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Digitalization and skills in Spain: regional differences and gender gaps

Digitalización y competencias en España: diferencias regionales y brechas de género*

MYRIAM RODRIGUEZ-PASQUÍN
Department of Applied Economics, University of Murcia, Spain
myriam@um.es
ORCID: https://orcid.org/0000-0002-2792-4487

OLGA GARCÍA-LUQUE
Department of Applied Economics, University of Murcia, Spain
olga@um.es.
ORCID: https://orcid.org/0000-0002-5160-4272

MARÍA LÓPEZ-MARTÍNEZ
Department of Applied Economics, University of Murcia, Spain
marlomar@um.es
ORCID: https://orcid.org/0000-0002-6363-2852

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Abstract: Digital skills are increasingly necessary. When their level is unequal, problems of exclusion can arise in the regional and gender spheres. This paper analyzes both types of digital divides in Spain and their recent evolution. The indicator used is IRIS-DESI and its five dimensions: Connectivity, Human capital, Internet use, Integration of digital technology in companies and Digital public services. Using a hierarchical cluster analysis, the Spanish regions are classified according to their digital development. However, considering the gender gap, no clear regional pattern has been found, possibly due to the very complex and multifaceted nature of the digital economy

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Keywords: digitalization; digital skills; regional digitalization models; territorial digital divide; gender digital divide

Resumen: Las competencias digitales son habilidades cada vez más necesarias. Cuando su nivel es desigual pueden surgir problemas de exclusión en los ámbitos regional y de género. Este trabajo analiza ambos tipos de brechas digitales en España y su evolución reciente. El indicador utilizado es IRIS-DESI y sus cinco dimensiones: Conectividad, Capital humano, Uso de internet, Integración de la tecnología digital en las empresas y Servicios públicos digitales. Mediante un análisis de conglomerados jerárquico, se clasifican las regiones españolas según su desarrollo digital. Sin embargo, atendiendo a la brecha de género, no se ha encontrado un patrón regional claro, posiblemente por la propia naturaleza compleja y polifacética de la economía digital.

Palabras clave: digitalización; competencias digitales; modelos regionales de digitalización; brecha digital territorial; brecha digital de género

1. INTRODUCTION

The process of digitalization, initiated at the beginning of the 21st century, greatly intensified in 2020 due to the COVID-19 pandemic (Brändle and Manzanera, 2022). Digitalization has multiple advantages, and no group should be left behind in this process, although, so far, it has not occurred homogeneously. When there are differences in access, technical means, and opportunities to acquire technical skills, digital divides may appear among people, countries, and regions. These gaps can be caused by multiple factors, such as age, education, income, geographic area, or gender. This paper explores the last two factors, territory and gender, in terms of digital skills.

Although significant progress has been made in the use of Information and Communication Technologies (ICTs), gaps or imbalances persist. With the pandemic, the territorial digital divide has come to the fore, highlighting the connectivity deficits of rural areas, regional divergences in the pace of digital transformation, and the varying degrees of e-government and digital public service implementation at the national, regional, and local levels (European Commission, 2022).

In Spain, the relevance of regional disparities in multiple dimensions of well-being has been highlighted (Ayala and Ruiz-Huerta, 2020; Colino et al., 2020; De Maya et al., 2022; Faura-Martínez et al., 2020). The digital divide stands out as a new exclusive element (FOESSA Foundation, 2022), and it should be studied considering its territorial dimension. However, this perspective has scarcely been addressed.

Carmona and García (2007) point to supply and demand as explanatory causes of the geographic digital divide. In terms of supply, companies providing these services tend to operate in the richest and most developed areas. In terms of demand, users also tend to concentrate in the same regions, where there is greater economic capacity and an environment more conducive to innovation. Likewise, the geographical aspects of ICTs are associated with economic and social development, so adequate physical, technical, human, and institutional infrastructures are essential factors in explaining regional differences (Lera-López et al., 2009; Reig, 2017). Recently, some works (Capello and Lenzi, 2021; Capello et al., 2022) have highlighted the importance of studying digital services from a territorial perspective since technological transformations bring new opportunities for growth, which can increase interregional inequalities.

Our work also addresses the gender digital divide as increasing female presence in the digital world is one way of promoting equality and social progress (López-Martínez et al., 2021; Mariscal et al., 2019).

The latest studies on the gender digital divide show that digital inequality is mainly linked to people's technological skills and the benefits obtained from these online activities rather than access to the internet (De Andrés et al., 2020; Larsson and Viitaoja, 2020; Merino, 2021; OECD, 2020; ONTSI, 2022; Rodríguez-Pasquín et al., 2021). Thus, digital competencies are fundamental for gaining access to the opportunities provided by the digital era. These competencies range from basic skills,

which allow users to interact online and consume digital goods and services, to advanced skills, which enhance job opportunities (Vuorikari et al., 2016).

Therefore, acquiring and developing digital skills, together with the fight against the gender digital divide, are priorities in European Union (EU) and member state policies to combat digital exclusion. These policies have been reinforced following the COVID-19 pandemic (European Commission, 2021a).

The study is organized as follows. First, the objectives of the work are defined, and the methodological aspects of the analysis are detailed. Then, the results are presented, in aggregate form, in Spain and its regions, known as autonomous communities, including a detailed analysis from the gender perspective. Finally, the main conclusions are drawn.

2. MATERIAL AND METHODS

The objective of this work is twofold. First, we aim to analyze the degree of digitalization in Spanish regions and its recent evolution to establish relationships with other socioeconomic variables that could explain the differences detected. The hypotheses guiding this first objective are:

- H1: 'Rich' regions have a higher level of digitalization than 'poor' ones.
- H2: Between 2016 and 2020, a process of regional convergence in ICT use took place.

Secondly, we analyze the level of digital skills of the Spanish population through a gender perspective and delve into the differences observed among the Spanish autonomous communities. We determine the level and type of digital skills of the Spanish population as a whole to establish a framework of reference. Then, we determine the position of women by studying the gender gaps. With this second objective, the following research question is addressed: do the most technologically developed regions have a smaller gender gap in digital skills?

The paper uses quantitative data collected by the Spanish National Statistics Institute (INE) and the Regional Statistical Institute of La Rioja (RiojaStat). The Statistical Package for the Social Sciences (SPSS) program was employed for cluster analysis to group and characterize the regions according to their level of digital development.

