etelä-Suomi	63.2	64.3	**63.4**
38	UK	South West (UK)	62.3	68.0	**63.0**
39	FI	Länsi-Suomi	62.5	64.7	**62.8**
40	SE	Norra Mellansverige	62.2	64.9	**62.6**
41	CH	Zürich	62.2	59.7	**61.9**
42	FI	Pohjois- ja Itä-Suomi	61.3	64.7	**61.7**
43	CH	Espace Mittelland	61.9	60.5	**61.7**
44	DE	Hamburg	61.0	63.9	**61.4**
45	CH	Nordwestschweiz	61.2	59.2	**60.9**
46	BE	Prov. Vlaams-Brabant	60.1	66.6	**60.9**
47	UK	West Midlands (UK)	60.0	67.0	**60.9**
48	CH	Région lémanique	60.5	62.0	**60.7**
49	FR	Île de France	61.0	58.6	**60.7**
50	UK	East Midlands (UK)	59.8	66.0	**60.6**
51	UK	North West (UK)	59.2	68.3	**60.4**
52	UK	Scotland	59.0	69.0	**60.3**
53	BE	Prov. Brabant Wallon	59.0	68.4	**60.2**
54	CH	Zentralschweiz	59.9	59.6	**59.9**
55	CH	Ostschweiz	60.0	59.0	**59.9**
56	UK	Wales	58.3	68.5	**59.6**
57	UK	East of England	58.4	66.8	**59.5**

R	CODE	REGION	DIM1	DIM2	HIDDI
58	BE	Prov. Antwerpen	58.3	67.1	**59.4**
59	AT	Wien	58.8	63.5	**59.4**
60	UK	Yorkshire and The Humber	58.0	68.2	**59.3**
61	EE	Eesti	58.7	63.8	**59.3**
62	UK	Northern Ireland (UK)	58.1	61.9	**58.6**
63	DE	Berlin	58.1	60.9	**58.5**
64	DE	Niedersachsen	57.9	62.2	**58.4**
65	DE	Rheinland-Pfalz	56.9	63.4	**57.7**
66	FR	Alsace	58.0	54.8	**57.6**
67	DE	Hessen	57.1	61.2	**57.6**
68	BE	Prov. Oost-Vlaanderen	55.6	66.5	**57.0**
69	IE	Southern and Eastern	55.9	64.2	**57.0**
70	FR	Rhône-Alpes	57.4	54.0	**57.0**
71	DE	Nordrhein-Westfalen	56.2	61.2	**56.9**
72	ES	Comunidad de Madrid	55.9	63.3	**56.9**
73	UK	North East (UK)	55.0	67.5	**56.6**
74	FR	Provence-Alpes-Côte d'Azur	57.0	54.1	**56.6**
75	BE	Prov. West-Vlaanderen	54.7	68.5	**56.5**
76	FR	Aquitaine	56.4	56.3	**56.4**
77	FR	Midi-Pyrénées	56.5	54.8	**56.3**
78	CH	Ticino	55.4	61.9	**56.2**
79	DE	Bremen	55.8	57.9	**56.1**
80	AT	Vorarlberg	55.2	62.0	**56.1**
81	DE	Schleswig-Holstein	55.4	60.1	**56.0**
82	FR	Bretagne	55.9	56.2	**55.9**
83	AT	Tirol	55.0	62.0	**55.9**
84	DE	Baden-Württemberg	55.1	60.3	**55.8**
85	DE	Bayern	55.1	60.3	**55.8**
86	AT	Oberösterreich	55.0	60.9	**55.8**
87	BE	Région de Bruxelles-Capitale	53.8	68.6	**55.7**
88	AT	Niederösterreich	55.0	60.7	**55.7**
89	AT	Salzburg	55.3	58.7	**55.7**
90	BE	Prov. Limburg (BE)	53.9	65.8	**55.5**
91	FR	Bourgogne	55.4	55.1	**55.3**
92	FR	Languedoc-Roussillon	55.2	54.3	**55.1**
93	BE	Prov. Luxembourg (BE)	53.0	68.3	**54.9**
94	ES	Illes Balears	53.4	64.6	**54.9**
95	ES	Comunidad Foral de Navarra	53.7	62.5	**54.8**
96	AT	Steiermark	54.0	59.4	**54.7**
97	FR	Haute-Normandie	54.7	53.7	**54.6**
98	FR	Pays de la Loire	54.6	53.1	**54.4**
99	FR	Centre (FR)	54.4	54.4	**54.4**
100	DE	Saarland	53.1	62.7	**54.3**
101	BE	Prov. Namur	52.4	66.7	**54.3**
102	DE	Sachsen	53.3	58.9	**54.0**
103	CZ	Praha	52.4	62.9	**53.8**
104	AT	Kärnten	52.7	60.9	**53.7**
105	AT	Burgenland (AT)	52.7	59.3	**53.6**
106	MT	Malta	51.5	67.4	**53.6**
107	ES	Cataluña	52.0	63.8	**53.5**
108	FR	Lorraine	53.4	54.0	**53.5**
109	FR	Auvergne	53.3	54.5	**53.4**
110	FR	Champagne-Ardenne	53.3	54.4	**53.4**
111	ES	Aragón	51.9	63.1	**53.3**
112	DE	Thüringen	52.5	58.0	**53.2**
113	FR	Limousin	53.3	52.4	**53.2**
114	DE	Sachsen-Anhalt	52.3	57.7	**53.0**

