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An analysis of the key role of human and technological development in the smart specialization of smart European regions

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Abstract

The Europe 2020 development strategy prioritizes the so-called Smart Regions, reflecting the European Commission's commitment to geographical "specialization". Accordingly, the European regions have developed innovation strategies for smart specialization. A key element in these development strategies is the technological factor, which is clearly influenced by the level of human development in the region. This article analyses the convergence between citizens' capacities and technological development in a region. Specifically, we analyse 129 NUTS 2 regions in Europe, using official data provided by Eurostat. To measure human development, this article proposes a Smart Human Index based on a synthetic indicator incorporating three dimensions; in addition, we use two dimensions to construct an indicator of regional technological development. The results show that a region's technological capacity clearly depends on its inhabitants' degree of formal education, while their use of technologies depends on the citizens' degree of social openness and cultural level.

Keywords: Smart regions; smart specialization; human capital; technological development; Europe; NUTS 2.

1. Introduction

The market economy in which we live is currently giving rise to a series of transformations affecting cities and regions around the world. Technological advances are driving a process of continuous adaptation, which, together with the recent economic crises, are triggering changes in the competitiveness of companies and territories. Against

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this backdrop, governing authorities, politicians, technicians and experts acknowledge that one of the most suitable ways of managing these large concentrations of individuals and objects is through the so-called "Internet of things", robotics, and artificial intelligence. In fact, the convenience of interconnecting elements, linking them in turn to the network, and automating processes is expanding beyond this scope of "*smart cities*", and extending outwards towards "*smart regions*".

That said, Information Communication Technologies (ICTs) are not in themselves enough to effect this transition; rather, the key to future development is the ability to develop new ideas and recombine existing knowledge assets. However, it is hard to identify the best paths forward in this regard. Hence, the European Union (EU) has forged an ambitious strategy for growth called Europe 2020. At the core of this development strategy is *smart specialization*, a vision of regional growth possibilities built around existing place-based capabilities (McCann and Ortega-Argilés, 2015). This strategy centres on three priorities for growth: it should be smart, sustainable and inclusive. In this regard, the main support for funding *smart regions* in Europe comes from the European Structural and Investment Funds, reflecting the European Commission's commitment to fostering geographical "specialization" according to each territory's potential, and collaboration between public institutions and private entities.

EU regions have developed national or regional innovation strategies to achieve *smart specialization*. This strategy has emerged in Europe in the context of the EU's Europe 2020 strategy and has been widely adopted in European regional and innovation policy (Piirainen et al., 2017; Balland et al., 2018). They thus establish a strategic framework for innovation-driven economic transformation, and identify the main priorities for investment. Likewise, advances are being made in emerging opportunities and market developments aimed at building a competitive advantage based on the combination of their strengths in research and innovation with the needs of business.

Therefore, smart regions should generate new growth dynamics for Europe, based on bottom-up entrepreneurship and innovation. Smart specialization strategies can take advantage of numerous new growth opportunities for all regions, by aligning their smart specialization investments promoted by businesses in new European value chains. Synergies thus emerge between the different public and private financing mechanisms that support these investment dynamics. In this, both human capital as well as technological and innovation capital have a fundamental role to play (Krammer, 2017).

Human capital is fundamental to the development of a country or region. The literature contains different studies about what factors can be considered determinants of human capital (Ang et al., 2011; Barro and Lee, 2013; Hanushek et al., 2015; Moura and Ravishankar, 2015; Belitz and Mölders, 2016; and Tiba and Omri, 2017). Bearing in mind that there may be a number of different variables that influence human capital, measuring it is understandably complex. It is generally measured through indicators based on the use of variables with a certain weighting scheme (Haq, 1996; Romer, 1989; Noorbakhsh, 1998; Garcia del Valle and Puerta, 2001; Hastings, 2011; and Annoni et al., 2017). In practice, indexes are composed of indicators or variables and, depending on what is being measured and the objective, they may have different dimensions. Experts typically work with a percentage scale, where the variables are re-scaled to values ranging from 0 to 100, and they use a cross-sectional database with structural conditions. Finally, the creators of the index apply subjective weights to build the index and, in some cases, are advised by experts in planning or urban governance. The first objective of this paper is to propose an index of human capital applied to regions using data from Eurostat NUTS 2 level (Nomenclature of Territorial Units for Statistics) based on a synthetic indicator incorporating three dimensions: social openness, culture and education.

Other key element is the ICT that it is one of the 11 thematic objectives of the cohesion policy in 2014-2020. Although there are several proposals of indicators of different institutions and organizations (CAF, 2016; WEF, 2016; EU, 2016 and 2018; RICYT, 2018; OECD, 2017 and 2018; UNESCO, 2018; CEPALSTAT, 2018; ITU, 2018), the most used measure at regional level is the the Regional Competitiveness Index (Annoni et al., 2017). However, this is based on three dimensions: Technological readiness, Business sophistication and Innovation and this does not regard the use and capacity that Kottemann and Boyer-Wright (2009), Andoh-Baidoo et al. (2014) and Qureshi and Najjar (2017) consider that they play a key role. Thus, the second objective of this paper is to developed a measurement of technological development based in a double dimension: use and capacity that they are measurement using four indicators that allow us to compile all the data related to use, both in terms of access and applications, and the capacity of new technologies, in aspects regarding employment and investment.

The level of human capital in each region is undoubtedly a key element in their societies' adoption of new technologies. In this respect, Capello (1999), Madon (2000), Duncombe (2001) and Kenny (2002) consider that ICTs improve the social welfare because they improve health and education. DiMaggio et al. (2001) show that the ICT improve the social capital, the political participation and the culture. Samoilenko and Ngwenyama (2011) consider human capital to be one of the key factors in the expansion of ICT, while Yu et al. (2017) have proposed a theoretical model that shows that the impact of ICT adoption behaviour is moderated by information literacy and digital skills. Moreover, Qureshi (2010) shows that ICT allow processes of social inclusion, and citizens increase their chances of achieving personal freedoms through their use.

Therefore, the relationships between technological development and human capital are essential in helping to consolidate smart cities or regions. Thus, Pater and Lewandowska (2015) analysed innovation in 225 NUTS 2 EU regions in 2008-2010, with a particular focus on human capital. They reached the conclusion that the lack of investment in the field of human capital is one of the basic determinants of the different results achieved in innovation. Gouvea et al. (2018) analysed the relationship between human development measured by means of the Human Development Index (HDI), the technological level measured by the Network Readiness Index (NRI) and environmental sustainability according to the Environmental Performance Index (EPI). They found that ICT and human development had a significant influence on environmental sustainability; however, they did not analyse the relationship between ICT and human development. All of these studies emphasize the importance of human capital and ICT in the development of smart regions but there is a lack in the analyses of the relationships between ICT and human development. The third objective of this paper is to solve this lack through test the hypothesis that a region's technological capacity and use directly depends on its citizens' capacities.

In this sense, we analyse how the regions' efforts are taking shape, and what elements can help improve the efficiency of these efforts. To that end, we analyse the factors or variables that determine which regions are more efficient in terms of growth based on the relationships between human capital and ICT. Thus, we establish a number of indicators of human capital along with other indicators of technological development in European regions, using existing data to build models that elucidate the associated relationships. In this sense, the key objective is to demonstrate that a region's technological capacity and use directly depends on its citizens' capacities. Thus, whether a region can be referred to as "smart" is directly determined by its capacities in terms of human resources.