Measuring digitalization levels has been carried out as proposed by the European Commission, which involves preparing a composite index called the Digital Economy and Society Index (DESI) based on a broad set of indicators. The DESI provides a synthetic and comparable figure of member countries' degree of digitalization, although it is not available at the regional level. Until 2020, DESI was a weighted arithmetic average of five dimensions: Connectivity, Human Capital, Integration of Digital Technology, Use of Internet Services, and Digital Public Services. The weight of the first two dimensions (Connectivity and Human Capital) was 25% in each case; Integration of Digital Technology was 20%, and Use of

Internet Services and Digital Public Service each had a weight of 15% (European Commission, 2018, p. 18).

Following the same methodology, RiojaStat has designed the Information Society Index of La Rioja (IRIS, in its Spanish acronym), which provides disaggregated information at the territorial level. Therefore, it is very relevant for the regional analysis of the digitalization process in Spain (Jiménez et al., 2018). However, IRIS is only available for the period 2016-2020, as it has not yet been adapted to the recent changes that the DESI calculation underwent in 2021 (European Commission, 2021b). This has conditioned the temporal analysis carried out in this work, which is limited to the aforementioned period (2016-2020), as there are no regional data for Spain compatible with the new DESI methodology at this time.

Likewise, other regional indicators related to digitalization from the INE are used, such as per capita income, the population's education levels, and investment in Research and Development (R&D).

This work also addresses the study of digital competencies, specifically Basic and Usability Skills, composed of two indicators:

- *Frequent internet users*: the percentage of people using the internet at least once a week during the last 3 months.
- *At least basic digital skills*: percentage of frequent internet users with basic or above-basic digital skills.

This second indicator takes the digital skills shown by frequent users as a reference, typified in four areas (Table 1): Information, Communication, Problem-solving, and Software Skills (for content manipulation). In addition, four levels of skills have been established (Eurostat, 2019), which, starting with the most advanced, are the following:

- Above-basic: above basic in all four domains or areas.
- Basic: at least basic skills in all four domains.
- Low: at least one domain with no skills, up to three.
- No skills: no activities performed in any of the four domains, despite declaring having used the internet at least once during the last 3 months.

The lack of data on digital skills for 2018 should be noted. Despite this, our paper gives an account of the evolution of digital skills in Spain between 2016-2020 from a territorial perspective. In addition, it shows the dynamics of the higher level of digital skills (above-basic) acquired by the population in each autonomous community. This is an indicator that has scarcely been analyzed at the regional level.

Information on the levels and types of digital skills is also available by gender for years 2017, 2019, and 2020, which is not the case for the global indicators (DESI and IRIS). This makes it possible to calculate regional gender gaps in the most advanced digital skills, i.e., those above the basic levels, since the differences between the sexes are less relevant when comparing basic digital skills. The gender gap is calculated in relative terms [(M-F)/F] and expressed as a percentage. Thus, a positive sign indicates a disadvantage for women (by expressing the extent to which

the male indicator is higher than the female one) and the opposite in the case of a negative sign.

Finally, to facilitate reading, we use the ISO 3166-2 codes for the autonomous communities without the indicator for Spain (ES). This is a standard published by the International Organization for Standardization (ISO), which is included in Annex 1 of this work. We also provide the denomination of each region in English and Spanish, as well as its location on the map.

Table 1. Type of digital skills

Areas-Domains	Skill	Levels
Information	• Copying or moving files or folders • Saving files on internet storage space • Obtaining information from public service websites • Finding information about goods or services • Seeking health-related information	Basic: one activity Above-basic: more than one activity
Communication	• Sending/receiving emails • Uploading self-created content to any website to be shared • Telephoning/video calls on the internet • Participating in social networks	Basic: one activity Above-basic: more than one activity
Problem-solving Skills	List A • Transferring files between computers or other devices • Installing software and applications (apps) • Changing settings of any software, including operating system or security programs List B • Making online purchases (in the last 12 months) • Selling online • Using online learning resources • Banking online	Basic: one or more activities only from A or only from B Above-basic: at least one activity from A and B
Software Skills (for content manipulation)	List A • Using word processing software • Using spreadsheet software • Using software to edit photos, video, or audio files List B • Creating presentations or documents integrating text, pictures, tables, or charts • Using advanced functions of spreadsheets to organize and analyze data (sorting, filtering, using formulas, creating charts) • Writing code in a programming language	Basic: one or more activities from list A and none from list B Above-basic: at least one activity from list B

Source: Own elaboration from Eurostat (2019) and RiojaStat, IRIS methodology.

3. RESULTS

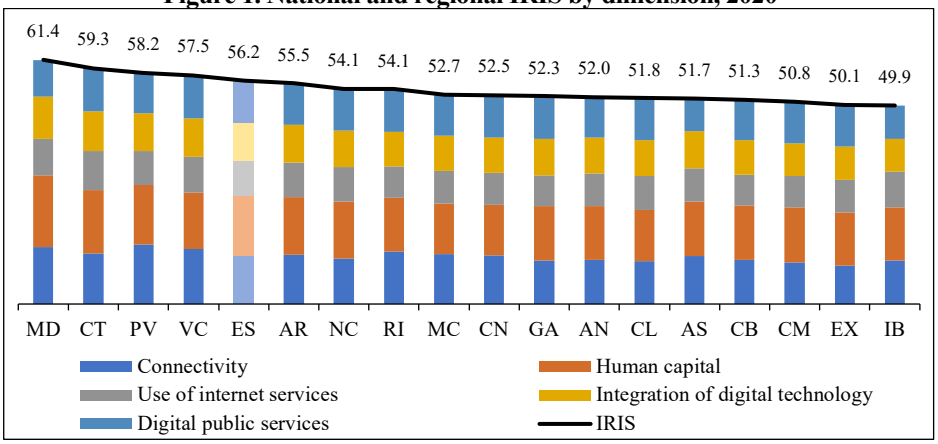
The main results of this work are presented below. First, we analyze the existing digital divide in the seventeen Spanish autonomous communities in 2020. We examine the possible relationships between the regional digital divide and other regional variables, such as Gross Domestic Product (GDP) per capita, Education

levels, and R&D expenditure. In addition, we perform a cluster analysis to classify the different Spanish regions according to their degree of digital development based on the five dimensions of IRIS. Second, the level of digital skills acquired by the population of each region during the period 2016-2020 is addressed. Third, regional gender gaps for above-basic digital skills and the evolution of these gaps are studied in the available years (2017, 2019 and 2020). We also contemplate the existence, or not, of a positive association between higher degrees of digitalization and smaller gender digital gaps, referring to the most advanced skills.