R	CODE	REGION	DIM1	DIM2	HIDDI
115	PT	Área Metropolitana de Lisboa	50.8	65.4	**52.7**
116	FR	Basse-Normandie	52.3	53.4	**52.4**
117	FR	Poitou-Charentes	52.1	53.8	**52.3**
118	FR	Corse	51.3	57.2	**52.1**
119	HU	Közép-Magyarország	49.8	66.8	**52.0**
120	ES	País Vasco	50.7	60.3	**51.9**
121	ES	Ciudad Autónoma de Ceuta	49.9	63.9	**51.7**
122	ES	Cantabria	50.2	61.9	**51.7**
123	FR	Nord - Pas-de-Calais	51.4	53.9	**51.7**
124	FR	Franche-Comté	51.4	53.9	**51.7**
125	BE	Prov. Liège	49.5	66.2	**51.6**
126	FR	Picardie	51.1	54.0	**51.5**
127	ES	Comunidad Valenciana	49.5	63.8	**51.4**
128	IE	Border, Midland and Western	49.7	62.3	**51.3**
129	HU	Közép-Dunántúl	48.8	67.1	**51.2**
130	SK	Bratislavský kraj	49.3	63.5	**51.2**
131	ES	Principado de Asturias	49.3	61.9	**50.9**
132	ES	Ciudad Autónoma de Melilla	49.2	62.4	**50.9**
133	BE	Prov. Hainaut	48.3	67.6	**50.8**
134	CZ	Stredni Cechy	49.1	60.1	**50.5**
135	DE	Mecklenburg-Vorpommern	49.0	59.1	**50.3**
136	ES	Andalucía	47.8	64.1	**50.0**
137	LV	Latvija	48.0	62.9	**49.9**
138	SK	Východné Slovensko	47.5	64.4	**49.7**
139	FR	Guyane	47.4	63.9	**49.6**
140	ES	Región de Murcia	47.4	63.1	**49.5**
141	ES	Canarias (ES)	47.5	62.5	**49.5**
142	ES	La Rioja	47.7	61.2	**49.4**
143	TR	Istanbul	46.8	65.7	**49.3**
144	ES	Castilla-la Mancha	47.4	61.2	**49.2**
145	SI	Zahodna Slovenija	47.5	59.7	**49.1**
146	ES	Castilla y León	47.3	59.6	**48.9**
147	DE	Brandenburg	47.9	55.5	**48.9**
148	ES	Extremadura	46.6	63.5	**48.8**
149	SK	Stredné Slovensko	46.7	60.5	**48.5**
150	SK	Západné Slovensko	46.0	62.6	**48.1**
151	ES	Galicia	46.0	61.0	**47.9**
152	CZ	Jihozápad	45.8	61.3	**47.8**
153	CZ	Moravskoslezsko	45.8	60.9	**47.8**
154	CZ	Jihovýchod	45.6	59.5	**47.4**
155	HU	Nyugat-Dunántúl	44.8	64.5	**47.3**
156	CY	Kypros	44.0	65.2	**46.7**
157	SI	Vzhodna Slovenija	44.7	59.4	**46.6**
158	LT	Lietuva	44.2	62.3	**46.5**
159	CZ	Stredni Morava	44.1	61.0	**46.3**
160	EL	Attiki	43.7	62.9	**46.2**
161	TR	Bati Anadolu	43.4	63.5	**46.0**
162	PT	Região Autónoma da Madeira	42.8	63.5	**45.5**
163	FR	Martinique	43.7	57.5	**45.5**
164	CZ	Severovýchod	43.4	58.5	**45.4**
165	HU	Dél-Dunántúl	42.4	64.7	**45.3**
166	PT	Região Autónoma dos Açores	42.2	64.5	**45.1**
167	PL	Region Centralny	42.5	57.0	**44.4**
168	FR	Guadeloupe	43.0	53.8	**44.4**