The rest of the article is structured as follows. First, we develop a literature review in order to examine how the process of specialization is occurring in the regions. We then analyse the human capital and technological development, focusing on identifying the factors that exert the greatest influence on them. In the third section, the aim is to gain an understanding of the measurement processes by means of indicators and indexes, and propose several indicators for *smart regions* in Europe. Lastly, we analyse the relationships between technological and human capital, estimating the efficiency of the regions by means of a cross-sectional model with constant returns to scale. We apply the model to each of the various dimensions of regional technological capacity and use. Finally, we present the main conclusions of the analysis and suggest lines for future research.

2. Literature review

The origins of the concepts of *smart regions* and *smart specialization* can be found in the pioneering work of Marshall (1931) and Schumpeter (1947). The combination of high-tech industry, science parks, technology networks and regional innovation policies, developed in the 1980s and 90s, gave rise to the term "regional innovation systems". These regional innovation systems can also be considered as part of the national innovation systems, though the features of the national systems still apply when the focus is on smaller areas (Buesa et al., 2006). It is also worth emphasizing that the concept of region contains an important level of governance of economic processes, between national and local or municipal levels, as highlighted by Asheim and Cooke (1999). In short, these regional innovation systems (Camagni, 1991; Cooke et al., 1997; Asheim & Gertler 2005; Cooke, et al., 2004) can be considered as a forerunner to the smart specialization systems.

Smart specialization was initially developed by the Expert Group ‘Knowledge for Growth’ in 2008 (McCann and Ortega-Argilés, 2015). The starting point for the Knowledge for Growth Expert Group was the innovation system research and theory applied at the level of regional innovation systems (RIS). All regions seeking financing through the EU's Cohesion and Structural Funds for the current programming period 2014-2020 are required to develop third-generation Research and Innovation Strategies, called "regional innovation smart specialization strategies" (RIS3).

Smart specialization arises from the idea that EU regions have different economic and institutional structures that shape the possibilities for their future development (Kroll, 2015). Foray (2014) argues that smart specialization requires moving from ‘horizontal’ policies aimed at general framework conditions to ‘vertical’ policies targeting specific fields or technologies. In this context, both human capital as well as technological and innovation capital have a fundamental role to play (Krammer, 2017).

Human capital is fundamental to the development of a country or region but its measurement and the key factors is not clear. In this sense, analysing the literature, we can identify a number of opposing arguments and claims. Thus, the work of Barro and Lee (2013) points to the importance of educational achievement, while Hanushek et al., (2015) criticize that approach. It should also be borne in mind that cognitive capabilities are closely related to productivity and innovative capacity, such that any increases in human capital should be accompanied by a rise in both productivity and the capacity to generate and absorb new technologies. In this regard, the studies of Ang et al. (2011) and Moura and Ravishankar (2015) show that human capital is an important factor in explaining differences in productivity between countries. Similarly, energy is also considered an essential factor and it should be aligned with the other factors of production, in addition to being related to them, as argued by Tiba and Omri (2017). The number of patents is also a key measure because it indicates the degree of competitiveness of a particular country, given that this figure can reflect a country's level of scientific as well as economic development. Furthermore, as pointed out by Belitz and Mölders (2016), the number of patents may be an indicator of R&D productivity.

Human capital is generally measured through indicators or variables related to education, such as literacy levels or the educational qualifications of the inhabitants of a territory (Romer, 1989). In addition, there are the human development indexes, an initiative originating with the work of Pakistani economist Haq (1996) and the ideas on capacity put forward by Sen (1999). It started out as an attempt to classify countries in terms of other variables not traditionally used in economics, such as education (literacy rate, enrolment by level of education, etc.), health (birth rate, quality of life, life expectancy, etc.) or other areas (for example, military spending). This index aims to measure these variables through a composite index, using indicators related to the three abovementioned aspects. It has been the subject of criticism by Wolff et al., (2011), McGillivray (1991), Srinivasan (1994), and McGillivray and White (2006), and alternative indexes have been proposed by Noorbakhsh (1998), Garcia del Valle and Puerta (2001), and Hastings (2011). Currently, one of the most commonly-used country-level indexes is the one developed by the Word Economic Forum. The Global Human

Capital Report in WEF (2017) ranks 130 countries on how well they are developing their human capital, on a scale from 0 (worst) to 100 (best) across four thematic dimensions and five distinct age groups, in order to capture the full human capital potential profile of a country. It is intended as a tool that can be used to assess progress within countries and point to opportunities for cross-country learning and exchange. It is also worth mentioning the available indicators for level of education from the UNESCO (2018), Institute for Statistics (UIS).

We should also note the indexes at city level that include a specific human capital dimension. These include the City Development Index (CDI) by UN-Habitat (2012); the Global Cities Index (GCI) by Atkearney (2012); the Global Economic Power Index (GEPI) by PricewaterhouseCoopers and the Partnership for New York City (2012); the Global Power City Index (GPCI) by The Institute for Urban Strategies at The Mori Memorial Foundation in Tokyo, 2008-2012; the Global City Competitiveness Index (GCCI) by The Economist Intelligence Unit Limited (2012); and the Human Development City Index (HDCI) by Lopez et al., (2014).

At regional level, however, one of the most widely applied indexes containing a human dimension is the Regional Competitiveness Index (RCI) (Annoni et al., 2017), which is based on the approach of the Global Competitiveness Index developed by the World Economic Forum. It covers a wide range of issues, including innovation, governance, transport and digital infrastructure, as well as measures of health and human capital. It was developed to measure different dimensions of competitiveness at the regional level. The first edition was published in 2010, and the 2013 and 2016 editions are currently available. The RCI reveals the strengths and weaknesses of each NUTS 2 regions in the EU, providing guidance as to what each region should focus on, taking into account its specific situation and its overall level of development. Moreover, the regions can use the index to identify their strengths and weaknesses, and to shape their development strategies. As a novel feature, it includes online interactive dashboards that facilitate comparisons between all regions, as well as comparisons between regions that have a similar GDP per capita (Annoni et al., 2017). It is made up of 11 pillars that describe the different aspects of competitiveness, which are in turn classified into three groups or dimensions: Basic, Efficiency and Innovation. The Basic group includes five pillars: (1) Institutions; (2) Macroeconomic Stability; (3) Infrastructure; (4) Health; and (5) Basic Education. The Efficiency group includes three pillars: (6) Higher Education, Training and Lifelong Learning; (7) Labour Market Efficiency; and (8) Market Size. Lastly, the Innovation group comprises (9) Technological Readiness; (10) Business Sophistication; and (11) Innovation.

There are two types of indicator related to human capital, coming under the Basic Education pillar. The idea here is that there is a relationship between the results obtained in terms of schooling and economic growth (see Sianesi and Reenen, 2003, or Krueger and Lindahl, 2001; Hanushek and Wößmann, 2007, for an overview). Since these indicators use data from the PISA report, they assess students' proficiency in three core subjects: science, reading and mathematics. That said, the data are at country rather than regional level. On the other hand, another way of measuring it is through the efficiency dimension labelled Higher Education, Training and Lifelong Learning. In this case, five indicators are included, applied at NUTS 2 level: Population aged 25-64 with higher educational attainment (ISCED 5-8); Lifelong learning; Early school leavers; Accessibility to universities; and Gender balance in tertiary education. The sources of data for each are, respectively, Eurostat (LFS); Eurostat Regional Statistics; Eurostat Structural Indicators; Nordregio, EuroGeographics, GISCO, EEA and ETC-TE; and Eurostat LFS.