3.1. Territorial digital divide

Figure 1 shows an IRIS and its dimensions with the corresponding weighting for the Spanish regions and the national total in 2020. Only four regions are above the national average of 56.2. The Community of Madrid stands out with an IRIS above 60, followed by Catalonia, the Basque Country, and the Valencian Community. The high indicator obtained by the Community of Madrid can be explained, following Capello et al. (2022), by the fact that most regions containing national capitals have fully developed digital service economies.

Figure 1. National and regional IRIS by dimension, 2020



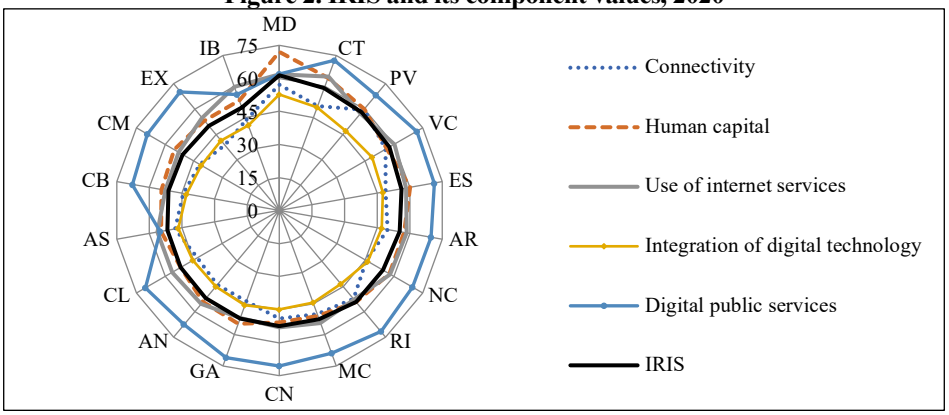
Source: Own elaboration from Riojastat, IRIS data.

Extremadura and the Balearic Islands are at the opposite extreme, with an indicator close to 50. The Human Capital dimension contributes the most to the index, both in Spain and all the autonomous communities, despite having the same weighting as Connectivity. The least relevant dimension is Use of Internet Services.

If we consider the amounts in the IRIS index and its dimensions without weighting (Figure 2), the highest value corresponds to Digital Public Services, except in the Balearic Islands and Asturias (where Use of Internet Services is more relevant) and in the Community of Madrid (where Human Capital stands out). The dimension

with the lowest values is Integration of Digital Technology, referring to the implementation of ICTs in companies. Connectivity, linked to digital infrastructures, also has low values in some regions, such as Extremadura and Castilla-La Mancha. However, Connectivity and Use of Internet Services tend to have similar values in most regions.

Figure 2. IRIS and its component values, 2020



Source: Own elaboration from Riojastat, IRIS data.

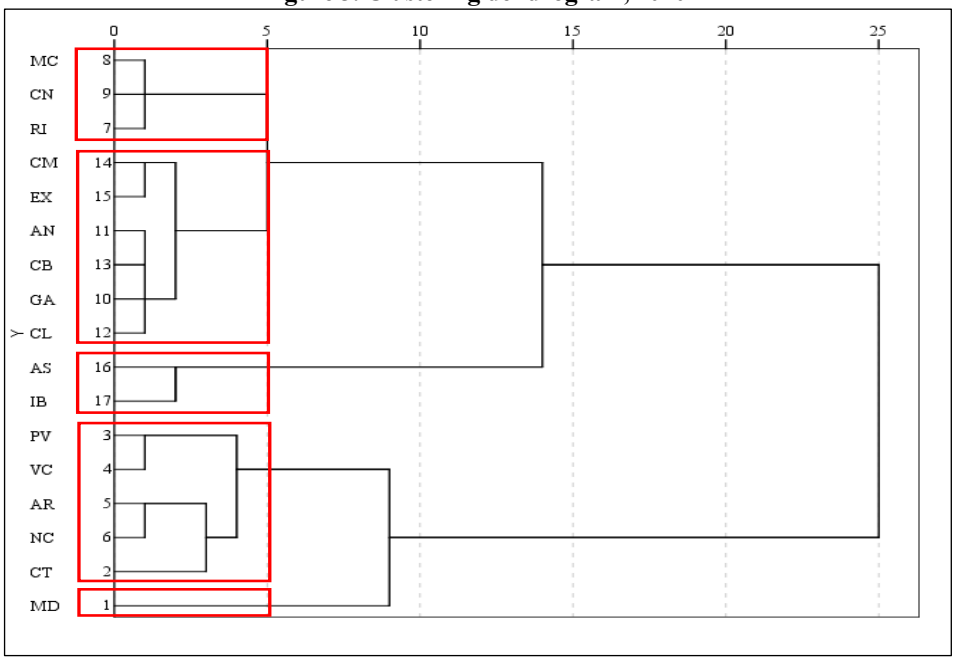
We performed a hierarchical cluster analysis using Ward's method to obtain a typology of regions with similar traits based on the five dimensions included in the IRIS synthetic indicator. This method provides the partition minimizing variance or within-cluster inertia, using squared Euclidean distances between points. The best features of Ward's method are its simplicity and the fact that it is based on a natural quality criterion because it uses the F value (like ANOVA) to maximize the significance of the differences between clusters (Randriamihamison et al., 2021). Figure 3 shows the graphical representation, called a dendrogram, that is commonly used for model selection (choice of the number of clusters) and interpretation of the results.

Observing the dendrogram (Figure 3), five clusters have been determined. The results are stable; that is, the solution does not depend on the order of cases. Annex 2 shows the values of the statistical measures of each cluster. The first cluster includes a single element, the Community of Madrid, with average values well above the national average in four of the five IRIS dimensions (Annex 2). The high level of the Human Capital dimension is notable, but this region obtains a lower result than the Spanish average in the Digital Public Services dimension.

As already mentioned, the fact that the capital of Spain is located in this region gives it an advantage as a technological pole, which explains its higher degree of digitalization. After the Community of Madrid, the five autonomous communities with the highest degrees of digital development make up the second cluster (Catalonia, the Basque Country, the Valencian Community, Aragon, and Navarre), with average

values higher than those of the Spanish total in all the IRIS dimensions. In contrast, the following clusters have a lower degree of digitalization than the national total. The third cluster brings together two regions, the Balearic Islands and Asturias, and it is characterized by the lowest average value in the Digital Public Services dimension. The six autonomous communities grouped in the fourth cluster (Castile and Leon, Galicia, Cantabria, Andalusia, Extremadura, and Castilla-La Mancha) share the lowest values in the Connectivity and Integration of Digital Technology dimensions. Finally, the fifth cluster comprises La Rioja, the Canary Islands, and the Region of Murcia, where the Human Capital dimension obtains the lowest values.

