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Information society and socio-economic characteristics in Europe: a typology of regions

Sociedad de la Información y características socioeconómicas en Europa: una tipología de regiones

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Abstract

Research on the Information Society and its socio-economic context is limited at the European regional level. This research aims to identify the socio-economic and technological factors that define the underlying structure of household-individual (H+i) digital development, at NUTS 2 level, using Factor Analysis, with data that have been collected from Eurostat, and characterise the socio-economic environments associated with advanced ICT use using Cluster Analysis. We show that, at the regional level in Europe, the use of advanced ICT_H+i is related to GDP pc, the qualification of the population and high-tech employment; broadband internet access is associated with employment and the average educational level of the population; and the degree of innovation, business growth and ICT employment are decoupled from the level of ICT_H+i. The model defines a spatial performance that contrasts the southern and eastern European regions, with high availability of ICT infrastructures but low advanced use of them; with the central-northern regions, the most advanced in the EU in terms of ICT access and use, with adequate infrastructure and high upper-middle education levels that allow for the improvement of ICT skills and regional digital transformation.

Keywords: Information and communication technologies (ICTs); households and individuals (H+i); socio-economic and technological factors; digital development; NUTS 2.

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Resumen

La investigación sobre la Sociedad de la Información y su entorno socioeconómico es reducida a escala regional europea. Esta investigación pretende: identificar los factores socioeconómicos y tecnológicos que definen la estructura subyacente del desarrollo digital de los hogares-individuos (H+i), a nivel NUTS 2, mediante Análisis Factorial, con datos obtenidos de Eurostat; y caracterizar los entornos socioeconómicos asociados al uso avanzado de las TIC con Análisis Clúster. Mostramos que, a nivel regional, en Europa, el uso de las TIC avanzadas de los H+i se relaciona con el PIB pc, la cualificación de la población y el empleo en alta-tecnología; el acceso a internet por banda ancha se asocia al empleo y al nivel educativo medio de la población; y el grado de innovación, crecimiento empresarial y el empleo TIC se desvinculan del nivel de TIC_H+i. El modelo define un comportamiento espacial que contrapone las regiones europeas del sur y este, con alta disponibilidad de infraestructuras TIC, pero reducido uso avanzado de ellas; frente a las del centro-norte, las más avanzadas de la UE en el acceso y uso de las TIC, con adecuada infraestructura y alto nivel educativo superior-medio que permiten el perfeccionamiento de destrezas TIC y la transformación digital regional.

Palabras clave: Tecnologías de la Información y Comunicación (TIC); hogares e individuos; factores socioeconómicos y tecnológicos; desarrollo digital; NUTS 2.

1. Introduction

The digital development of a region is regarded as the process that drives the transformation of the region towards the information and knowledge society and makes it possible to modify conditions through the generation and processing of information and knowledge in order to, from then on, improve competitiveness, innovation and the adoption of information and communication technologies (ICTs) (Gónzalez-Relaño, R. et al., 2021). In this context, such processes are reliant on the provision of ICT equipment and Internet access, both being fundamental elements to achieve the digitalisation of a region (Hernández & Maudos, 2021).

ICTs access and usage has produced the so-called digital society. This is when the public, companies and institutions establish their relationships (social, administrative, employment, consumption, etc.), while simultaneously generating data and information via digital devices and platforms, giving rise to digital development (Ruiz-Rodríguez, et al., 2018). Therefore, digital technologies are a constant component of the lives of individuals and companies, with these becoming dependent on digital technologies and their specific infrastructures.

The rapid progress of ICTs at global level is sparking the interest of many researchers, motivating them to focus their research on the impact of the diffusion of ICTs on the socio-economic growth of regions. According to Stanley et al. (2018), the socio-economic characteristics of a region may or may not favour access to, and advanced use of, ICTs in that region. In this context, outstanding modern theories such as neo-Schumpeterian ones (Schumpeter & Nichol, 1934; Malacarne, 2018; Garbin & Marini, 2021) and the neoclassical growth theory (Solow, 1956), have pointed out the positive relationship between the socio-economic characteristics of a territory/region and the development of technology, including ICTs. Consequently, these theories suggest that ICTs constitute a key input for a region to improve the production process, modernise technology and enhance workforce skills. They also entail a result (collection of data and complex information) that makes competitiveness and complex technology essential elements of the regional business fabric (Jordá-Borrell, 2021).

The EU policy to achieve the digitalisation of European society dates back to 1999 with the "e-Europe" plan, which intended to create an information society for all. In the first decade of the twenty-first century, within the framework of the Lisbon Strategy, the policy focused on increasing Internet connections; development of services, applications and contents; and fostering knowledge and information through Plan i2010. In the second decade of the century, under the "Europe 2020 Strategy for smart, sustainable and inclusive growth" the European Digital Agenda was implemented, with the aim of reducing the digital divide, and also a Digital Single Market Strategy (Muñoz & Pérez, 2017). Recently, the EU approved the so-called second digital strategy 2020-30, whose objectives are specified in the "2030 Digital Compass": a society with citizens and professionals prepared for the digital future; sustainable, secure and efficient digital infrastructures; a digital transformation of companies; and an extensive digitalisation of public services.

Consequently, in Europe, the use of basic ICTs reveals uniform regional behaviour (Ruiz-Rodríguez et al., 2020). European regions have high values of usage of basic ICTs, with those of a social nature predominating, while the use of more complex or advanced ICTs by European users (educational, healthcare, e-commerce, administrative, etc.) vary between regions (Alzahrani et al., 2018; Berkowsky et al., 2017); and are in keeping with their socio-economic environment (educational level and degree of access to the technology, infrastructures, financing, business dynamics, etc.) (Lee & Porumbescu, 2019; Yera et al., 2020).

Thus, Ragnedda & Kreitem (2018) points out that the socio-cultural and economic background of the population is an important factor in the digital inequalities between the households and individuals of European regions, as these are determined by the different uses and abilities that people may have developed to obtain greater benefits from ICTs. Accordingly, for the use of digitalisation to be effective, the public, companies and institutions must utilise and take advantage of ICTs investment. This means that the human resources must be equipped with sufficient technological and digital skills (Hernández & Maudos, 2021). Similarly, different authors indicate that both the most advanced uses of ICTs (healthcare, finances, research, etc.) (Lucendo-Monedero et al., 2019)DD and the production of ICTs (companies with ICTs specialists) require people with medium-high levels of education (Alfaro et al., 2017).