Other key element in the smart specialization strategy is the development of information and communication technologies (ICT). In the 2014-2020 funding period, more than 20 billion euros are available from the European Regional Development Fund (ERDF) and the Cohesion Fund for investments in ICT. These investments support the European Commission's efforts to create a digital single market, which has the potential to generate additional growth of up to 250 billion euros.

Enhancing access to, and use and quality of, ICTs is one of the 11 thematic objectives of the cohesion policy in 2014-2020. The ERDF prioritizes the extension of broadband deployment and the roll-out of high-speed networks; the development of e-commerce and ICT products and services; and strengthening ICT applications for e-government, e-learning, e-inclusion, e-culture and e-health.

The ICT measures may receive additional support under other thematic objectives, and are also included in many smart specialization strategies. The shift from a classical approach to the ICT sector towards a local/regional/national "digital agenda" integrated within the smart specialization strategy is enabling regions to identify the ICT investment priorities that are most relevant to their territory. In this regard, both ICT use and ICT capacity play a fundamental role, most notably in developing countries (Kottemann and Boyer-Wright, 2009; Andoh-Baidoo et al., 2014; Qureshi and Najjar, 2017). Therefore, as argued by Beniger (1996), the diffusion of internet access and use by citizens are relevant variables when it comes to measuring and developing an information society. Similarly, Neirotti et al. (2014) consider R&D investment in both the private and public sectors as a proxy variable for technological development and human capital, measuring regions' capacity with respect to new technologies.

The level of innovative capacity of a region directly influences the ways in which the technology is disseminated within the region. Thus, different studies have shown that the production of knowledge is highly geographically concentrated. Feldman (1993) suggests that firms producing innovations tend to be based in areas endowed with resources, and that these resources accumulate as a result of the success that a region enjoys with its innovations. Given all of the above, it can be inferred that some of the key aspects in a *smart region* are innovation and ICT—from both the perspective of citizens' use of new technologies as well as the different regions' capacity in terms of employment and investment. As such, it would be useful to have tools to monitor and assess these aspects.

In this regard, a number of different institutions and organizations have established Science, Technology and Innovation indicators, primarily related to aspects of R&D investment in terms of GDP, human resources (jobs) devoted to R&D, R&D results, technological results, technological innovation, patents, scientific publications, university entrepreneurship, etc., Notable examples include the following:

- OECD (2018): Main Science and Technology Indicators. Contains the main updated R&D indicators.
- OECD (2018): ANBERD Database. The OECD's ANalytical Business Enterprise Research and Development (ANBERD) database presents annual data on Research and Development (R&D) expenditures by industry and was developed to provide analysts with comprehensive data on business R&D expenditures. The ANBERD database incorporates a number of estimations that build upon and extend national submissions of business enterprise R&D data by industry (main activity/industry orientation).
- UNESCO (2018). The UNESCO Institute for Statistics (UIS) is the statistical office of UNESCO and is the UN depository for global statistics in the fields of

education, science, technology and innovation, culture and communication. The UNESCO Institute for Statistics (UIS) helps countries to collect data by developing methodologies and applying standards to produce internationally-comparable indicators.

- ECLAC: Science and Technology Indicators for Development. The Economic Commission for Latin America and the Caribbean (ECLAC) has created CEPALSTAT (2018), a database compiling science and technology indicators, most notably ICT indicators, differentiating between access and use.
- WEF (2016): Global Information Technology Report. Features the Networked Readiness Index, which offers a general overview of current state of ICT readiness in the world.
- EU (2016): Innobarometer. The Innobarometer is a survey of activities and attitudes related to innovation. Each year, it gathers opinions and feedback from the general public and European businesses and provides a unique source of direct information on innovation for policy makers. As of 2015, the survey is based on a standard questionnaire to help monitor change in how companies manage their innovation activities, plan investment to modernize their business, and tackle barriers to the commercialization of innovation. The Innobarometer 2016 captures the main behaviours and trends in innovation-related activities in EU businesses.
- EU (2018): EUROSTAT Science, technology and innovation statistics.
- RICYT (2018): Ibero-American and Inter-American Network of Science and Technology Indicators
- CAF (2016): Technological Innovation Indicators for Latin American and Caribbean countries.
- ITU (2018): ICT Development Index (IDI) of the International Telecommunication Union (ITU)—a composite measure, which generates country scores from the weighted addition of 11 indicators.

At the regional level, it should be noted that, just as with human capital, a key index is the Regional Competitiveness Index (RCI), the third dimension of which relates to innovation (Total innovation dimension) and contains three pillars: Technological readiness, Business sophistication and Innovation.

- Technological readiness. This pillar measures the level at which households and enterprises use technology. To that end, it is divided into two components (sub-pillars):
    - household use of technology, or private use, with three indicators: Households with access to broadband; Individuals buying over internet; Household access to internet. The source used is Eurostat Regional Information Statistics.
    - and with regard to companies, commercial use, with seven indicators: Availability of latest technologies; Firm-level technology absorption; Technological adoption; FDI and technology transfer; Enterprises having purchased online (at least 1%); Enterprises having received orders online (at least 1%); and Enterprises with fixed broadband access. The source used is the World Economic Forum - Global Competitiveness Index and Eurostat Community Survey on ICT usage and e-commerce.

    Due to the characteristics of the data, the sub-pillar related to households is measured at the regional level, while the business sub-pillar is at the country level, due to the lack of data at the regional level. The overall pillar score is computed as a simple average of the two sub-scores, with the same country-level enterprise score assigned to all regions within that country.
- Business sophistication. The level of business sophistication indicates the degree of a firm's productivity and its potential for responding to competitive pressures. Specialization in sectors with high added value contributes positively to regional competitiveness. This pillar includes indicators related to Employment (K-N sectors), and gross value added (GVA) (K-N sectors and Innovative SMEs collaborating with others. This pillar is measured at the NUTS 2 level, using data sourced from Eurostat Regional Statistics and the Regional Innovation Scoreboard, 2016 - DG Grow.
- Innovation. This pillar has been designed to capture both the regional potential to innovate as well as a region's actual performance in innovative activities. Indicators: Total patent applications, Core Creativity Class employment, Knowledge workers, Scientific publications, Total intramural R&D expenditure, Human Resources in Science and Technology (HRST), Employment in technology and knowledge-intensive, High-tech patents, ICT patents, Biotechnology patents, Exports in medium-high/high-tech manufacturing, Sales of new-to-market and new-to-firms innovation. It is measured at the NUTS 2

level, using data sourced from Eurostat, Eurostat Regional Science and Technology Statistics, and the Regional Innovation Scoreboard, 2016 - DG Grow.

Thus, in this paper, in order to determine how "smart" a region is according to its technological development and innovation, we have used a double technological dimension: use and capacity that they are measurement using four indicators that allow us to compile all the data related to use, both in terms of access and applications, and the capacity of new technologies, in aspects regarding employment and investment.