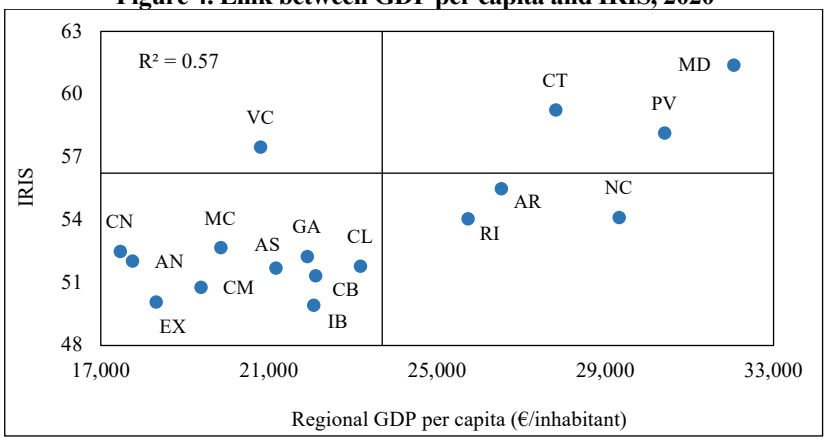
Figure 3. Clustering dendrogram, 2020



Source: Own elaboration from Riojastat, IRIS data.

There was a positive association between per capita income and the IRIS of the different autonomous communities in 2020 (Figure 4). Considering the national averages of GDP per capita and the IRIS synthetic indicator, 23,693 €/person (vertical line) and 56.2 (horizontal line), respectively, we can see that all the regions with a GDP per capita below the Spanish average also have lower levels of digitalization (lower left quadrant), except for the Valencian Community. However, not all those that exceed Spain in income achieve an IRIS above the average (upper right quadrant). Thus, for example, La Rioja is a relatively rich region but with a digital development indicator (IRIS) close to that of some poor regions, such as the Region of Murcia or the Canary Islands.

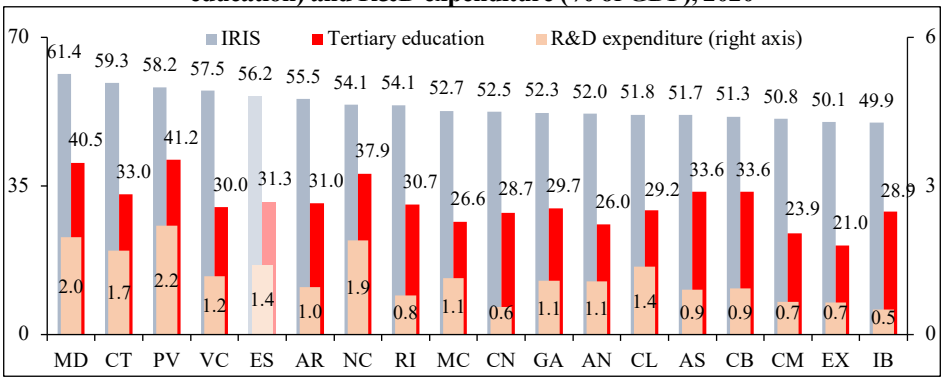
Figure 4. Link between GDP per capita and IRIS, 2020



Source: Own elaboration from INE and Riojastat.

In short, there is a high correlation between regional levels of per capita income and digitalization indexes, with the coefficient of determination (R^2) reaching 0.57. Therefore, the first hypothesis is generally supported, although with some qualifications. Thus, the higher the per capita income, the higher the degree of digitalization, although some regions, such as the Valencian Community, show a higher IRIS than expected based on their income, while the opposite is true for Navarre, Aragon, and La Rioja.

Figure 5. IRIS, Higher education (% of population aged 16 and over with tertiary education) and R&D expenditure (% of GDP), 2020



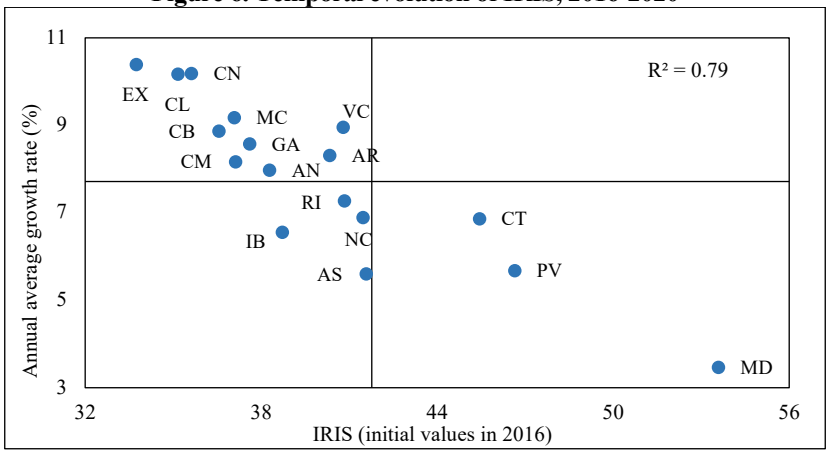
Source: Own elaboration from INE and Riojastat.

In turn, regions with a higher IRIS tend to have a better-educated adult population and higher R&D expenditure (Figure 5). However, we can find some autonomous communities in the north, such as Cantabria or Asturias, where higher

education levels are widespread among their adult populations but which have low degrees of digitalization. The aging of the populations in these communities could explain this result.

To test the second hypothesis, Figure 6 shows the IRIS values for each region in 2016 and their annual average growth rate (AAGR) for the period 2016-2020. Bearing in mind that the initial IRIS figure for the country as a whole was 41.8 (vertical line) and its AAGR was 7.7% (horizontal line), we can see that the three regions that started with higher digitalization levels than the Spanish average in 2016 (the Community of Madrid, the Basque Country, and Catalonia) had a lower growth rate during the period. In contrast, the three regions that in 2016 had the lowest IRIS (Extremadura, Castile and Leon, and the Canary Islands) were the ones with the highest growth rates, at more than 10% per year. Therefore, a convergence took place in the regional digitalization process, which corroborates the second hypothesis, although there are still relevant differences.