169	ITI	Emilia-Romagna	42.0	60.0	**44.3**
170	CZ	Severozápad	41.9	59.1	**44.1**
171	ITI	Provincia Autonoma di Trento	41.9	57.0	**43.9**
172	HU	Észak-Magyarország	40.6	64.9	**43.8**
173	HU	Dél-Alföld	40.3	65.1	**43.5**
174	ITI	Lombardia	41.2	58.4	**43.5**
175	ITI	Friuli-Venezia Giulia	41.2	57.9	**43.4**
176	ITI	Veneto	41.0	58.4	**43.3**
177	PL	Makroregion Pólnocny	40.9	58.6	**43.2**
178	PL	Makroregion Poludniowo-Zachodni	40.7	59.7	**43.2**
179	PT	Centro	40.3	61.7	**43.1**
180	PL	Makroregion Poludniowy	40.7	58.3	**43.0**
181	PT	Algarve	39.9	62.8	**42.9**
182	ITI	Liguria	40.5	58.8	**42.9**
183	HR	Kontinentalna Hrvatska	40.2	60.3	**42.8**
184	ITI	Marche	40.4	58.7	**42.8**
185	HU	Észak-Alföld	39.6	63.8	**42.7**
186	ITI	Toscana	40.1	58.1	**42.4**
187	ITI	Piemonte	39.9	58.6	**42.3**
188	TR	Dogu Marmara	39.5	59.9	**42.1**
189	TR	Akdeniz	39.3	61.0	**42.1**
190	PL	Makroregion Pólnocno-Zachodni	39.4	59.2	**42.0**
191	PT	Alentejo	38.9	62.5	**41.9**
192	ITI	Lazio	39.2	58.9	**41.7**
193	ITI	Provincia Autonoma di Bolzano/Bozen	39.4	57.3	**41.7**
194	ITI	Valle d'Aosta/Vallée d'Aoste	39.4	56.9	**41.6**
195	PT	Norte	38.7	60.9	**41.6**
196	RO	Bucuresti - Ilfov	37.9	62.9	**41.1**
197	TR	Ege	37.9	62.2	**41.0**
198	EL	Nisia Aigaiou, Kriti	37.7	61.0	**40.7**
199	EL	Voreia Ellada	37.7	60.9	**40.7**
200	ITI	Umbria	37.8	57.9	**40.4**
201	FR	La Réunion	39.0	49.1	**40.3**
202	TR	Orta Anadolu	37.1	61.2	**40.2**
203	ITI	Sardegna	37.4	58.0	**40.0**
204	ITI	Abruzzo	37.2	58.7	**40.0**
205	PL	Region Wschodni	37.3	57.8	**40.0**
206	TR	Bati Karadeniz	36.3	60.9	**39.5**
207	BG	Yugozapaden	35.6	62.8	**39.1**
208	HR	Jadranska Hrvatska	36.1	58.7	**39.1**
209	TR	Bati Marmara	35.8	60.8	**39.0**
210	ITI	Molise	35.2	56.7	**37.9**
211	RO	Vest	33.6	64.4	**37.6**
212	MK	Poranesna jugoslovenska Republika Makedonija	34.0	61.0	**37.5**
213	TR	Dogu Karadeniz	34.2	57.3	**37.2**
214	ITI	Basilicata	34.1	57.3	**37.1**
215	ITI	Sicilia	33.7	57.6	**36.8**
216	RO	Nord-Vest	32.8	62.5	**36.6**
217	EL	Kentriki Ellada	33.3	57.8	**36.5**
218	ITI	Campania	33.2	57.2	**36.3**
219	BG	Severen tsentralen	32.3	61.9	**36.1**
220	ITI	Puglia	33.0	55.6	**36.0**
221	TR	Ortadogu Anadolu	32.4	54.6	**35.3**
222	BG	Severoiztochen	31.4	60.4	**35.2**
223	ITI	Calabria	31.8	56.7	**35.0**
224	BG	Yuzhen tsentralen	30.4	58.5	**34.1**