3. Methodology

First of all, we have developed an index of human capital with the intention to combine various capacities of human capital that involve particular types of competences or knowledge that can mark one region out against another. There are evident limitations; namely that the available information is relatively scarce, and in many cases even comes from the city level, making it necessary to transform the data from Eurostat NUTS 3 level to NUTS 2. (The reason for selecting this source is to set this analysis in the European space). This is a novel feature and we believe that a bottom-up application is more powerful than a top-down application, such as that used in the RCI. In addition, the proposed indicator incorporates aspects that go beyond education—the basis for the Higher Education, Training and Lifelong Learning pillar defined in the RCI—by including additional elements related to the openness of the society and cultural potential of the region.

Taking into account the information available and the dimensions that we want to include in the proposed index, we establish three groups of indicators. The first is social openness towards other cultures, which determines how multicultural the society is and its direct relationship with improved capacities. In this sense, Di Maria and Stryszowski (2009) considered this element key because the possibility of migration, blurring the borders between economic systems at different levels of development, reduces economic growth. The second is culture; the social elements in this group also indicate human capital motivated by learning and, therefore, along with the first group of indicators, this falls within the sphere of tacit knowledge. The third is education, which includes the level of education or the explicit knowledge acquired in basic compulsory education and university studies. The variables used in each case can be seen in Table 1. Without a doubt, the greatest limitation and the greatest source of complexity in its determination relates to the cultural dimension, since the information available is limited and defined at

NUTS3 level. That made it necessary to transform the information to NUTS 2 level through a process of aggregation, and has given us to access to information related to other important variables in the measurement of the cultural level of a region.

(Table 1 near hear)

The study covers a number of European NUTS 2 regions with official information available in Eurostat. We have data for 18 countries in 2014, with 8 Belgian NUTS 2 regions, 6 in Bulgaria, 8 in the Czech Republic, 4 in Denmark, 22 in Germany, 1 in Estonia, 1 in Ireland, 19 in Spain, 21 in France, 2 in Croatia, 1 in Latvia, 1 in Lithuania, 16 in Poland, 2 in Slovenia, 4 in Finland, 6 in Sweden, 2 in the United Kingdom and 5 in Norway; in total, 129 European NUTS 2 regions.

The method used to obtain each of the indicators is based on the application of a principal components analysis. This allows us to assign objective weights in the construction of the indicators. In this regard, the first step is re-scaling the variables on a scale of 0 to 100, with 0 corresponding to the lowest value taken by the variables in the regions under analysis, and 100 the maximum value. Once the variables have been re-scaled, principal components analysis is used to assign a weighting to each one to construct the indicators of openness, culture and education. Finally, with all the variables used to measure human capital, and following the methodology explained above, we have constructed a human indicator called the "Human Smart Index" (HSI) for each of the regions under study. The results for this and each of its components are shown in table 4 in the appendix.

The results reveal that the top-ranking regions in terms of the HSI are: Inner London (West) in the United Kingdom; Hovedstaden in Denmark; Île de France in France; Namur in Belgium; and Southern and Eastern Ireland. Conversely, the lowest-ranked regions are: the Bulgarian regions of Severozapaden, Yugoiztochen and Yuzhen tsentralen; and the Czech regions Střední Čechy and Severozápad. Through this indicator (HSI) and its decomposition in the three dimensions, we can determine a European map of tacit knowledge capabilities (CLT, OPC) and explicit (EDU). In this sense, political decision makers should better distribute knowledge to avoid divergent sustainable growth.

In the case of technological development and innovation, we have used a double technological dimension: on the one hand, it relates to the use of the technology by citizens and institutions in every society under analysis; and on the other, it refers to the required development capacity in terms of investment and employment according to the selected variables available. Thus, using the same methodology as described for human capital, we construct four indicators that allow us to compile all the data related to use, both in terms of access and applications, and the capacity of new technologies, in aspects regarding employment and investment. The data were sourced from Eurostat, which provides information at NUTS 2 level for the variables listed in Table 2.

(Table 2 near hear)

Furthermore, the indicators of total use (USE) and total capacity (CAP) have likewise been estimated, combining their dimensions with all the variables included for each case. To that end, we have used objective weights, as recommended by Gerpott and Ahmadi (2015), determined using the same approach as for the abovementioned HSI. In addition, we have constructed a technological development indicator that takes into account the information available for all the variables used to measure ICT use and capacity. This indicator, which we term the technological index (TI), allows us to analyse the technological development of the different regions. Table 5 in the appendix lists the values of this index and each of its components for the 129 European NUTS 2 regions under study.

The top five regions in aggregate ICT use (USE) are Oslo og Akershus in Norway; Hovedstaden in Denmark; and Stockholm, West and East-Middle in Sweden, all of which are northern European regions. On the contrary, the bottom positions are held by regions in Bulgaria, Croatia and Poland. In terms of capacity (CAP), Inner London–West in the United Kingdom; Braunschweig in Germany; Hovedstaden in Denmark; and Stuttgart and Oberbayern in Germany, occupy the top five positions. The lowest-ranked regions are in Bulgaria and Poland—as was the case with the USE indicator—but in this case along with Spanish regions such as Ceuta, Melilla, Canarias, Extremadura and Castilla-La Mancha. If we analyse the values achieved for the TI we see that the results change very little, with the top positions held by regions of Northern Europe and the bottom positions filled by regions in Bulgaria and Poland. In this regard, a study of European cities carried out by Alfaro et al. (2017) produced similar results, identifying two factors or indicators of technological efficiency: use and capacity.

4. Main results

First of all, to test the validity of the proposed measurement, we have compared the results obtained in the Human Smart Index with those of the RCI Efficiency dimension, Higher Education, Training and Lifelong Learning. Specifically, we have taken the 119 regions with data available for both indexes and compared the results through a correlation coefficient. The coefficient values are small when each of the dimensions of our index is taken separately (the largest value corresponds to the dimension of education, with a coefficient of 0.37), showing that we need to consider all the dimensions to effectively measure a region's human capital. However, when considering the HSI as a whole, the correlation coefficient reaches a value of 0.54, showing a close relationship with the equivalent RCI results. This thus demonstrates the good performance of our proposed measure.

If we analyse, in the case of the technological development and innovation indicator, the relationship with the RCI in terms of the results obtained, we find a correlation of 0.87 between our indicator of use, USE, and the Total Innovation dimension of the RCI. The similarity is even closer with the RCI dimension of Technological readiness, registering a correlation of 0.90. In the case of our capacity indicator, CAP, the relationship with the Total Innovation dimension is 0.85 revealing a fairly close similarity in terms of the results obtained. Finally, if we compare our TI with the indicator proposed by the RCI, we find a correlation coefficient of 0.75, indicating a fairly close similarity, albeit somewhat lower than the previous one. This could be due to the greater weight that the RCI assigns to factors related to ICT use.

Bearing in mind the fundamental nature of the relationship between human capital and technological development, the hypothesis that we aim to test in this study is that a region's technological capacity and use directly depends on its citizens' capacities. Thus, whether a region can be referred to as "smart" is directly determined by its capacities in terms of human resources. To that end, we assume a production function with constant returns to scale, in which production is determined by the human resources.