Figure 6. Temporal evolution of IRIS, 2016-2020

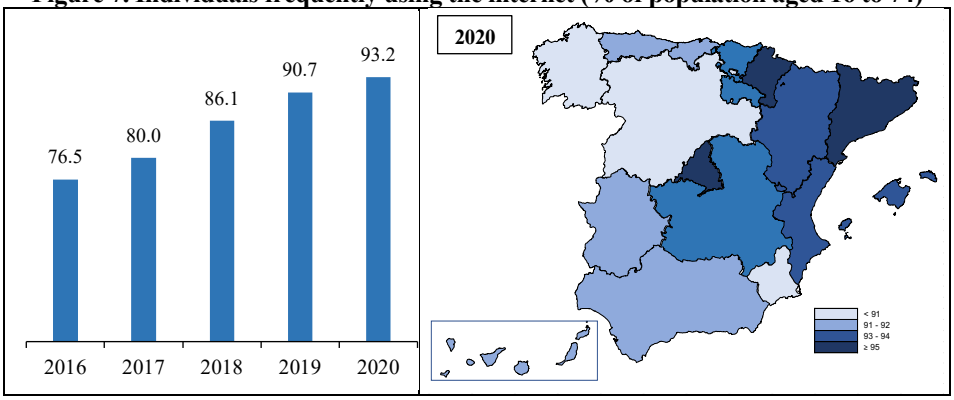


Source: Own elaboration from Riojastat, IRIS data.

3.2. Regional digital skills

If we focus on digital competencies in Spain and its autonomous communities, in 2020, 93% of Spaniards were *frequent internet users* (Figure 7). This figure has increased steadily since 2016, although it is striking that the smallest increase occurred in 2020, contrary to what might be expected. However, the margin of progress is decreasing since most of the population uses the internet on a regular basis. The data by region show slight differences, with the Community of Madrid, Catalonia, and Navarre in the lead, with values above 95%, while Castile and Leon, the Region of Murcia, and Galicia are below 91%.

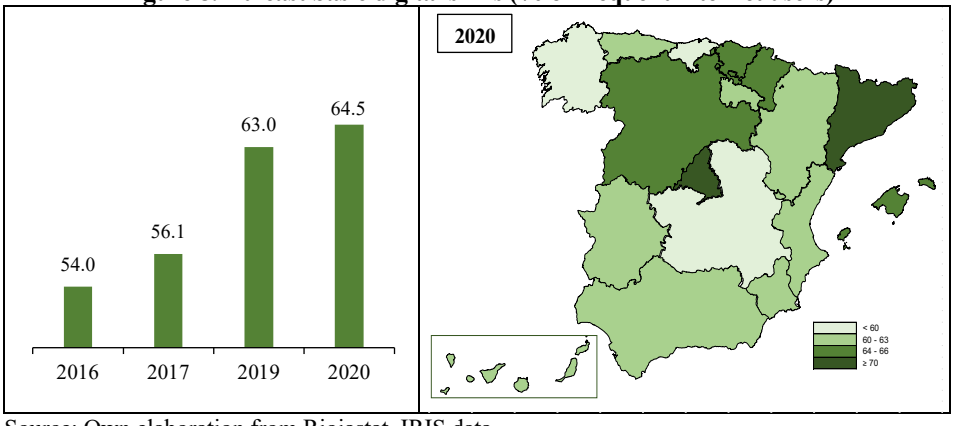
Figure 7. Individuals frequently using the internet (% of population aged 16 to 74)



Source: Own elaboration from Riojastat, IRIS data.

Almost 65% of frequent users had *At least basic digital competencies* in 2020 (Figure 8), slightly higher than in 2019, which is again surprising, as it seems that the consequences of the COVID-19 pandemic have not had a powerful impact on the acquisition of digital competencies. Since there is no information on digital competencies for 2018, that year is omitted in Figure 8 and the following figures. The regional analysis shows that the differences are somewhat greater than in the previous indicator, although only Castilla-La Mancha, Cantabria, and Galicia have figures below 60%, while the Community of Madrid and Catalonia are slightly above 70%.

Figure 8. At least basic digital skills (% of frequent internet users)

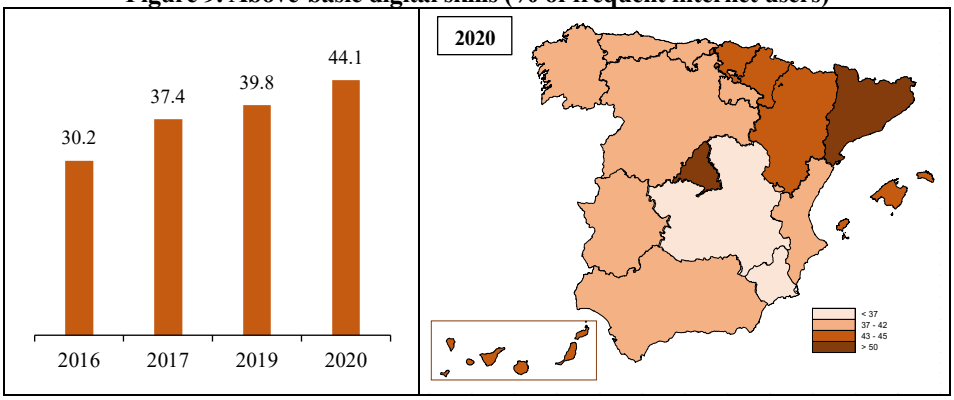


Source: Own elaboration from Riojastat, IRIS data.

However, when analyzing *Above-basic digital skills* (Figure 9), we found that users who had above-basic overall digital skills in the four skill areas only accounted for 44% in 2020. The progression has been relevant during the period studied despite the

somewhat erratic behavior of the data. Regional differences are very relevant in this case, with the Community of Madrid and Catalonia leading with figures slightly above 50%, while Castilla-La Mancha and the Region of Murcia have percentages below 37%, which means there is a 17-point difference between Madrid and the Region of Murcia.

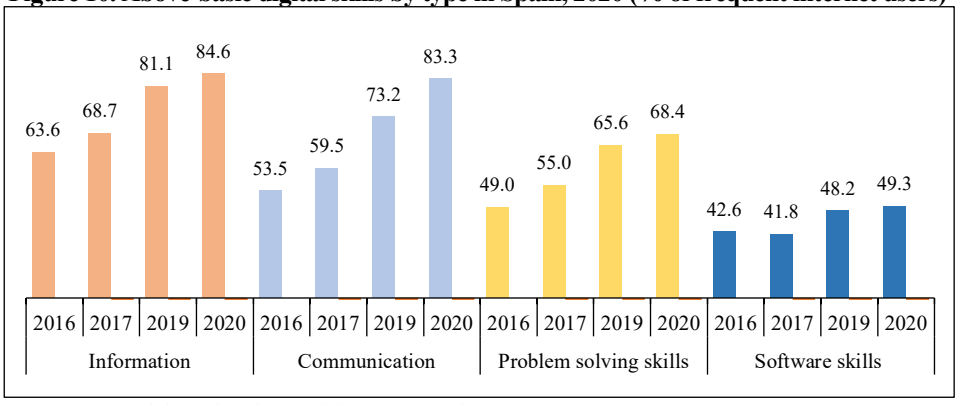
Figure 9. Above-basic digital skills (% of frequent internet users)



Source: Own elaboration from Riojastat, IRIS data.