The successful introduction of ICTs in a region therefore requires an adequate level of training; a sufficiently high GDP per capita to generate wealth and innovation (creation of software, human capital management processes, etc.) (Erazo & Castro, 2011); a diversified and potent business development and significant employment in telecommunication companies (Jordá-Borrell, 2021). Ultimately, this leads one to think that the ability of regions to access ICTs and use them efficiently (individuals, institutions, companies, etc.) is linked to their socio-economic characteristics (Moyano, 2020). Hence, in this research, the use of ICTs by the public is defined as a multifactorial and multicausal phenomenon; so different factors and causes concur when it comes to explaining their implementation in correlation with regional socio-economic dynamics. It is now known that the influence of the ICT factor is maximised when this interacts with other economic, social and innovation factors, etc. (Jordá-Borrell & López-Otero, 2020).

Currently, empirical research on the information and communication society at regional scale within the EU (NUTS 2 level) is insufficient, especially the analysis of its relationship with the socio-economic environment. Moreover, when this topic has been addressed, studies have focused above all on the factors that determine basic digital development (Cruz-Jesus et al., 2016). Iden-

tification of this research gap has led to the proposition of the following hypotheses, and their corresponding research questions:

1. There are few differences between regions in terms of Internet access for the European population because the policies of the EU and national governments on communications equipment and infrastructures have helped significantly reduce such possible inequalities. This leads us to ask the following question. Are the regions with good telecommunications infrastructure coverage, such as the availability of broadband, those that most use advanced ICTs?
2. The distance between regions, in terms of the use of social networks by the population, is small, while the dissimilarities between regions in the use of advanced ICTs are important. Are these latter differences associated with the socio-economic characteristics of the regions? Which socio-economic factors or elements are more important? Is the innovation and business capacity of a region associated with the advanced use of ICTs by the population of that region?

In this context, the aim of this study is, first, to identify the socio-economic (related to training, business and regional wealth) and technological (innovation, digitalisation, etc.) factors that may define the underlying structure of the digital development of households and individuals (ICT_H+i); and second, to characterise the socio-economic environments that are associated with the advanced use of ICTs at NUTS 2 regional level in Europe. To this end, the following are necessary: 1) Identify the interaction between the socio-economic variables and ICT_H+i access and usage by means of factor analysis (FA); 2) Establish a typology of regions (NUTS 2) according to the socio-economic environment and ICT access and usage by means of a cluster analysis (CA).

2. Theoretical framework

In recent decades, the great diffusion of ICTs has given rise to a transformation of the world towards an information society. Thus, the physical limits of geographical storage capacity, transmission of information (universality) and simultaneity and speed of information have been surpassed (García, 2013). Thanks to ICT infrastructures and equipment, individuals and governments now have much better access to information and knowledge than before in terms of scale, scope and speed.

Hence, in order for such diffusion of ICTs to take place, equipment that facilitates high-quality access to Internet is needed. The EU and national and regional governments have taken a number of actions to modernise telecommunications infrastructures and, more specifically, provide broadband. This helps foster and drive its use by the public, companies and institutions, and the availability of such infrastructures has a positive effect on regional economies (Appiah-Otoo & Song, 2021). These infrastructures, along with the corresponding devices and associated applications, are becoming increasingly diverse, and now it is not so much "those who have" and "those who do not have" but rather the present analysis focuses on the degree of use and its different patterns (Salemink et al, 2017). To date, usually, the greater the frequency of Internet use, the greater the associated skills, and vice versa. However, the level of digital skills of human capital is also related to the educational and training levels attained by the population, with training being one of the keys of the digital transformation of Europe (European Commission, 2021). Human capital, as is known, is the basis of regional competitiveness, stimulating employment, technological and business growth and, accordingly, GDP growth (Hernández & Maudos, 2021).

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In this respect, the European Commission (2016) has proposed that everybody should have the opportunity to prosper, choose freely and participate, with security, in the information society, regardless of age, gender or professional situation. To this end, the population need to acquire certain digital capabilities and skills related to information (information on goods and services, looking for information on health, organising and saving information), communication (sending/receiving e-mails, participation in social networks, etc.), resolution of problems (online services, online sales and purchases, Internet banking, etc.) and use of software (use of spreadsheets, photo editing programs, video or audio files, creation of presentations or documents that include text, images, tables or graphs, etc.) (Hernández & Maudos, 2021). Aptitudes and skills are considered to be advanced if the population is capable of carrying out more than one of these activities.The digital transformation of society will take place when the advanced use of ICTs is adopted by large sectors of the population, as information and knowledge are decisive variables for increasing the technological and human capacity to generate, process and produce (Castells, M. 2019). This fact is correlated with an educational level (medium and high) which enables the development of the skills necessary to use the technology more efficiently (Wirtz & Kurtz, 2017). This implies that a large part of society benefits from the ICTs, and is more disposed to accept the risks of using the technology (Billon, et al., 2021).

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It should not be overlooked that digitalisation is transforming jobs, threatening the stability of some with its automation and demanding the renewal of many of them, in order to make work more productive, while creating opportunities for workers whose education, training and digital skills and abilities allow them to better take advantage of the new technologies (Grigorescu et al., 2021). Therefore, the regions that invest in their human capital, and in the link between R&D and technology, will see their wealth increase. Digital aptitudes/skills are becoming increasingly primordial in order for people to improve their social position, work from home or start up their own business. They are also fundamental in allowing companies to increase their productivity and competitiveness, and they open up new business possibilities on the basis of the quality of their human resources; and consequently, provide new opportunities for European regions (Lamberti et al., 2021).

Investment in new technologies, including ICTs and digital technologies, will improve the working and economic conditions of the population and of companies, optimising the validity of resources, reducing production costs, initiating demand and stimulating much greater investment in all socio-economic sectors at state and regional level (Jorgenson & Vu, 2016; Pradhan et al., 2018). On the other hand, it is also associated with an increase in the production of R&D. Investment in R&D and innovation tends to be concentrated in knowledge-intensive sectors, also known as high-technology sectors. In these sectors, companies mainly use R&D to obtain a competitive advantage and the skills of human capital constitute a fundamental input, including their ability to use ICTs (Sandu & Ciocanel, 2014).

Nonetheless, it is still necessary to further investigate the interaction between the use of advanced ICTs by individuals and households (ICT_H+i) (Jordá-Borrell et al., 2018) and the regional socio-economic environment, as the results of previous studies (with both large and small samples) continue to be partial and disparate. Some authors (Caridad et al., 2014) affirm that access to and use of advanced ICTs are indispensable in order to intensify the competitiveness of regions. Meanwhile, other studies indicate that ICTs alone do not increase regional GDP but rather need to be accompanied by other factors (Bahrini & Qaffas, 2019; Iammarino et al, 2018).

Therefore, the ideas put forward in this section justify the treatment of variables such as GDP per capita, educational and training levels of the population, employment, R&D expenditure, the generation of patents, business dynamics, etc.; as variables representative of the regional socio-economic environment associated with the population's capacity to access and use ICTs in the region. They also reveal the need to analyse the interaction, or the different relationships that exist, between the socio-economic variables and ICT access and usage in order to provide a typology of regions at NUTS 2 level in accordance with the intensity and characteristics of these relationships.