There are four resulting models for each variable for the year 2014, capturing two types of relationship—use and capacity—as a function of the human resources indicators, on a logarithmic scale for linear analysis. The estimated models yield the results summarized in Table 3, and follow the specifications below in accordance with the abbreviations used for the established indicators.

$$\log(UACC)_i = \delta_{10} + \beta_{11}\log(OPC)_i + \beta_{12}\log(EDU)_i + u_1 \quad (1)$$

$$\log(UAPP)_i = \delta_{20} + \beta_{21}\log(OPC)_i + \beta_{22}\log(EDU)_i + u_2 \quad (2)$$

$$\log(CEMP)_i = \delta_{30} + \beta_{31}\log(CLT)_i + \beta_{32}\log(EDU)_i + \beta_{33}\log(USE)_i + u_3 \quad (3)$$

$$\log(CINV)_i = \delta_{40} + \beta_{41}\log(CLT)_i + \beta_{42}\log(EDU)_i + \beta_{43}\log(USE)_i + u_4 \quad (4)$$

where the variables enter the model on a logarithmic scale, β denotes the elasticity of the variable in question with respect to the endogenous variable, and u are uncorrelated random variables with zero mean and constant variance.

(Table 3 near hear)

The results in Table 3 achieved are acceptable in terms of goodness-of-fit for the 129 observations used, although the relationship with technological capacity is more significant that that with use, as can be seen by the values of the coefficients of determination (R^2).

In the first equation, technological access (UACC) basically depends on the citizens' social openness (OPC) as well as their explicit knowledge, that is, their level of formal education (EDU). The second equation shows a similar relationship to the previous one; in this case, the use of technologies for different applications (UAPP) is directly related to the social openness dimension (OPC). In addition, explicit knowledge, in terms of educational qualifications (EDU), also turns out to be significant. Moreover, its significance increases after removing outliers from the sample, specifically regions in Bulgaria (BG).

In summary, between human dimensions, culture and education, analysed in relation to technological use, formal education is the most relevant; in other words, the educational level of the population (EDU). Among the social capacities, it is openness that most clearly determines technological use.

Focusing now on the third equation, regarding technological capacity in employment (CEMP), we observe a significant direct relationship with explicit knowledge (EDU) and non significant with cultural capacities in terms of tacit knowledge (CLT). In the case of

Capacity, there is also a clear cause and effect relationship with the region's technological use (USE).

Lastly, the fourth equation reveals a clear significant relationship between technological capacity in investment (CINV) and human capital variables relating to cultural capabilities (CLT) and formal training (EDU), as was the case with technological use in the region. In this case, we were not able to incorporate a direct relationship with the human capacity of openness; only indirectly through the USE variable. The situation clearly points to a significant relationship with explicit knowledge.

In summary, we can conclude by noting that in this case, technological capacity has a clear interconnection and dependence on human resources with an evident relationship—more important than that for use—with explicit knowledge. The estimated relationships can be seen in Figure 1.

(Figure 1 near hear)

5. Conclusions

The importance of human capital and ICT in the region development when it comes to generating smart specialization strategies in smart regions has been demonstrated in the literature review carried out. In response, a series of indicators have been proposed for the human capital, technological and innovative level of the region. Notably, at the level of human capital, bottom-up indicators from the NUTS 3 to NUTS 2 level have been generated, due to the lack of information at the regional level. This approach is clearly more accurate than the top-down approach used, for example, in the RCI.

The analysis of the relationships between human capital and technological development for 129 European regions suggests that the technological capacity of a region clearly depends on its citizens' competences, both tacit and explicit; however, the latter—that is, the inhabitants' level of education—is more influential. On the other hand, the use of technologies is clearly related to the characteristics of its inhabitants. However, the fundamental dimensions in this case are those related to tacit knowledge, such as the citizens' degree of social openness. The capacities of European citizens are thus fundamental for technological development, although, given the high level of qualifications and technological facilities in our society, use tends to be influenced by factors such as creativity, skill, or multiculturalism. Nevertheless, for technological development in terms of capacity, what is needed is indeed human capital with high levels of education. Therefore, from all this it can conclude that improving the level of education of citizens can be key to improving the technological capabilities that are key to development.

This study opens up a line of research that should be followed up with panel data analysis to allow a dynamic analysis of these relationships. Likewise, the causality of this relationship should be further examined, as it is not entirely clear if it is ICT that influences human capital or human capital which influences the level of implementation of new technologies. Moreover, it is worth exploring further how the cross-country differences in these relationships influence a process of economic convergence or divergence, supported by migration flows. In this respect, we need additional economic variables as well as more observations.

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Tables

Table 1. Human capital variables

Indicator	Variable
Social openness to other cultures (OPC)	Nationals population
	EU foreigners population
	Non-EU foreigners population
Culture (CLT)	Number of museum visitors
	Cinema attendance
	Number of public libraries
Educational Training (EDU)	Pupils and students enrolled from upper secondary education to Doctoral or equivalent level (ISCED 3, 6-8)

Source: Own Elaboration.

Table 2. Information and communications technology variables

Indicator	Variables
Use-acces (UACC)	Households with access to the internet at home
	Individuals who accessed the internet away from home or work
Use-aplications (UAPP)	Individuals who ordered goods or services over the internet in the last year
	Individuals who online purchases: travel and holiday accommodation
	Individuals who used the internet for interaction with public authorities in the last year
	Individuals who used internet for participating in social networks
	Individuals who used internet for Internet banking
Capacity-employment (CEMP)	Employment in technology and knowledge-intensive in all NACE activities
	Human Resources Persons employed in science and technology
	Total R&D personnel and researchers at Full-time equivalent (FTE)
Capacity-investment (CINV)	Intramural R&D expenditure (purchasing power standard (PPS) per inhabitant at constant 2005 prices)
	Intramural R&D expenditure (percentage of gross domestic product)
	Intramural R&D expenditure in higher education sector (purchasing power standard (PPS) per inhabitant at constant 2005 prices)

Source: Own elaboration on indexes used by Eurostat.

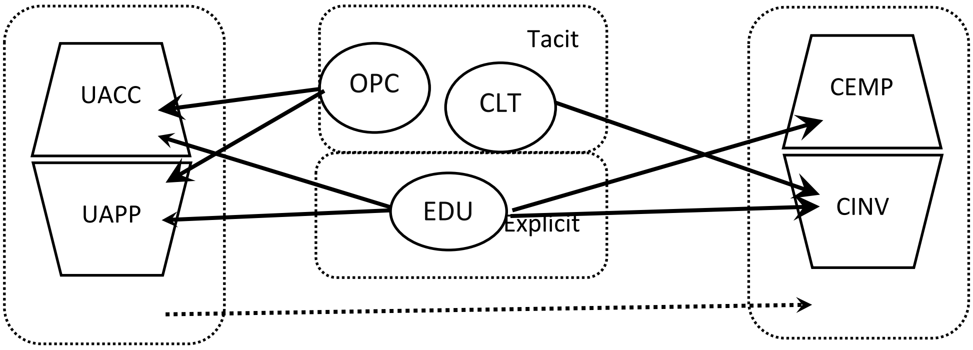
Table 3. Models (OLS estimators).

Exogenous / Model	UACC	UAPP	CEMP	CINV
Constant	1.78 *** (5.19)	1.67 *** (2.90)	-1.07 * (-1.65)	-4.07*** (-5.11)
OPC	0.48*** (9.10)	0.53 *** (9.22)		
CLT			0.26 (1.51)	0.47 ** (2.22)
EDU	0.24 ** (2.46)	0.19 * (1.80)	0.51 *** (5.52)	0.63 *** (5.55)
USE			0.51 *** (7.65)	0.83 *** (10.03)
R^2	0.431	0.426	0.513	0.613
Glejser	0.897	5.88 *	2.03	1.38
Observ/outlier	129/BG(6)	129/BG(6)	129	129

Note: t statistic brackets. Signification level: (***)=0.01 (**)=0.05 (*)=0.10.