The percentage of advanced users is very uneven when looking at the different areas considered (Figure 10). While in Information and Communication, almost 85% of users had digital competencies above basic skills in 2020, in Content Development, the number was less than 50%. This last area is also the one that shows the timidest progress in the period, compared to the strong progression in the area of Communication, where there was a large increase in 2020 due to the mobility restrictions brought on by the pandemic.

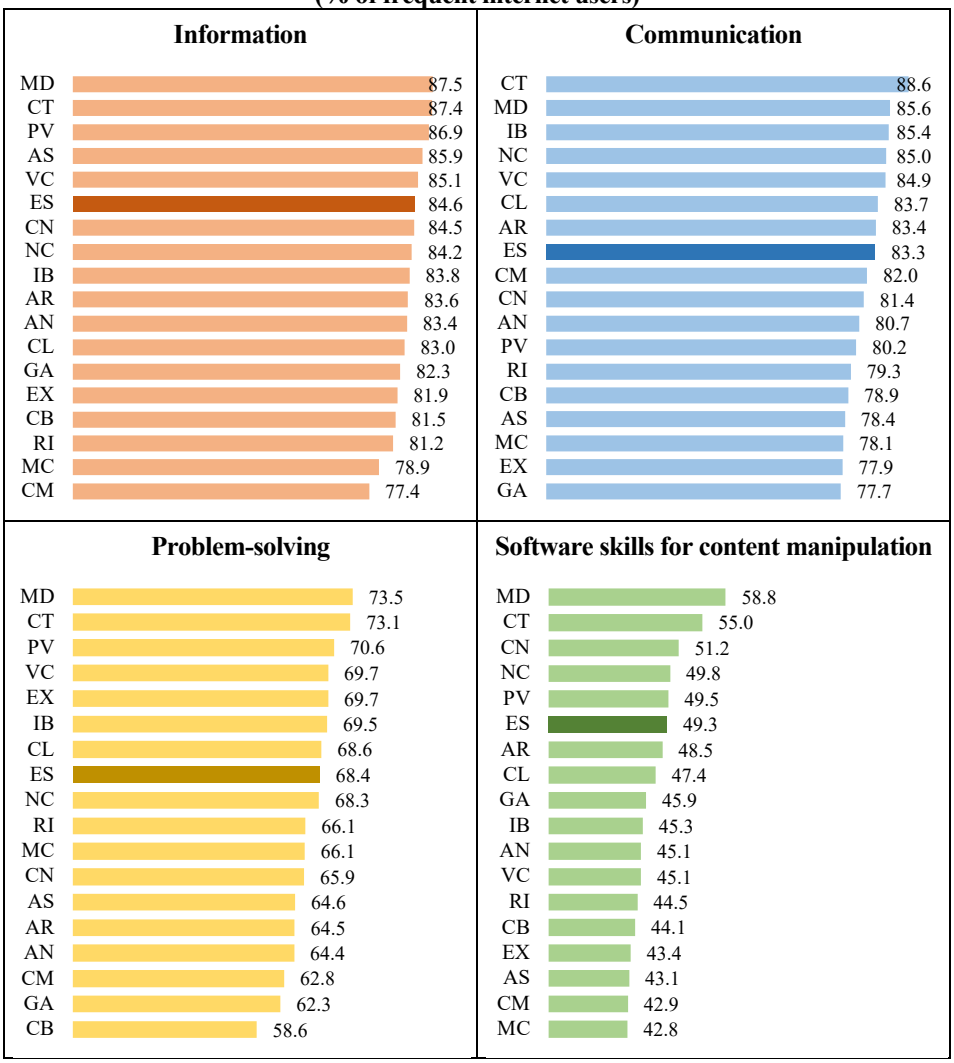
Figure 10. Above-basic digital skills by type in Spain, 2020 (% of frequent internet users)



Source: Own elaboration from Riojastat, IRIS data.

The differences among regions are significant (Figure 11), with the areas where the percentage of users with digital competencies above basic is lower, i.e., Problem-solving and, above all, Content Development. The Community of Madrid and Catalonia are in the top positions in all the areas (The Community of Madrid above Catalonia except in Communication), while the last positions are shared among several regions, with Castilla-La Mancha and the Region of Murcia predominating.

Figure 11. Above-basic digital skills by type and autonomous communities, 2020 (% of frequent internet users)

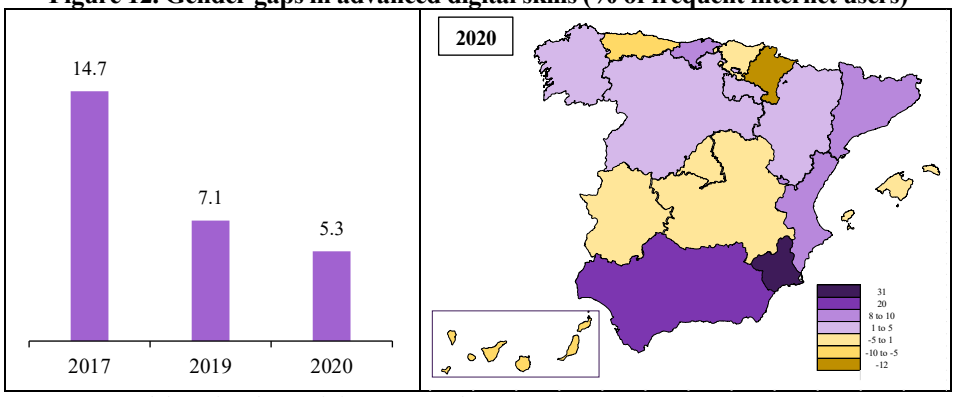


Source: Own elaboration from Riojastat, IRIS data.

3.3. Regional gender gaps in advanced digital skills

The calculation of the gender gap among frequent internet users with above-basic digital skills shows an unfavorable result for women of just over 5% in 2020, with a decreasing trend over the period studied (Figure 12).