R	CODE	REGION	DIM1	DIM2	HIDDI
225	RO	Centru	30.3	59.1	**34.1**
226	RO	Sud-Est	29.5	60.0	**33.4**
227	BG	Yugoiztochen	29.4	60.1	**33.4**
228	TR	Kuzeydogu Anadolu	30.2	53.6	**33.3**
229	BG	Severozapaden	29.3	59.2	**33.2**
230	RO	Sud - Muntenia	29.1	60.2	**33.1**
231	TR	Güneydogu Anadolu	29.6	54.8	**32.9**
232	RO	Nord-Est	28.8	59.7	**32.8**
233	RO	Sud-Vest Oltenia	29.3	55.5	**32.7**

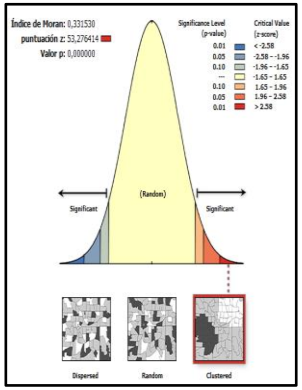
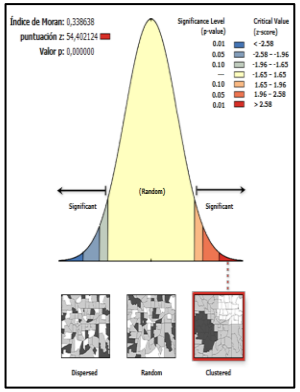
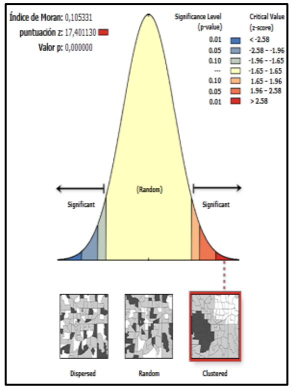
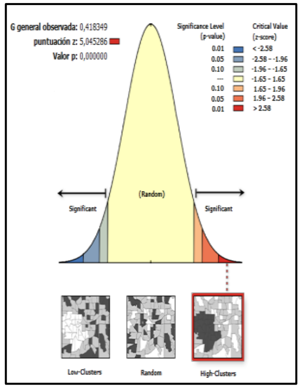
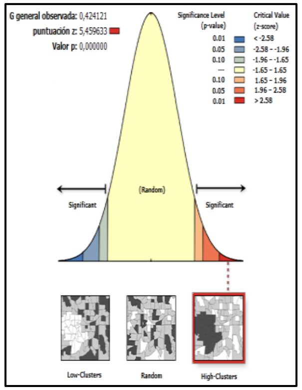
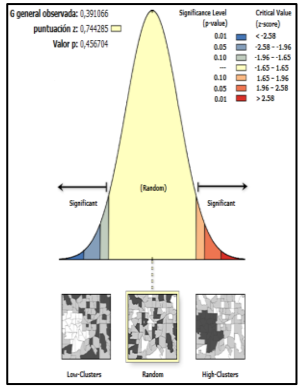
R	**Number of ranking**
***CODE**	**Code of Country**
AT	**Austria**
BE	**Belgium**
BG	**Bulgaria**
CH	**Switzerland**
CY	**Cyprus**
CZ	**Czech Republic**
DE	**Germany**
DK	**Denmark**
EE	**Estonia**
EL	**Greece**
ES	**Spain**
FI	**Finland**
FR	**France**
HR	**Croatia**
HU	**Hungary**
IE	**Ireland**
IS	**Iceland**
ITI	**Italy**
LT	**Latvia**
LU	**Luxembourg**
LV	**Lithuania**
MK	**Macedonia**
MT	**Malta**
NL	**Netherlands**
NO	**Norway**
PL	**Poland**
PT	**Portugal**
RO	**Romania**
SE	**Sweden**
SI	**Slovenia**
SK	**Slovakia**
TR	**Turkey**
UK	**United Kingdom**