Figures

Figure 1. Relationship graph: technological development and human capital



Appendix

Table 4. Human Smart Index (HSI) and each of its components

Regions	Country	OPC	CLT	EDU	HSI
Bruxelles region	Belgium	49,36	51,85	48,20	**47,53**
Prov. Antwerpen	Belgium	33,80	51,04	24,11	**45,03**
Prov. Oost-Vlaanderen	Belgium	24,30	50,87	31,66	**44,84**
Prov. Hainaut	Belgium	26,14	37,50	22,04	43,73
Prov. Liège	Belgium	28,68	38,19	28,92	42,98
Prov. West Vlaanderen	Belgium	15,74	46,69	18,47	42,73
Prov. Namur	Belgium	17,61	37,82	25,87	**48,17**
Prov. Vlaams-Brabant	Belgium	28,88	44,85	34,71	**45,13**
Yugozapaden	Bulgaria	9,84	49,17	38,92	37,29
Yuzhen tsentralen	Bulgaria	8,85	47,29	23,77	***33,10***
Severoiztochen	Bulgaria	9,53	49,45	29,29	34,17
Yugoiztochen	Bulgaria	8,79	48,13	19,02	***31,37***
Severozapaden	Bulgaria	8,37	51,79	14,63	***30,47***
Severen tsentralen	Bulgaria	8,57	45,97	32,59	36,22
Praha	Czech Republic	26,30	51,18	64,43	43,61
Jihovýchod	Czech Republic	15,20	43,66	26,13	35,05
Moravskoslezsko	Czech Republic	10,82	39,66	25,93	***33,92***
Jihozápad	Czech Republic	15,44	35,21	43,39	37,84
Severozápad	Czech Republic	14,82	39,28	18,28	***33,20***
Střední Morava	Czech Republic	10,91	38,28	25,74	34,79
Severovýchod	Czech Republic	14,38	41,12	22,42	***33,99***
Střední Čechy	Czech Republic	13,82	44,19	14,34	***31,98***
Hovedstaden	Denmark	26,81	62,50	39,16	**49,18**
Midtjylland	Denmark	18,76	53,87	32,98	42,04
Southern Denmark	Denmark	17,54	49,97	26,36	40,06
Nordjylland	Denmark	15,31	42,70	29,35	38,34
Berlin	Germany	25,95	60,71	32,85	41,30
Hamburg	Germany	25,91	51,45	33,98	39,26
Oberbayern	Germany	35,99	55,53	30,16	41,99
Darmstadt	Germany	38,59	50,69	31,76	39,15
Düsseldorf	Germany	25,99	46,04	38,84	37,67
Stuttgart	Germany	34,84	53,12	25,99	40,18
Leipzig	Germany	15,00	52,04	31,85	37,77
Dresden	Germany	13,03	62,30	25,52	39,09
Arnsberg	Germany	23,34	47,82	31,90	36,63
Hannover	Germany	25,76	46,33	25,30	38,24
Mittelfranken	Germany	29,45	50,95	33,56	40,85
Detmold	Germany	22,36	44,01	21,48	35,48
Sachsen-Anhalt	Germany	13,40	51,12	23,08	***33,86***

Regions	Country	OPC	CLT	EDU	HSI
Braunschweig		20,01	46,59	28,76	35,39
Freiburg		25,91	48,60	23,74	37,96
Oberpfalz		23,77	45,08	18,69	40,15
Karlsruhe		31,67	54,83	30,42	40,98
Schleswig-Holstein		17,68	49,15	21,28	***34,07***
Saarland		24,75	45,01	25,96	39,37
Weser-Ems		17,34	45,71	19,23	37,17
Chemnitz		11,98	48,79	21,96	***33,82***
Kassel		25,00	46,60	24,23	38,72
Eesti	Estomia	41,69	52,77	30,52	**45,40**
Southern and Eastern	Ireland	92,37	50,48	28,25	**47,60**
Comunidad de Madrid	Spain	26,44	51,29	32,34	40,92
Cataluña		30,27	50,38	25,62	40,13
Comunidad Valenciana		26,60	48,38	26,79	39,75
Andalucía		17,18	50,32	25,37	37,31
Aragón		22,36	45,79	24,25	38,50
Región de Murcia		26,79	47,25	26,17	37,94
Canarias		17,73	45,35	21,78	36,98
Castilla y León		15,08	48,89	27,16	37,19
Illes Balears		30,99	59,77	18,46	39,77
Galicia		13,84	47,42	24,00	36,51
País Vasco		18,41	48,03	23,72	38,43
Principado de Asturias		14,61	47,16	22,57	34,87
Comunidad Foral de Navarra		21,48	45,21	25,22	40,30
Cantabria		18,85	45,11	21,82	39,33
Castilla-la Mancha		18,06	56,41	19,45	39,41
Estremadura		12,09	44,62	21,60	35,27
La Rioja		24,56	49,60	39,27	41,29
Ciudad Autónoma de Ceuta		17,61	48,10	20,05	***33,83***
Ciudad Autónoma de Melilla		30,66	51,14	20,17	34,58
Île de France	France	25,91	62,60	33,47	**48,58**
Rhône-Alpes		19,80	40,42	27,50	41,19
Midi-Pyrénées		18,06	42,37	27,84	40,58
Alsace		23,87	46,64	26,49	41,33
Pays de la Loire		14,34	40,92	23,76	40,27
Nord-Pas-de-Calais		14,64	41,14	26,41	38,77
Languedoc-Roussillon		18,37	40,48	25,50	41,66
Upper Normandy		15,24	38,23	23,91	40,18
Brittany		12,77	37,62	25,20	39,75
Picardy		19,05	33,56	20,69	42,36

Regions	Country	OPC	CLT	EDU	HSI
Lorraine		17,61	44,12	24,23	44,67
Champagne-Ardenne		17,16	42,28	24,03	38,03
Bourgogne		16,59	39,70	21,51	39,85
Poitou-Charentes		13,44	35,11	21,84	40,91
Auvergne		17,52	40,46	23,97	41,34
Lower Normandy		12,72	45,88	21,23	43,82
Limousin		17,14	35,86	22,00	39,57
Franche-Comté		17,87	38,31	22,33	40,55
Corsica		16,86	44,81	17,68	***33,67***
Provence-Alpes-Côte d'Azur		18,00	44,78	24,08	40,00
Aquitaine		14,97	40,71	25,23	41,30
Continental Croatia	Croatia	8,44	44,39	45,48	38,78
Adriatic Croatia		8,55	41,40	42,90	38,20
Latvia	Latvia	45,17	32,07	25,30	40,84
Lithuania	Lithuania	9,06	47,11	30,57	37,34
Mazowieckie	Poland	8,09	41,08	41,08	40,88
Łódzkie		7,68	39,13	30,69	35,55
Małopolskie		7,81	53,55	37,77	40,85
Dolnośląskie		7,75	43,26	34,21	37,84
Wielkopolskie		7,63	36,94	31,91	37,74
Pomorskie		7,72	42,86	32,02	36,92
Zachodniopomorskie		7,76	40,86	27,11	35,30
Kujawsko-Pomorskie		7,61	37,88	27,75	35,12
Lubelskie		7,75	40,70	31,45	35,94
Śląskie		7,60	38,50	25,92	35,27
Podlaskie		7,75	39,54	28,43	34,92
Świętokrzyskie		7,62	43,98	25,31	35,08
Warmińsko-Mazurskie		7,66	37,74	24,36	35,38
Podkarpackie		7,79	37,67	24,42	35,70
Opolskie		7,73	36,94	25,96	38,36
Lubuskie		7,74	33,49	19,14	36,18
Western Slovenia	Slovenia	19,54	51,29	36,87	42,42
Eastern Slovenia		17,09	36,22	20,74	39,42
Helsinki-Uusimaa	Finland	19,13	47,14	37,20	39,83
West Finland		12,64	45,39	35,86	39,90
South Finland		14,66	48,21	30,80	39,73
North & East Finland		10,79	39,30	33,02	35,70
Stockholm	Sweden	21,15	71,61	31,05	**44,97**
West Sweden		20,60	48,67	28,80	41,11
South Sweden		25,64	47,64	31,35	39,05
Småland and the islands		14,22	38,72	25,30	37,59