3. Methodology

3.1. Territorial scope of study, data and variables

This paper analyses the relationship between socio-economic characteristics and Internet access of households and the advanced/basic use of ICTs by individuals (ICT_H+i) in the NUTS 2 regions (nomenclature of territorial units for statistics, a hierarchical system for dividing the economic territory of the EU, and the spatial unit of reference in the present study). On the one hand, using FA, 15 variables have been chosen from a total of 26 (Appendix A) which, according to theory, show a relationship between socio-economic characteristics of a territory (level of wealth, educational level, innovative capacity and business dynamics) and ICTs access and usage by households and individuals (Table 1). The data of these variables have been obtained from the regional statistics of Eurostat for 2019, and when data for this year is not available, data for 2018 has been selected.

On the other hand, a population of 333 regions of the European Union has been used, which includes the NUTS 2 regions of the 27 countries belonging to the European Union (EU), the 26 regions of Turkey (country in accession negotiations with the EU), the 41 regions of the United Kingdom, as at the time of study they belonged to the EU, the 7 regions of Norway (country belonging to the European Economic Area) and the 8 regions of Switzerland (member of the European Free Trade Association - EFTA). However, the lack of data at NUTS 2 level in some countries made it necessary to use: i) the NUTS 1 level for Germany, Greece, Poland and the United Kingdom; ii) and NUTS 1 or NUTS 0 level for some regions of Turkey, and regions that make up NUTS 1 in eastern Anatolia and in eastern Europe.

Table 1: Description of Variables

TYPOLOGY	VARIABLES	YEAR	DESCRIPTION AND UNIT OF MEASURE	EUROSTAT SOURCE
LEVEL OF WEALTH	GDP per capita compared to the EU28 average in PPP	2019	Regional gross domestic product (PPS per capita as % of EU28 average).	https://ec.europa.eu/eurostat/databrowser/view/tgs00006/default/table?lang=en
	Unemployment rate in the population aged 15-74 years old	2019	Percentage of the unemployed population aged 15-74 years old.	https://ec.europa.eu/eurostat/databrowser/view/lfst_r_lfu3rt/default/table?lang=en
LEVEL OF EDUCATION	Population aged 25-64 with tertiary education	2019	Percentage of the population aged 25-64 with tertiary education (Tertiary education ISCED 5-8).	https://ec.europa.eu/eurostat/databrowser/view/EDAT_LFSE_04__custom_2315836/default/table?lang=en
	Working population aged 15-64 with secondary and tertiary education	2019	Percentage of the working population aged 15-64 with secondary and tertiary education (Tertiary education ISCED 3-8).	https://ec.europa.eu/eurostat/databrowser/view/LFST_R_LFP2ACTRC__custom_2338730/default/table?lang=en
LEVEL OF INNOVATION	Employment in High Technology Sectors	2019	Employment in high-technology sectors as a percentage of total employment. (Statistical classification of economic activities in the European Community; NACE Rev. 2 codes-2-digital level: 09, 19, 21, 26, 51, 58-79 and 90)	https://ec.europa.eu/eurostat/databrowser/view/HTEC_EMP_REG2__custom_2338815/default/table?lang=en
	Patent applications as a share of GDP	2012	Number of patent applications with respect to GDP in billions.	https://ec.europa.eu/eurostat/databrowser/view/PAT_EP_RTOT__custom_2339933/default/table?lang=en
	Intramural spending on R&D	2017	Domestic R&D expenditure as a percentage of GDP	https://ec.europa.eu/eurostat/databrowser/view/RD_E_GERDREG__custom_596580/default/table?lang=en
BUSINESS DYNAMICS	Growth rate of employment in telecommunications	2018	Percentage of net employment growth of in telecommunications sectors (with respect to previous year).	https://ec.europa.eu/eurostat/databrowser/view/SBS_R_NUTS06_R2__custom_2340087/default/table?lang=en
	Net Growth of the Number of Companies	2018	Percentage of net growth of number of companies in industry, construction and services sectors (with respect to previous year).	https://ec.europa.eu/eurostat/databrowser/view/BD_ESIZE_R3__custom_597161/default/table?lang=en
LEVEL OF ACCESS ICTs	Households with internet access	2019	Percentage of total number of households where anyone in the household has the possibility to access Internet from home.	https://ec.europa.eu/eurostat/databrowser/view/isoc_r_iacc_h/default/table?lang=en
	Households with broadband	2019	Percentage of total number of households that have broadband Internet access.	https://ec.europa.eu/eurostat/databrowser/view/ISOC_R_BROAD_H__custom_2341129/default/table?lang=en

TYPOLOGY	VARIABLES	YEAR	DESCRIPTION AND UNIT OF MEASURE	EUROSTAT SOURCE
LEVEL OF USE ICTs	Individuals who access the Internet on a daily basis	2019	Percentage of total number of individuals who use Internet on a daily basis for any type of consultation.	https://ec.europa.eu/eurostat/databrowser/view/ISOC_R_IUSE_I__custom_2341207/default/table?lang=en
	Individuals who used the Internet for online banking	2019	Percentage of total number of individuals who access Internet to conduct banking transactions.	https://ec.europa.eu/eurostat/databrowser/view/ISOC_R_IUSE_I__custom_595421/default/table?lang=en
	Individuals who used the Internet for the sale of goods and service	2019	Percentage of total number of individuals who access Internet for the sale of goods and services.	https://ec.europa.eu/eurostat/databrowser/view/ISOC_R_IUSE_I__custom_2315292/default/table?lang=en
	Individuals who used the Internet to interact with public authorities	2019	Percentage of total number of individuals who access Internet to interact with public authorities.	https://ec.europa.eu/eurostat/databrowser/view/ISOC_R_GOV_I__custom_595365/default/table?lang=en

Source: Prepared by the authors

3.2. Statistical analysis

To confirm the hypotheses and the objectives set out, the research was undertaken in two stages:

1. First, a factor analysis (FA) was conducted, using the IBM SPSS v24 program, to identify the interdependencies between the ICT_H+i variables and the socio-economic variables (Table 1) on the basis of a total of 26 variables available for the NUTS 2 regional level. The FA is a multivariate statistical technique that identifies the interdependencies between a set of variables, joining them by means of common factors that are not directly observable (Pérez & Méndez., 1995); and therefore show, in this research, the underlying dimensions between the socio-economic aspects of European regions and the digital development of their households and population (ICT_H+i). An exploratory type of FA was conducted using the principal components method, which is based on the principle of maximising the variance explained, and the first factor is that which justifies better and greater variance, the second accounts for the largest amount of the remaining residual variance, being independent of the first factor, and so on with the successive factors which explain small amounts of the total variance (Frías-Navarro & Pascual, 2012). Likewise, and with the same aim, a factor matrix was obtained rotated by the Varimax method, an orthogonal rotation method that reduces the number of essential factors to a minimum to justify and interpret the set of variables observed and studied.
2. On the basis of the resulting factor model, a cluster analysis (CA) was performed using the IBM SPSS v26 program, to establish a typology of regions according to the interaction between ICT access and usage by households and individuals and the socio-economic characteristics of European regions. The CA makes it possible to group the regions according to similarity of their characteristics (variables). Using the factor scores obtained in the FA, two types of analysis of conglomerates were performed: i) hierarchical (with the Ward method and squared Euclidean distance), apt for establishing the optimum number of conglomerates in the data, and subsequently carrying out the analysis of the dendrogram, opting for a distance of 10 with 5 groups; ii) subsequently, with the non-hierarchical k-means method (making it possible to process an unlimited number of cases), the regions were assigned to the resulting groups and their main characteristics defined (final averages or centres of the conglomerates) according to the variables of classification (factors). Moreover, for each of the clusters, a statistical analysis

(centrality and dispersion) was performed for each of the primary variables used in the FA (15) in order to characterise each of the clusters in greater detail.

4. Results

4.1. Factor analysis

The structure of interrelationships between the socio-economic aspects of European regions and the digital development of households and individuals (ICT_H+i), resulting from the factor analysis, is made up of 4 factors (Tables 2 and 3) based on 15 variables. The resulting factor model explains 70.036 % of the total variance, with a KMO of 0.858, and a determinant of 0.00003601, a very low level. These factors are:

Factor 1. This factor (36.45 % of the variance explained) encompasses all the variables of Internet access and usage, associated with GDP per capita, employment in high-technology sectors and the population with higher education level (degrees, masters and doctorates). The European Commission (2021) revealed the importance of the level of education for the acquisition of digital skills; such is the relevance of having or not having higher studies that, of the total population with studies, 93.9 % of this population developed digital skills, compared with the population without studies, where only 59.3 % have managed to develop such skills. This factor could be called ICT_H+i and GDP per capita.

Factor 2. This accounts for 11.76 % of variance explained and comprises the positive association of the generation of patents and R&D expenditure variables. This component would explain the relationship between R&D expenditure in all sectors and the generation of patents, and could be termed R&D and Patents.

Factor 3. This accounts for 11.69 % of variance explained, combining the population with the secondary and tertiary education (medium-high), households with broadband and the unemployment rate variables. This component presents different signs in its correlation; thus, when the unemployment rate falls it is because the number of households with broadband and the population with a medium-high level of education increase. This factor could be designated Human Capital and ICT infrastructure.

Factor 4. This accounts for 10.14 % of variance explained, and associates the following variables: growth rate of employment in telecommunications and net growth of the number of companies. It indicates that in regions with employment growth in the telecommunications sector this is linked to growth of the business fabric. Both of these have positive factor loads, implying that these variables are not directly associated with ICT usage by households and individuals. This factor could be called Business growth and employment in telecommunications.

4.2. Cluster analysis

A cluster analysis of k-means was performed on the basis of 4 complex variables (factors), identifying 5 homogeneous groups of European regions, which are set out ordered from lesser to greater intensity of access and advanced use of ICTs by households and individuals (Table 4 and Map 1).

Cluster 1 (32.52 % of regions). This encompasses the regions of Eastern Europe, plus Turkey, northern and central Italy, Portugal and the Spanish region of Castilla La Mancha (Map 1). This cluster is defined by the negative character of Factor 1 (ICT_H+i and GDP per capita). These regions have a GDP per capita below the European average (48 % with respect to the European average of 66.77 %). The regions belonging to this cluster have a lower level of socio-economic development than the rest, as they have an above-average unemployment rate, a low growth rate of employment in telecommunications (2.24 %), with Internet access of 84.21 % (five percentage points below the average) and advanced use of ICTs (online sales and interaction with public authorities) well below the average (close to 30 percentage points), although they do have an extensive access infrastructure (98.51 % of households with broadband).

Cluster 2 (14.28 % of regions). This group is defined by Factor 3 (Human Capital and ICT infrastructure). Here we differentiate between two subgroups, marked by differences between levels of infrastructure, levels of digital skills and unemployment rates:

- Cluster 2.1, comprising regions of southern Europe (Greek, Italian and Andalucía and Extremadura in Spain), territories with a low socio-economic level: the average GDP per capita of this cluster is 55.36%, (40 percentage points below the European average), with a high unemployment rate (19.08 % compared with the European average of 7.05 %). Internet access of households of the regions of this Cluster 2.1 is 80.00 % with broadband and covers 99.05% of households, and they have human resources with tertiary education (5.57 % compared with the European average of 4.14 %). Nonetheless, there is a low use of online banking (32.52 %, twenty-four percentage points below the European average) and sale of goods and services, only 5.36 % compared with the average of 19.43 %.
- Cluster 2.2 corresponds to French regions, except those of the centre, characterised by a high GDP per capita, 94.32 %, close to the European average, and a working population of medium-high educational level, slightly below the European average (71.07 % compared with the European average of 81.15 %). This is also the case for the net growth of the number of companies, 0.58 %, while the unemployment rate of 10.60% is closer to the European average. These are regions that have still not achieved total coverage, with Internet access for 87.25 % of households, of which 90.26 % have broadband, compared to the figures of 89.50 % and 98.20 % of the European average, respectively. This deficit of ICT access infrastructures makes it difficult to develop digital skills since, as can be observed in the data, the advanced use of sale of goods and services is present in close to 20 % of households, and advanced use for online banking and interaction with public authorities is slightly above 60 % of households.

Cluster 3 accounts for 38 % of European regions and is defined positively by Factor 1 (ICT_H+i and GDP per capita). It includes territories of Sweden, Finland, Estonia, Latvia, Denmark, regions of northern Germany, the Netherlands, Belgium, the United Kingdom, Ireland, north-eastern Spain (plus the Islas Canarias), Austria, Switzerland, the Czech Republic and some capitals and regions of eastern Europe. They are regions that have a GDP per capita slightly above the European average (126.88 % compared with the European average of 95.77 %), and a level of ICT access infrastructure of 94.14 % of households, of which 99.30 % have broadband compared with the European average of 98.20 %. They also have a growth of the business population of 1.03%, 84.36% of the active population have higher studies and employment in high-technology sectors is 4.31 %, all slightly above the European average (0.83 %, 81.15 % and 3.61 % respectively).