****REGION**: NUTS 1/NUTS 2

APPENDIX C. Indices and maps of spatial autocorrelation

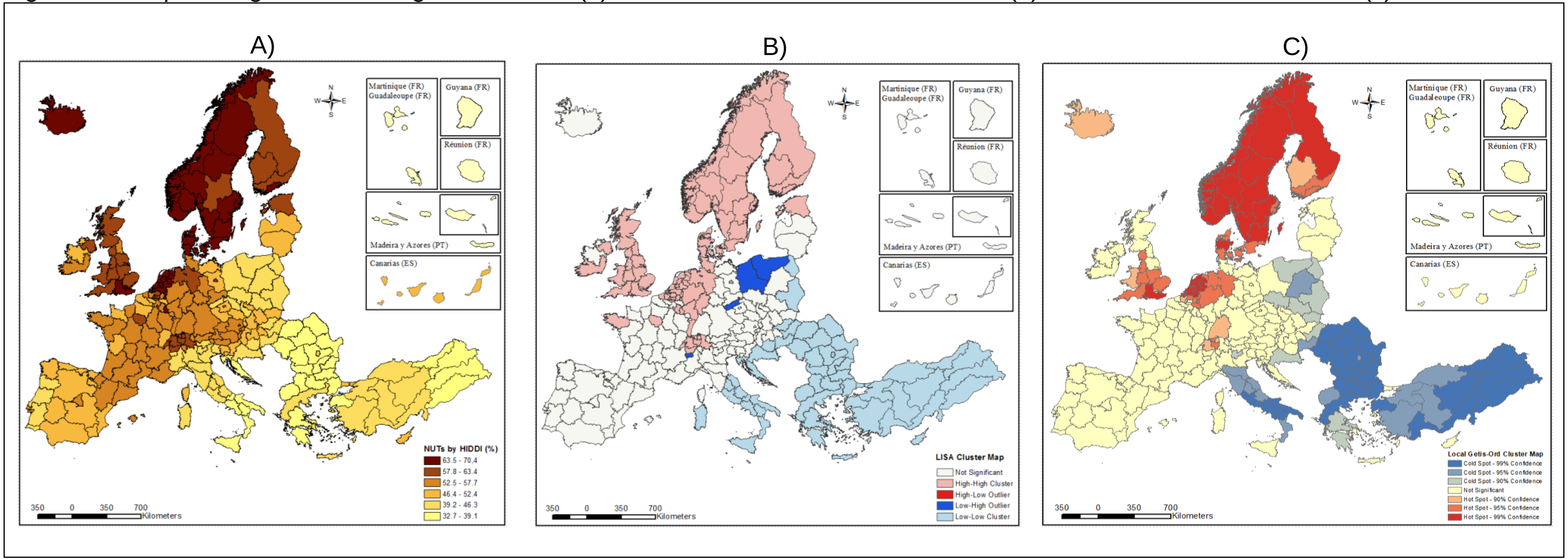
Figure 1. Moran's Global Index and Getis-Ord General G Index for the HIDDI and its dimensions of European regions.