Regions	Country	OPC	CLT	EDU	HSI
Upper Norrland		14,89	39,25	40,51	40,04
East Middle Sweden		16,86	45,19	36,30	39,50
Inner London - West	United Kingdom	44,43	44,83	86,79	**49,85**
Inner London - East		39,95	47,13	20,59	34,75
Oslo og Akershus	Norge	25,24	55,97	38,76	43,85
Vestlandet		18,40	57,67	31,37	43,19
Trøndelag		17,62	57,86	50,74	**46,29**
Agder og Rogaland		21,06	56,18	24,79	41,45
Nord-Norge		17,12	56,14	31,27	42,33

Notes: Social openness to other cultures (OPC); Culture (CLT); Educational Training (EDU) and Human Smart Index (HSI)

In bold the regions in the first decile (HSI), 12 higher positions. In bold and italic regions in the worst decile (HSI), 12 lower positions.

Table 5. Technological index (TI) and each of its components

Regions	Country	UACC	UAPP	USE	CEMP	CINV	CAP	TI
Bruxelles region	Belgium	61,06	53,75	56,59	37,57	29,09	33,18	46,73
Prov. Antwerpen		67,65	57,61	60,33	43,89	37,29	37,25	51,13
Prov. Oost-Vlaanderen		64,48	56,72	58,08	44,22	29,75	33,84	49,27
Prov. Hainaut		45,21	41,28	41,98	27,23	20,26	23,00	36,12
Prov. Liège		51,25	46,89	48,10	32,29	22,59	26,14	40,38
Prov. West Vlaanderen		65,37	51,86	54,59	36,33	17,51	24,77	43,83
Prov. Namur		56,70	50,83	52,58	37,81	17,48	25,34	43,06
Prov. Vlaams-Brabant		72,25	59,86	63,26	48,57	46,91	44,08	55,09
Yugozapaden	Bulgaria	32,58	23,09	24,97	42,90	17,85	27,16	29,66
Yuzhen tsentralen		15,02	11,22	13,70	24,98	8,86	16,01	***18,45***
Severoiztochen		20,79	18,86	20,32	26,30	9,61	17,12	***22,29***
Yugoiztochen		16,77	13,32	15,26	20,69	8,93	14,76	***18,41***
Severozapaden		8,45	15,18	14,98	19,65	8,47	14,60	***17,83***
Severen tsentralen		14,99	18,98	18,14	22,15	8,75	15,40	***20,72***
Praha	Czech Republic	63,29	41,21	48,19	70,09	39,50	50,24	51,15
Jihovýchod		35,95	35,42	37,19	69,08	30,48	41,67	43,33
Moravskoslezsko		32,78	31,18	34,11	36,36	16,84	23,98	32,96
Jihozápad		38,52	33,37	36,50	40,19	20,22	26,80	35,59
Severozápad		32,82	32,08	33,61	32,64	10,20	19,12	30,85
Střední Morava		34,78	32,90	35,94	36,39	18,78	24,96	34,17
Severovýchod		36,56	30,89	35,68	39,85	18,26	25,79	34,02
Střední Čechy		45,75	37,62	41,60	43,68	22,69	28,83	38,87
Hovedstaden	Denmark	85,53	88,33	85,88	72,70	57,24	59,97	**73,99**
Midtjylland		79,48	80,72	79,00	52,57	29,65	36,77	**61,36**
Southern Denmark		72,87	76,02	74,12	46,39	23,58	31,44	56,59
Nordjylland		69,13	76,61	74,05	45,07	21,41	29,73	55,82

Regions	Country	UACC	UAPP	USE	CEMP	CINV	CAP	TI
Berlin	Germany	65,02	57,44	62,68	59,64	40,94	44,72	55,21
Hamburg		76,27	65,42	70,75	62,66	36,12	43,80	59,23
Oberbayern		58,68	49,96	56,64	68,04	57,06	56,28	56,27
Darmstadt		63,86	55,74	61,42	55,97	40,63	43,13	53,71
Düsseldorf		66,76	54,81	60,69	46,55	23,61	31,03	48,69
Stuttgart		59,85	51,45	57,18	61,02	69,89	59,31	57,16
Leipzig		56,11	46,68	54,06	50,72	25,05	33,24	45,93
Dresden		56,11	46,68	54,06	48,26	41,01	39,75	47,86
Arnsberg		66,76	54,81	60,69	45,33	22,06	29,95	48,25
Hannover		65,59	55,54	61,63	50,89	29,21	35,49	50,96
Mittelfranken		58,68	49,96	56,64	55,06	44,46	44,26	51,40
Detmold		66,76	54,81	60,69	47,32	25,24	32,17	49,13
Sachsen-Anhalt		55,81	47,24	53,67	43,21	19,20	27,53	43,52
Braunschweig		65,59	55,54	61,63	53,68	80,64	61,92	59,75
Freiburg		59,85	51,45	57,18	55,15	32,33	38,17	49,96
Oberpfalz		58,68	49,96	56,64	55,21	25,80	34,72	48,34
Karlsruhe		59,85	51,45	57,18	58,54	50,28	49,07	53,71
Schleswig-Holstein		63,29	56,84	61,51	48,58	20,35	29,94	49,05
Saarland		56,68	47,44	55,14	43,33	20,70	28,62	44,25
Weser-Ems		65,59	55,54	61,63	45,45	14,45	25,70	47,33
Chemnitz		56,11	46,68	54,06	45,00	22,97	30,46	44,49
Kassel		63,86	55,74	61,42	47,62	24,12	31,45	49,27
Eesti	Estomia	61,03	52,29	54,28	41,96	19,83	27,22	45,14
Southern and Eastern	Ireland	71,14	53,27	58,08	37,98	23,54	28,87	46,22
Comunidad de Madrid	Spain	74,31	52,88	57,16	45,15	23,41	31,47	47,43
Cataluña		65,12	48,59	51,48	32,26	20,65	25,26	41,64
Comunidad Valenciana		55,63	39,87	42,88	23,74	15,83	19,93	34,68
Andalucía		56,50	37,20	40,43	18,29	15,41	17,93	32,48
Aragón		55,63	44,28	46,82	28,31	15,24	21,11	37,17
Región de Murcia		55,04	38,74	42,39	22,45	14,27	18,71	33,82
Canarias		57,93	38,09	40,71	18,41	11,23	15,53	32,21
Castilla y León		52,76	36,79	40,77	24,45	15,72	20,01	33,34
Illes Balears		66,55	49,81	51,71	27,97	10,14	17,79	39,36
Galicia		54,19	40,19	44,20	24,91	14,48	19,64	34,83
País Vasco		65,69	45,48	52,38	36,11	26,33	29,89	42,85
Principado de Asturias		56,77	38,65	43,68	26,02	13,95	19,77	34,75
Comunidad Foral de Navarra		59,92	41,30	47,51	32,92	23,55	27,08	39,51
Cantabria		57,64	42,66	47,13	27,86	14,33	20,40	36,79
Castilla-la Mancha		52,48	41,25	43,59	20,09	11,38	16,17	33,13
Estremadura		49,34	35,68	38,06	17,59	12,58	16,11	30,24
La Rioja		55,06	37,90	42,94	29,95	15,34	21,72	35,19