They are regions that have achieved a high level of digital skills, well above the European average, with regard to the use of online banking (72.74 %, compared with the European average of 56.75 %) 25.39 % for sale of goods and services compared with 19.43 % in Europe as a whole and 66.79 % for use with the public authorities, compared with the European average of 55.94 %.

Cluster 4 (13.98 % of regions). This encompasses a large part of the regions of Germany, Austria, southern Finland and Sweden, a central nucleus of France and the British region of East Anglia-Berkshire. This group is mainly delimited by Factor 2 (R&D and Patents). They are territories with high values of access to, and advanced use of, ICTs (66.54 % compared with the European regional average of 55.94 % in use with public authorities, and 69.78 % compared with the European average of 56.76 % for online banking.

From a socio-economic point of view, these regions have a high GDP per capita, 50 percentage points above the European average (143.06 %, compared with the European average of 95.77 %), a growth rate of employment in telecommunications almost double the European average (8.06 % compared with 5.35 for Europe), and the percentage of employment in high-technology sectors (5.04 %) is two percentage points above the European average. All of this is based on a high level of investment in R&D (3.5 % of GDP on R&D expenditure compared with the European average of 1.64 %) which gives rise to a high number of patents (6.86 % compared with the European average of 2.63 %).

Cluster 5 includes 1.22 % of regions. It is made up of the German regions of Oberfranken, Münster and Detmold and the Polish region of Mazowiecki regionalny (Map 1), basically characterised by Factor 4 (business growth and employment in telecommunications). They are socio-economically advanced regions, with a GDP per capita above the European average (99.5 %), a growth rate of employment in telecommunications of 10.95 % compared with 5.36 % for Europe; 85.10 % of the working population have higher education and a high degree of ICT access and usage. These regions, therefore, have a high level of digital skills which results in a very high rate of growth of employment in telecommunications in parallel with business growth, with an unemployment rate lower than the European average (3.32 % compared with 7.05 % for Europe).

After the clustering of each of the clusters of regions, the cartographic representation of these shows a clear north-south-east spatial component, in the interaction between the ICT access and usage of individuals and households and their socio-economic characteristics (Map 1). The analysis of clusterisation underlines the verification of the proposed hypothesis, that is, that territories that have a high socio-economic level intensify their investment in the access and use of advanced ICTs:

- The regions of Germany, Norway and the north of Spain have an above-average socio-economic level, which has enabled them to reinforce their digital development, the degree of innovation and investment (patents, R&D expenditure), business growth and employment in the ICT sector (Cluster 3). Therefore, the dynamism of these variables indicates that the GDP per capita has predisposed them to apply regional policies to foster the access and use of advanced digitalisation, training and employment; while at the same time it can be affirmed that these policies have been successful (Clusters 4 and 5).

- However, the regions of southern Italy, Spain and Greece, plus those of eastern Turkey (Cluster 2.1) have a low rate of growth of business start-ups, along with a low GDP per capita and little

training of their human capital. It follows that the threshold of these indicators does not make it possible to tackle the high unemployment rate and the limited knowledge of advanced ICTs.

Table 2. Total Variance Explained

Total variance explained									
Component	Initial eigenvalues			Sums of charges squared of Extraction			Sums of charges squared by rotation		
	Total	% of variance	% Accumulated	Total	% of variance	% Accumulated	Total	% of variance	% Accumulated
1	6,419	42,795	42,795	6,419	42,795	42,795	5,467	36,448	36,448
2	1,619	10,791	53,585	1,619	10,791	53,585	1,764	11,761	48,209
3	1,439	9,595	63,181	1,439	9,595	63,181	1,753	11,688	59,897
4	1,028	6,855	70,036	1,028	6,855	70,036	1,521	10,138	70,036
5	0,987	6,577	76,613						
6	0,776	5,173	81,786						
7	0,605	4,037	85,822						
8	0,538	3,589	89,411						
9	0,418	2,785	92,196						
10	0,333	2,218	94,414						
11	0,276	1,837	96,251						
12	0,206	1,374	97,625						
13	0,183	1,223	98,847						
14	0,118	0,786	99,633						
15	0,055	0,367	100,000						

Extraction method: principal component analysis.

Source: Prepared by the authors

Table 3: Rotated component matrix

Rotated component matrixa				
	Component			
	1	2	3	4
Individuals who used the Internet for online banking	0.924			
Individuals who access the Internet on a daily basis	0.881			
Individuals who used the Internet to interact with public authorities	0.857			
Population aged 25-64 with tertiary education	0.840			
Households with Internet access	0.790			
Individuals who used the Internet. for the sale of goods and services	0.759			
GDP per capita compared to the EU28 average in PPP	0.736			
Employment in High Technology Sectors	0.572			
Patent applications as a share of GDP		0.853		
Intramural spending on R&D		0.782		
Working population aged 15-64 with secondary and tertiary education			0.769	
Households with broadband			0.702	
Unemployment rate in the population aged 15-74 years old.			-0.610	
Net Growth of the Number of Companies				0.795
Growth rate of Employment in Telecommunications				0.790

Extraction method: principal component analysis.
Rotation method: Varimax with Kaiser normalisation
a. The rotation has converged in 5 iterations