	Moran's Global I				Getis-Ord General G		
	HIDDI	**DIM1**	**DIM2**		**HIDDI**	**DIM1**	**DIM2**
Moran´s Index	**0.330**	**0.339**	**0.105**	Observed General G	**0.418**	**0.424**	**0.391**
Expected Index	-0.004	-0.004	-0.004	Expected General G	0.388	0.389	0.389
Variance	0.000	0.000	0.000	Variance	0.000	0.000	0.000
z - score	**53.28**	**54.40**	**17.40**	**z - score**	**5.045**	**5.459**	**0.744**
p - value	0.000	0.000	0.000	p - value	0.000	0.000	0.457
Spatial relationships	Contiguity edges only			Spatial relationships	Contiguity edges only		

HIDDI	DIM1	DIM2	HIDDI	DIM1	DIM2
					
Given the z score of 53.276 there is a less than 1% likelihood that this clustered pattern could be the result of random chance.	Given the z score of 54.4 there is a less than 1% likelihood that this clustered pattern could be the result of random chance.	Given the z score of 17.4 there is a less than 1% likelihood that this clustered pattern could be the result of random chance.	Given the z score of 5.045 there is a less than 1% likelihood that this high-clustered pattern could be the result of random chance.	Given the z score of 5.459 there is a less than 1% likelihood that this high-clustered pattern could be the result of random chance.	Given the z score of 7.44 the pattern could be the result of random chance.