Regions	Country	UACC	UAPP	USE	CEMP	CINV	CAP	TI
Ciudad Autónoma de Ceuta		74,03	42,74	48,46	13,92	7,85	12,54	34,48
Ciudad Autónoma de Melilla		61,60	38,94	43,36	13,43	8,34	12,77	32,06
Île de France	France	73,14	61,11	67,41	51,07	40,67	43,20	55,70
Rhône-Alpes		57,32	52,77	58,23	42,94	32,08	34,64	47,63
Midi-Pyrénées		57,59	49,94	56,17	44,52	47,64	42,43	49,37
Alsace		59,05	51,00	56,97	39,84	22,50	28,68	44,89
Pays de la Loire		58,46	51,69	56,71	35,96	17,88	24,85	43,55
Nord-Pas-de-Calais		59,03	52,07	55,98	30,35	15,06	21,78	42,02
Languedoc-Roussillon		65,37	58,26	64,03	30,52	26,52	27,38	47,27
Upper Normandy		56,13	46,51	53,14	34,03	19,27	24,88	41,47
Brittany		49,54	47,01	52,56	37,63	24,11	28,44	42,32
Picardy		53,55	47,00	51,80	28,36	18,45	22,21	39,79
Lorraine		53,58	51,00	55,32	33,23	17,64	23,85	42,07
Champagne-Ardenne		52,98	49,08	53,35	28,98	13,77	20,35	39,95
Bourgogne		51,59	52,62	55,87	32,30	15,58	22,48	41,80
Poitou-Charentes		59,62	49,84	56,78	29,93	15,10	21,36	41,55
Auvergne		52,44	43,88	50,69	30,25	25,57	26,56	40,13
Lower Normandy		44,12	42,11	46,27	31,21	17,82	22,94	36,93
Limousin		45,50	50,06	55,17	31,36	15,48	22,03	40,69
Franche-Comté		59,30	55,24	60,84	35,32	28,75	29,79	46,92
Corsica		38,30	42,42	45,10	9,35	9,85	13,04	31,20
Provence-Alpes-Côte d'Azur		56,75	52,18	58,57	37,99	28,97	31,14	45,82
Aquitaine		60,81	57,09	60,97	36,39	21,05	26,62	46,15
Continental Croatia	Croatia	38,62	25,20	29,54	28,75	14,19	20,56	28,30
Adriatic Croatia		38,00	23,70	28,36	26,32	9,84	17,59	***26,72***
Latvia	Latvia	36,54	42,83	40,24	35,60	12,37	21,66	36,10
Lithuania	Lithuania	29,38	34,61	32,73	40,21	15,44	25,02	33,52
Mazowieckie	Poland	42,04	29,58	34,95	51,10	22,39	32,13	36,78
Łódzkie		42,04	29,58	34,95	41,33	12,34	22,93	33,08
Małopolskie		35,70	25,77	30,69	31,03	17,45	22,88	29,92
Dolnośląskie		42,04	29,46	34,13	31,97	13,08	21,34	31,42
Wielkopolskie		32,23	23,47	27,62	26,50	12,31	18,68	***26,87***
Pomorskie		37,70	27,34	31,40	31,54	15,09	21,76	30,28
Zachodniopomorskie		32,23	23,47	27,62	22,83	9,38	16,40	***25,73***
Kujawsko-Pomorskie		37,70	27,34	31,40	23,93	9,69	16,53	27,93
Lubelskie		29,33	21,05	25,82	35,63	14,51	22,12	27,80
Śląskie		35,70	25,77	30,69	34,49	11,64	21,12	29,63
Podlaskie		29,33	21,05	25,82	27,47	11,60	18,44	***25,82***
Świętokrzyskie		29,33	21,05	25,82	31,22	9,58	18,16	***26,12***
Warmińsko-Mazurskie		37,70	27,34	31,40	25,63	9,14	16,91	28,18

Regions	Country	UACC	UAPP	USE	CEMP	CINV	CAP	TI
Podkarpackie		29,33	21,05	25,82	25,06	16,58	20,08	***26,10***
Opolskie		42,04	29,46	34,13	26,01	9,68	17,15	29,60
Lubuskie		32,23	23,47	27,62	24,89	8,59	16,34	***25,94***
Western Slovenia	Slovenia	48,06	40,03	44,11	47,46	30,84	35,98	42,17
Eastern Slovenia		40,87	33,40	36,80	35,07	21,84	25,64	34,33
Helsinki-Uusimaa	Finland	84,34	81,67	81,36	70,11	47,45	52,88	**69,20**
West Finland		73,69	68,75	71,04	45,06	35,44	36,69	56,27
South Finland		73,69	69,03	72,03	42,42	28,39	32,41	54,88
North & East Finland		67,35	65,32	67,19	39,12	33,24	33,60	52,84
Stockholm	Sweden	84,09	86,15	83,43	74,03	51,33	55,47	**71,57**
West Sweden		84,36	84,15	83,08	58,40	41,22	43,98	**66,21**
South Sweden		76,31	75,00	74,82	53,37	42,00	42,65	**61,05**
Småland and the islands		72,85	74,45	72,56	46,05	20,19	28,81	55,13
Upper Norrland		71,98	72,39	71,80	51,42	32,83	38,11	58,18
East Middle Sweden		84,96	81,78	81,52	53,75	42,99	43,49	**64,71**
Inner London - West	United Kingdom	89,84	75,58	77,80	85,23	62,60	75,07	**75,57**
Inner London - East		89,84	75,58	77,80	65,80	13,57	33,10	60,44
Oslo og Akershus	Norge	92,41	90,85	88,10	76,59	40,98	52,32	**73,54**
Vestlandet		81,79	82,21	78,74	55,93	24,59	35,29	**61,75**
Trøndelag		76,04	76,82	75,47	60,92	53,51	52,23	**65,43**
Agder og Rogaland		85,28	80,63	78,91	56,74	18,40	31,85	60,38
Nord-Norge		80,90	81,09	78,87	51,88	23,74	33,39	**60,75**

Notes: Use-acces (UACC); Use-aplications (UAPP); Use (USE); Capacity-employment (CEMP); Capacity-investment (CINV); Capacity (CAP) and Technology index (TI).
In bold the regions in the first decile (TI), 12 higher positions. In bold and italic regions in the worst decile (TI), 12 lower positions.