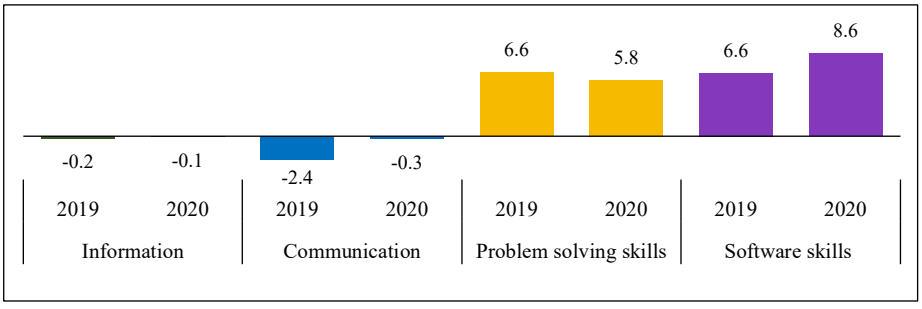
Figure 12. Gender gaps in advanced digital skills (% of frequent internet users)



Source: Own elaboration from Riojastat, IRIS data.

Although this situation does not seem particularly serious at the national level, it does show worrying signs at the regional level, with gaps for both genders. Thus, nine autonomous communities show adverse gaps for women, with the Region of Murcia standing out with a difference of over 30%, followed at some distance by Andalusia at 20%; the rest show figures below 10%. The other eight regions have unfavorable gaps for men, although the differentials are smaller, and only Navarre and Asturias have gaps of around 10%.

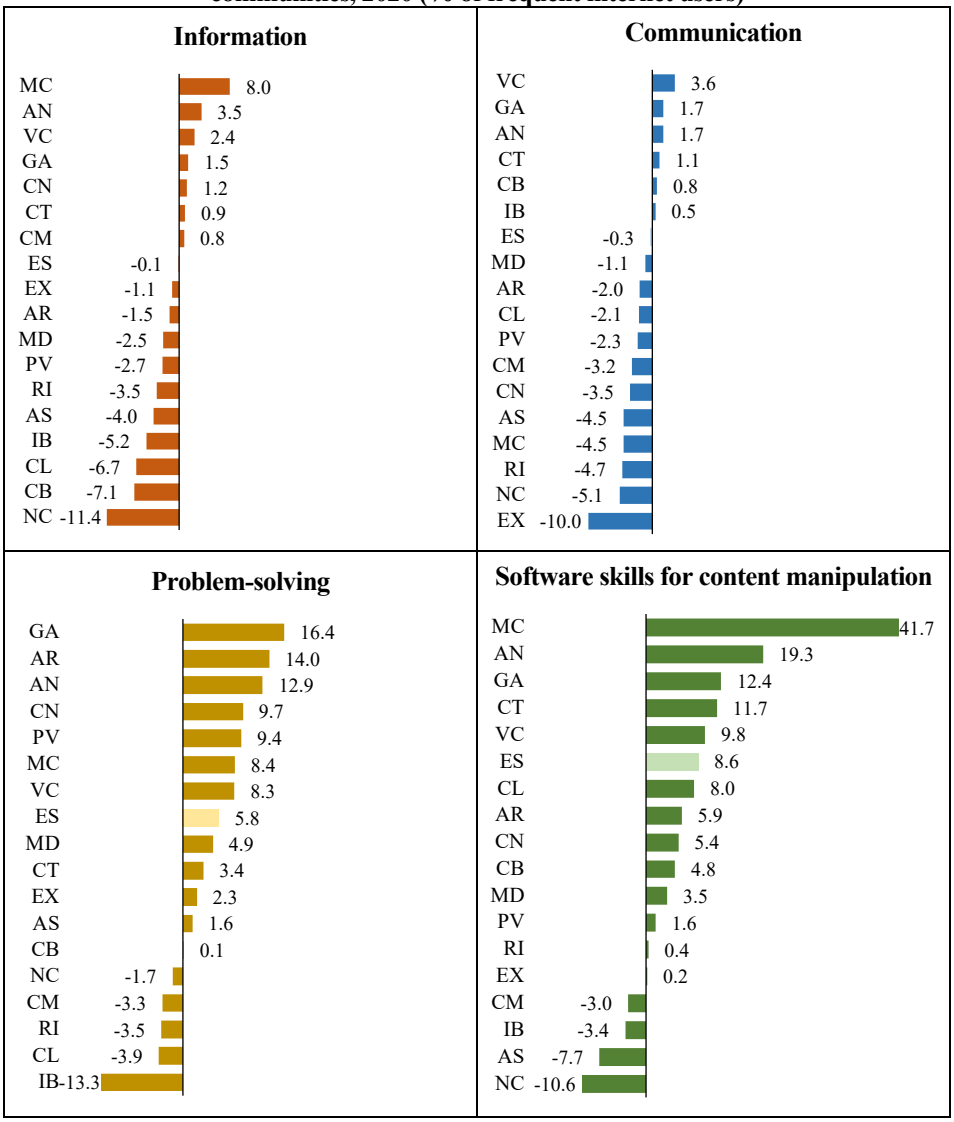
Figure 13. Gender gaps in advanced digital skills by type in Spain (% of frequent internet users)



Source: Own elaboration from Riojastat, IRIS data.

Figure 13 shows that the relevant gender gaps occur in the areas of Problem-solving and Content Development, both unfavorable to women. Problem-solving was reduced in 2020, while the gap in Content Development increased. On the other hand, in Information and Communication, there are hardly any gender disparities. The regional breakdown shows some notable aspects (Figure 14).

Figure 14. Gender gaps in advanced digital skills by type and autonomous communities, 2020 (% of frequent internet users)

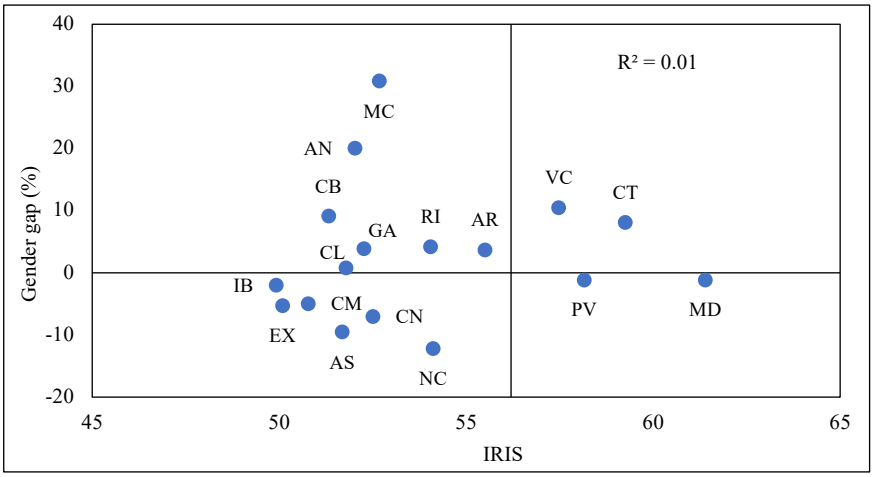


Source: Own elaboration from Riojastat, IRIS data.