Source: Prepared by the authors

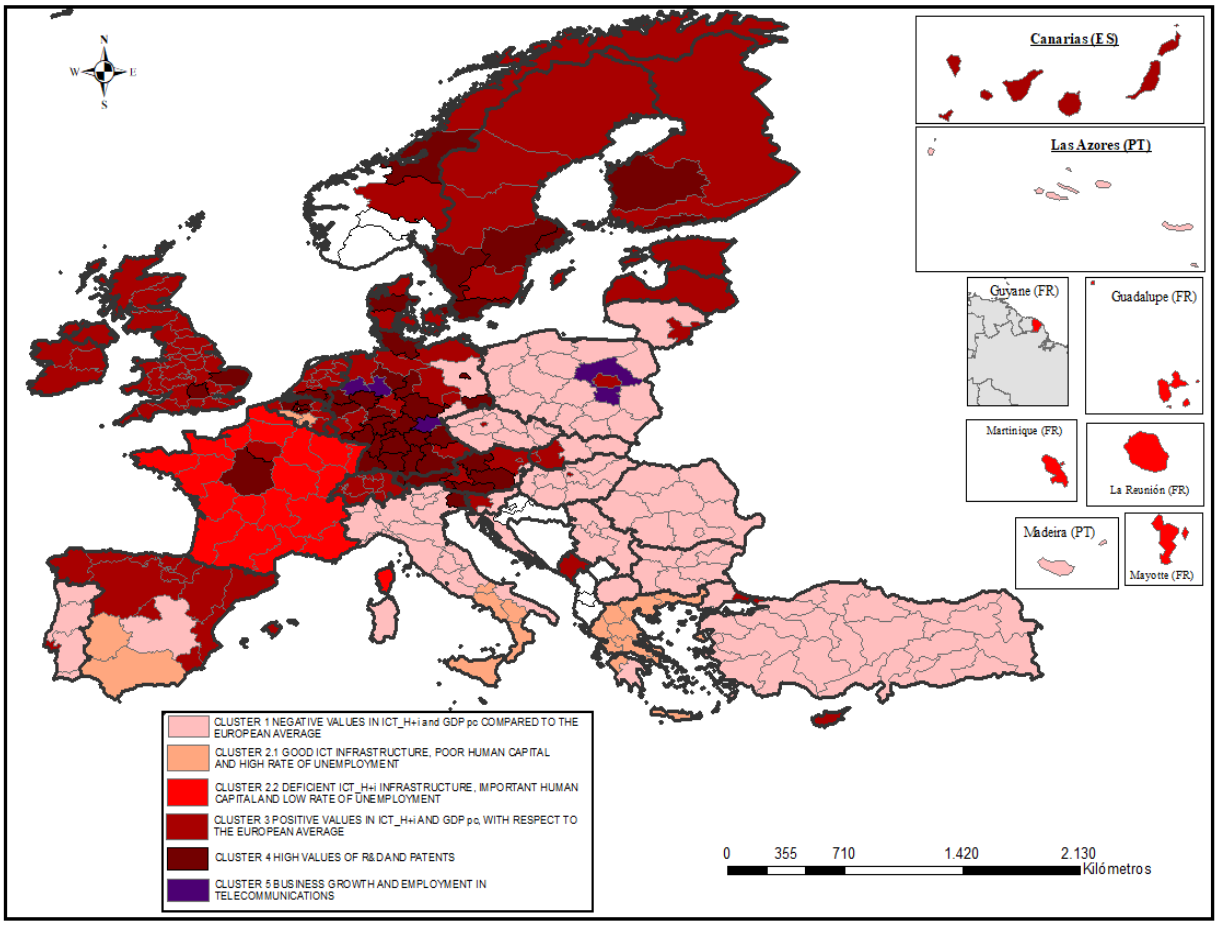
Table 4. Final cluster centres and regions belonging to each cluster

Final Cluster Centres					
	Cluster *				
	1	2	3	4	5
REGR factor score 1 for analysis 2	1.03862	-0.08873	0.7974	0.33906	0.00546
REGR factor score 2 for analysis 2	-0.22150	-0.07405	-0.46083	1.84045	0.03087
REGR factor score 3 for analysis 2	0.27708	-1.99215	0.38847	0.29088	0.51115
REGR factor score 4 for analysis 2	-0.13506	0.02182	-0.06323	-0.09727	6.45093

*factor scores

Source: Prepared by the authors

Map 1. Typology of regions according to the interaction between ICT and socio-economic characteristics in Europe.



Source: Prepared by the authors.

5. Discussion and Conclusions

The analyses performed and the results obtained have made it possible to confirm that good telecommunications infrastructure coverage (fixed networks, mobiles, broadband, fourth-generation mobile networks, LTE, etc.) does not guarantee the advanced use of ICTs, although, thanks to EU, national and regional policies, this deployment of ICT access infrastructures has almost been completed in European territory at regional level. Consequently, 53.63 % of European regions

have more than 90 % of their households with Internet access, and of this 53.63 % of European regions, 97 % of them have broadband access. This 97 % of European regions that have broadband access to Internet cover 90% of their households, making the regional map a homogeneous and uniform map in terms of Internet access (Ruiz-Rodríguez et al., 2020).

Almost one third of regions (Cluster 1), most of them peripheral (eastern Europe, Turkey, northern and central Italy, Portugal and the Spanish region of Castilla La Mancha), with a GDP per capita below the European average, are equipped with good telecommunications infrastructures, but still register a low level of advanced use of ICTs (online banking, sale of goods and services and interaction with public authorities).

This cluster is defined by the negative character of Factor 1 with respect to the centre of the conglomerate (ICT_H+i and GDP per capita). They are regions with a complete territorial deployment of ICT access infrastructure, but have still not developed advanced digital skills and abilities (Hernández & Maudos, 2021), as they have a use of Internet for the sale of goods and services and interaction with public authorities well below the European average (Cabello & Ortiz, 2013). Additionally, they have a low rate of growth of business start-ups, low levels of GDP per capita and education, values that do not facilitate improving the high unemployment rate and the low level of knowledge of advanced ICTs. As has been demonstrated in other studies, human capital makes it possible to increase the potential of territories to both generate and absorb advanced technology (Wang et al., 2020). As noted by Pick & Nishida (2015), there is a need to implement a long-term plan that motivates raising the level of qualifications of the human capital through training in advanced ICTs to expedite the creation of companies and employment.

Thus, responding to our research question of whether regions with good telecommunications infrastructure coverage (for example, the availability of broadband) are those that most use advanced ICTs, the analysis performed leads one to affirm that the ICT access infrastructure coverage variable alone does not predetermine an advanced use of these technologies, but rather this infrastructure must be accompanied by other socio-economic variables, as has been demonstrated by the factor analysis model has shown.

Consequently, it can be affirmed that the advanced use of ICTs in households spreads in accordance with the development of certain socio-economic characteristics of European regions. In particular, there is a clear association between ICT usage, GDP per capita and a tertiary level of education (Factor 1). This factor represents more than one third of the variance, demonstrates a positive association of variables and corroborates the starting hypothesis; which is none other than the fact that European regions with a high socio-economic level intensify their investment in the advanced use of ICTs by households and individuals (ICT_H+i). On the other hand, the degree of use of advanced ICTs, along with the regional variability of GDP per capita, the level of tertiary education and employment in high-technology sectors constitute the variables that will indicate a part of the digital divide and the regional heterogeneity in Europe, and therefore both of these are linked to factors of a social, economic and innovative nature (Jordá-Borrell & Lopez-Otero 2020).

An analysis of the medium and high educational levels of the active population show that a high percentage of population could acquire adequate technical and/or digital skills to disseminate technological change, that of the so-called fourth industrial revolution. This Factor 1 delimits a large group of regions (Cluster 3), almost 40 % of the total number, with a geographical distribution in the form of a crown (northern Europe, the regions of the south-west and the re-

gions of eastern Europe) that have attained a level of digital abilities above the European average. It comprises the regions that are geographically close to those included in Clusters 4 and 5 (highly-developed regions digitally and socio-economically). Hence, this seems to support the idea that technology attracts technology, and highlights the fact that this type of territorial behaviour is clearly akin to that of neighbouring regions (geographical proximity / vicinity) (Lucendo-Monedero, et al., 2019).