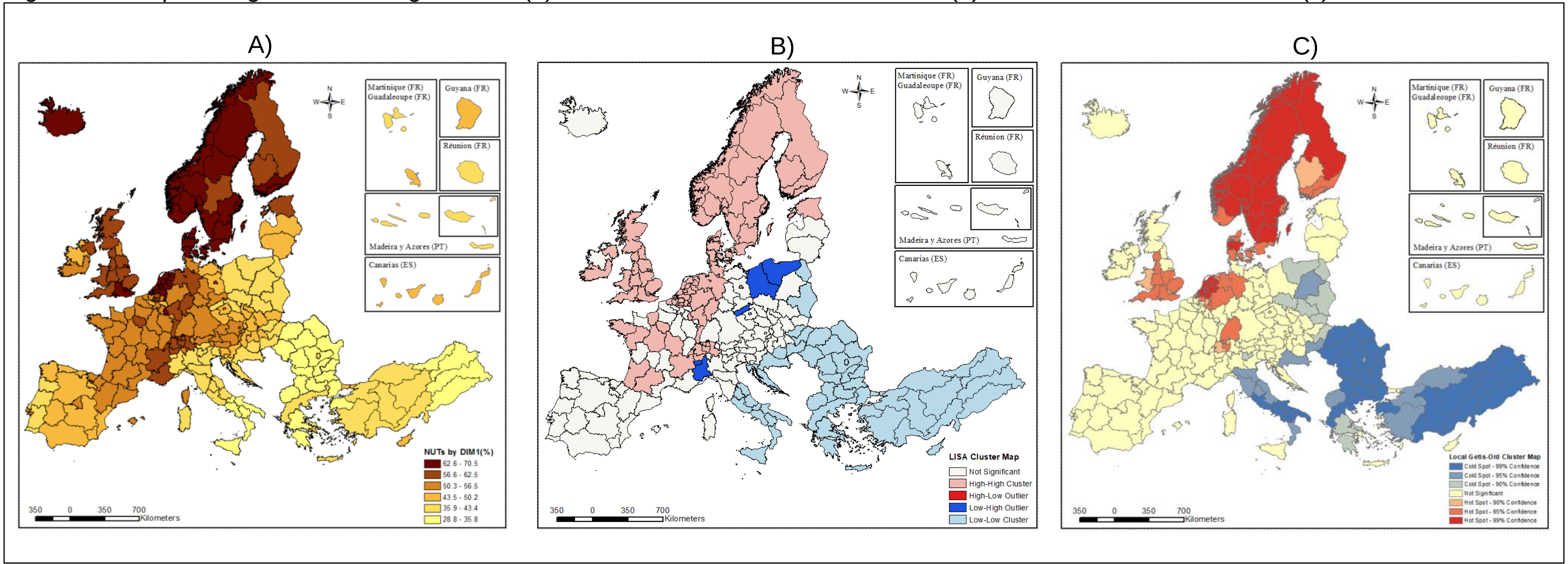
Source: Own preparation

Figure 2. European regions according to the HIDDI (a), the Anselin Local Moran's I - LISA (b) and the Getis-Ord Gi* index (c).



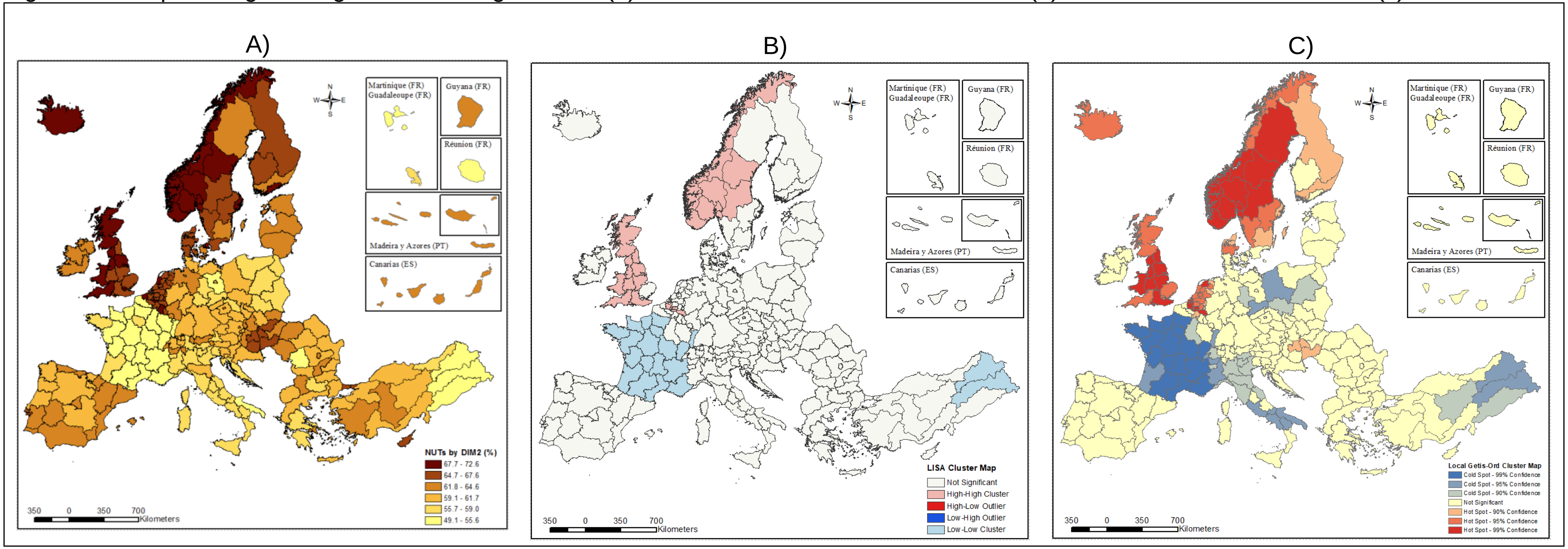
Source: Own preparation

Figure 3. European regions according to DIM1 (a), the Anselin Local Moran's I - LISA (b) and the Getis-Ord Gi* index (c).



Source: Own preparation

Figura 4. European regions regions according to DIM2 (a), the Anselin Local Moran's I - LISA (b) and the Getis-Ord Gi* index (c).



Source: Own preparation