Additionally, it should be noted that in Factor 3 (more than one tenth of the variance), the availability of ICT infrastructure (households with broadband) correlates with the population with a medium-high level of education variable and negatively with unemployment. This indicates that citizens who have ICT infrastructure (broadband) and a medium-high level of knowledge may obtain digital skills and will have lower levels of unemployment, and will therefore be able to achieve improvements in their standard of living (Hernández & Maudos, 2021). This Factor 3 defines Cluster 2, as it has a double significance depending on the positive or negative sign which the correlated variables show, and this implies that the cluster divides into two subgroups. Cluster 2.1 (southern European regions – Greece, Italy and Spain) with high unemployment rates, good broadband infrastructure and an adequate level of medium-high level of studies contains regions where only the presence of basic digital competencies can be observed, which will make a difference in the social process of creation of digital inequalities (Lamberti, et al., 2021). On the contrary, Cluster 2.2. (containing all the regions of France, except for the central area) has an unemployment rate around the European average, high levels of secondary and tertiary education, and a deficit of broadband ICT infrastructure. These characteristics evidence the idea indicated by Appiah-Otoo & Song (2021) that ICT access is the foundation for acquiring digital and technological skills and the full digitalisation of the territory. Thus, the behaviour of ICT infrastructures in France breaks the homogeneity of the European digital map.

However, regions that invest in human capital create wealth in their territory (Grigorescu, et al., 2021). Hence, the regions belonging to Clusters 3, 4 and 5, which account for 66.26 % of the total, are characterised by being the most advanced in the EU in terms of ICT access and usage by households and individuals. 84.31 % of the active population have intermediate or higher education, and have an adequate level of broadband infrastructure (98.72 % compared with the European average of 98.20 %). This educational level then enables the development of ICT skills (Billon et al., 2021) and, consequently, the digital transformation of these regions.

Furthermore, if the factor model developed is observed in its entirety, more than half of the socio-economic variables included in the model constitute another two factors (2 and 4), which include business dynamics, and regional R&D capacity in Europe, but not directly related with variables of ICT access and usage by the population. Thus, patents are associated with R&D in Factor 2, highlighting that investment in R&D gives rise to the development of patents, and consequently regions will be able to obtain competitive advantages (Sandu and Ciocanel, 2014). Hence, as these variables are not associated with any ICT variables, this implies that the relationship with ICT is of an indirect type, as the regions that have a high degree of investment in R&D have an above-average GDP per capita (Koutroumpis et al., 2020) and therefore will also embrace an advanced use of ICTs. This Factor 2 characterises Cluster 4, including territories that reveal that investment in R&D is primordial for socio-economic growth and for the development of ICT infrastructures (access) and vice versa. In other words, in order to have significant R&D investment it is necessary for regions to already have high socio-economic growth, with these conditions enhancing the deployment of ICT infrastructure (Nair et al., 2020; Alfaro Navarro et al., 2017; Jorgenson &

Vu, 2016; Lee et al., 2017; Pradhan et al., 2018). Currently, these are regions that are leading the so-called fourth industrial revolution, those that stand out due to technological transformations, artificial intelligence and the digital revolution (Wang L, et at., 2020). These regions are leaders in R&D and technological development with great pulling power and influence over other regions (Maneejuk & Yamaka, 2020).

In fact, the growth of employment in the telecommunications sector is linked to the growth of the business fabric in Factor 4. Therefore, this factor shows that in Europe it is not only necessary to have ICT infrastructures, but a population with a high digital skills is also required to benefit significantly from ICTs. Both elements are necessary in order to produce a transformation and innovation in regions and, consequently, an increase in the growth of both the business population and the corresponding job creation (Lahiguera, et al., 2020). Given that employment in telecommunications and the growth of the business fabric may be considered very relevant for the progress of European regions, it is worth considering whether it would have been convenient to complete the interaction between the socio-economic and ICT access and usage by households and individuals variables in the factor model with ICT access and usage by companies. Actually, the cluster analysis shows that those European regions that have a higher level of GDP per capita also have strong business dynamics along with an important volume of employment in telecommunications, which predisposes these regions to make a greater investment in R&D and to develop more patents (Cluster 5). On the other hand, it should be borne in mind that an increase in research expenditure may give rise to an increase in the number of patents and new technologies, as well as value added. This leads one to affirm that the capacity for investment in R&D is related to knowledge creation (Choi & Yi., 2018; Kuchiki, A. 2021) and the digital transformation of companies.

However, as the clusterisation indicates, on the basis of the factor analysis performed, an association between the advanced uses of ICTs (interaction with public authorities, sale of goods and services and online banking), high rates of growth of employment in telecommunications, high investments in R&D and a high volume of patent applications are only identified in a tiny part of European regions (1.22 %), specifically the German regions Oberfranken, Münster and Detmold and Mazowiecki regionalny in Poland (Cluster 5). The existence of a cluster with these characteristics supports the hypothesis that the regions with a higher GDP per capita have, or have managed to ensure that their population has, greater ICT access and the acquisition of sufficient digital skills to take advantage of an advanced use of ICTs (Stanley, Doucouliagos & Steel, 2018; Ali et al., 2020). According to the studies of Nair, Pradhan & Arvin (2020), although they are at country level, Germany is one of the leading economies in Europe and among the OECD countries with the highest degree of R&D investment, and European regions benefit from this, driven by the dynamism of Germany. It could be said that these are the regions that are leading the digital revolution in Europe. These regions are closely accompanied by the rest of the German länders, the regions of Austria, southern Finland and Sweden and the central nucleus of France (13.98 %, Cluster 4), where the level of investment in R&D is actually higher than in the previous regions of Cluster 5, benefiting from the physical proximity of the regions of Cluster 5, which are those that lead said digital revolution.

This research, therefore, is a clear contribution to the study of the digital, technological and socio-economic inequalities of European regions, and highlights the concentration of wealth, technological skills and knowledge in the central area of Europe and the need to increase the diffusion from these to peripheral areas (Balland & Boschma, 2021; J. Freeman et al., 2016). This fact evi-

dences the heterogeneity and territorial disparities of European regions, spotlighting the existing digital divide (Lucendo-Monedero et al., 2019). A typology of (NUTS 2) regions is provided, with regard to the assimilation and basic and advanced uses of ICTs. This taxonomy and the factor model developed constitute a basis for the implementation of European policies, with the intervention of national and regional actors, on the diffusion of the advanced use of ICTs.

Nevertheless, this study has its limitations, given that the number of variables included in the analysis is conditioned by the availability of regional data provided by Eurostat at NUTS 2 level. Further research is therefore highly recommended in order to increase the number of study variables related to the use of advanced digital technologies (artificial intelligence, big data, robots, drones, etc. associated with companies and households) which, moreover, should be regionalised and homogenised at regional level (NUTS 2). To this end, it would be convenient if Eurostat could publish more data on ICT_H+i, and especially on companies at NUTS 2 level, as this is the main level used by the European Union that may contribute to the promulgation of new territorial-regional policies for development and the reduction of inequalities (Pick & Nishida, 2015).

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Appendix A: The 26 variables initially included in the analysis

TYPOLOGY	VARIABLES	YEAR	DESCRIPTION AND UNIT OF MEASURE	EUROSTAT SOURCE
LEVEL OF WEALTH	GDP per capita compared to the EU28 average in PPP	2019	Regional gross domestic product (PPS per capita as % of EU28 average).	https://ec.europa.eu/eurostat/databrowser/view/tgs00006/default/table?lang=en
	Unemployment rate in the population aged 15-74 years old	2019	Percentage of the unemployed population aged 15-74 years old.	https://ec.europa.eu/eurostat/databrowser/view/lfst_r_lfu3rt/default/table?lang=en
	Unemployment rates educational level 5-8 between 15 and 64 years old	2019	Percentage of unemployed rates of educational level 5-8 and with ages between 15 and 64 years	https://ec.europa.eu/eurostat/databrowser/view/LFST_R_LFU3RT__custom_4538670/default/table?lang=en
	Activity rates	2019	Activity rates	https://ec.europa.eu/eurostat/databrowser/view/LFST_R_LFP2ACTRC__custom_4562366/default/table?lang=en
	Activity rates education level 5-8 among 15-64 year olds	2019	Participation rates in selected education levels 5-8 at regional level	https://ec.europa.eu/eurostat/databrowser/view/educ_uoe_enra15/default/table?lang=en
	Working population aged 15-64 with secondary and tertiary education	2019	Participation rates in selected education levels 3-5 at regional level	https://ec.europa.eu/eurostat/databrowser/view/LFST_R_LFP2ACTRC__custom_4562432/default/table?lang=en
	Working population aged 15-64 with secondary and tertiary education	2019	Percentage of the working population aged 15-64 with secondary and tertiary education (ISCED 3-8).	https://ec.europa.eu/eurostat/databrowser/view/LFST_R_LFP2ACTRC__custom_2338730/default/table?lang=en
	Unemployment rates by age, (25-65 years) and NUTS 2 regions	2019	Percentage of the unemployed population aged 25-65 years old.	https://ec.europa.eu/eurostat/databrowser/view/LFST_R_LFU3RT__custom_4538510/default/table?lang=en
LEVEL OF EDUCATION	Population aged 25-64 with tertiary education	2019	Percentage of the population aged 25-64 with tertiary education (ISCED 5-8).	https://ec.europa.eu/eurostat/databrowser/view/EDAT_LFSE_04__custom_2315836/default/table?lang=en
	Participation rates in education levels (5-8)	2019	participation rates of citizens in education levels 5-8	https://ec.europa.eu/eurostat/databrowser/view/educ_uoe_enrt05/default/table?lang=en
	Population aged 25-64 with tertiary education	2019	Percentage of population between 25 and 64 years old with tertiary education	https://ec.europa.eu/eurostat/databrowser/view/edat_lfse_04/default/table?lang=en
	% Population with studies 3-8	2019	Percentage of population with tertiary studies	https://ec.europa.eu/eurostat/databrowser/view/LFST_R_LFP2ACTRC__custom_4562502/default/table?lang=en
LEVEL OF INNOVATION	Employment in High Technology Sectors	2019	Employment in high-technology sectors as a percentage of total employment.	https://ec.europa.eu/eurostat/databrowser/view/HTEC_EMP_REG2__custom_2338815/default/table?lang=en
	Patent applications as a share of GDP	2012	Number of patent applications with respect to GDP in billions.	https://ec.europa.eu/eurostat/databrowser/view/PAT_EP_RTOT__custom_2339933/default/table?lang=en
	Intramural spending on R&D	2017	Domestic R&D expenditure as a percentage of GDP	https://ec.europa.eu/eurostat/databrowser/view/RD_E_GERDREG__custom_596580/default/table?lang=en

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TYPOLOGY	VARIABLES	YEAR	DESCRIPTION AND UNIT OF MEASURE	EUROSTAT SOURCE
BUSINESS DYNAMICS	Growth rate of employment in telecommunications	2018	Percentage of net employment growth of in telecommunications sectors (with respect to previous year).	https://ec.europa.eu/eurostat/databrowser/view/SBS_R_NUTS06_R2__custom_2340087/default/table?lang=en
	Net Growth of the Number of Companies	2018	Percentage of net growth of number of companies in industry, construction and services sectors (with respect to previous year).	https://ec.europa.eu/eurostat/databrowser/view/BD_ESIZE_R3__custom_597161/default/table?lang=en
LEVEL OF ACCESS	Households with Internet access	2019	Percentage of total number of households where anyone in the household has the possibility to access Internet from home.	https://ec.europa.eu/eurostat/databrowser/view/isoc_r_iacc_h/default/table?lang=en
	Households with broadband	2019	Percentage of total number of households that have broadband Internet access.	https://ec.europa.eu/eurostat/databrowser/view/ISOC_R_BROAD_H__custom_2341129/default/table?lang=en
LEVEL OF USE	Individuals who access the Internet on a daily basis	2019	Percentage of total number of individuals who use Internet on a daily basis for any type of consultation.	https://ec.europa.eu/eurostat/databrowser/view/ISOC_R_IUSE_I__custom_2341207/default/table?lang=en
	Individuals who used the Internet for online banking	2019	Percentage of total number of individuals who access Internet to conduct banking transactions.	https://ec.europa.eu/eurostat/databrowser/view/ISOC_R_IUSE_I__custom_595421/default/table?lang=en
	Individuals who used the Internet for the sale of goods and service	2019	Percentage of total number of individuals who access Internet for the sale of goods and services.	https://ec.europa.eu/eurostat/databrowser/view/ISOC_R_IUSE_I__custom_2315292/default/table?lang=en
	Individuals who used the Internet to interact with public authorities	2019	Percentage of total number of individuals who access Internet to interact with public authorities.	https://ec.europa.eu/eurostat/databrowser/view/ISOC_R_GOV_I__custom_595365/default/table?lang=en
	Individuals who used the Internet for civic participation	2019	Percentage of total number of individuals who access Internet to interact for civic participation.	https://ec.europa.eu/eurostat/databrowser/view/ISOC_R_IUSE_I__custom_4538591/default/table?lang=en
	Individuals who used the Internet to participate in social networks	2019	Percentage of total number of individuals who access Internet to participate in social networks.	https://ec.europa.eu/eurostat/databrowser/view/ISOC_R_IUSE_I__custom_4538615/default/table?lang=en

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Conflict of interest

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