On the one hand, as was to be expected, the most relevant gender gaps are unfavorable to women and occur in the areas of Problem-solving and, above all, Content Development. The very high value for the Region of Murcia in this area should be highlighted, with a gap of over 40%, followed by Andalusia, although at a great distance. On the other hand, in Information and Communication, gaps unfavorable to men are observed in most of the autonomous communities, although the differentials are much lower, with Navarre standing out in the former and Extremadura in the latter.

Finally, we cannot confirm that higher degrees of digital development, as measured by higher IRIS values, lead to smaller gender gaps in terms of above-basic digital skills. As Figure 15 shows, the correlation coefficient (R^2) between the two variables is zero. Thus, we find digitally developed regions (IRIS above the national average) with significant gender gaps unfavorable to women (the Valencian Community and Catalonia, in the upper right quadrant) and others with slight gaps unfavorable to men (the Community of Madrid and the Basque Country, lower right quadrant).

Figure 15. Links between gender gaps in advanced digital skills and IRIS



Source: Own elaboration from Riojastat, IRIS data.

Among the regions with less digital development (IRIS below the national average), there are territories with small gender gaps (close to zero), which show disadvantages for both men (lower left quadrant) and women (upper right quadrant). Gender inequality in advanced digital skills (above-basic) is very high in the Region of Murcia and Andalusia (very unfavorable to females) and, in the opposite direction, in Navarre and Asturias (unfavorable to males).

4. DISCUSSION AND CONCLUSIONS

The more or less intensive use of ICTs in the different Spanish regions corresponds, to a large extent, with their levels of income, corroborating the first hypothesis put forward in this paper. However, the figures also show that a high per capita income is a necessary but not sufficient condition for achieving a high IRIS. This is due to the fact that there are other factors, such as productive composition, the populations' levels of education, or R&D expenditure, which also influence the technological index. Thus, only the Community of Madrid, Catalonia, and the Basque Country exceed the Spanish average in the digital development indicator used, while this is not true for three other high-income regions (La Rioja, Aragon, and Navarre). The Valencian Community registers an above-average IRIS despite having a low per capita income. As for the regions with lower income levels, they generally have low digital indicators, such as Extremadura or Castilla-La Mancha.

Our results are in line with previous studies where the less digitally advanced regions are indicated (Carmona and García, 2007; Lera-López et al., 2009). There is also some correspondence with more recent studies, such as Capello and Lenzi (2021), which identify Castile and Leon, Castilla-La Mancha, Extremadura, La Rioja, and the Region of Murcia as autonomous communities with limited technological adoption.

Focusing on digital development in business, Ruiz-Rodriguez et al. (2018) obtain a similar order to the one shown here from IRIS, especially in the regions that have high degrees of digitalization (the Community of Madrid, Catalonia, Aragon, the Basque Country, Navarre, and the Valencian Community). Likewise, there is certain correspondence with our results in some of the intermediate and less digitally advanced regions (the Region of Murcia, Castile and Leon, Castilla-La Mancha, Cantabria, and the Canary Islands). Other more recent studies, using the previously mentioned DiGiX index or regional e-commerce, also identify the Community of Madrid as the most digitally advanced region and place Catalonia and the Basque Country above the national average. This position was shared by Navarre and the Balearic Islands in the years prior to 2020 (Cámara, 2019; Cámara and Ruiz-Sánchez, 2017; Pérez-Amaral et al., 2020).

The second hypothesis is also supported. In the period 2016-2020, there was an approximation in the use of ICTs among regions since digitalization grew more in the regions that started from lower levels.

As the European Commission (2022) warns, the existence of IT infrastructures alone does not lead to economic growth; they must be accompanied by policies that promote lifelong learning, the acquisition of digital skills, innovation, entrepreneurship, and governance. Hence it is essential to reduce regional disparities in educational outcomes to progress in digital transformation since improving training and qualifications among the population will expand employment opportunities and attract business in lagging regions (Adalet and Antona, 2019; Pérez-Amaral et al., 2020).

In an environment of intense digitalization, with 93% of the population identified as frequent internet users, the digital skills of the Spanish population are acceptable and are above the EU average (European Commission, 2022). However, when analyzing specific types of skills, a deficit is observed in content development. The regional breakdown shows large differences, and it is necessary to pay attention to the autonomous communities with the lowest values of advanced skills, such as Castilla-La Mancha and, especially, the Region of Murcia.

The study of gender gaps allows us to affirm that, as a whole, women are at a disadvantage in advanced skills (ONTSI, 2021), especially in the areas of Problem-solving and Content Development. The gap in Content Development in the Region of Murcia should be highlighted. On the other hand, in Information and Communication, men are at a disadvantage in many of the autonomous communities. These results show that women lag behind in digital skills that are more technical and key to digital literacy (Rebollo-Catalán et al., 2017). However, to answer our research question, no spatial pattern linking regional digital development and the gender gap in digital skills beyond basic skills is evident.

In any case, it is important to prevent some regions from stagnating and failing to progress in the most complex digital skills and to ensure that women are actively involved in areas where they tend to be less represented, particularly in regions where the digital divide unfavorable to women is greater.

Finally, using a cluster analysis, this work helps to guide policy action to promote the digital development of the most digitally backward regions (clusters 3, 4, and 5). Thus, the two regions included in cluster 3 would improve their degree of digitalization by prioritizing measures aimed at improving digital public services (fifth dimension of the IRIS synthetic indicator). The six autonomous communities in cluster 4 and the three in cluster 5 should focus their policies on improving connectivity and advancing technological diffusion in the business fabric (first and fourth dimensions of IRIS). The communities in clusters 4 and 5 should also center on digital training and human capital accumulation measures. These measures are especially important for the regions in cluster 5, which are clearly lagging behind in the indicators included in this second dimension of IRIS.

To sum up, as Capello and Lenzi (2021) point out, "the support for adoption of 4.0 technologies should be oriented not towards the pure digitalisation of traditional services, but should also solve citizens' needs, with a human (rather than technological) perspective." It is this recommendation that should frame the necessary regional and gender approaches to be incorporated into policy action.

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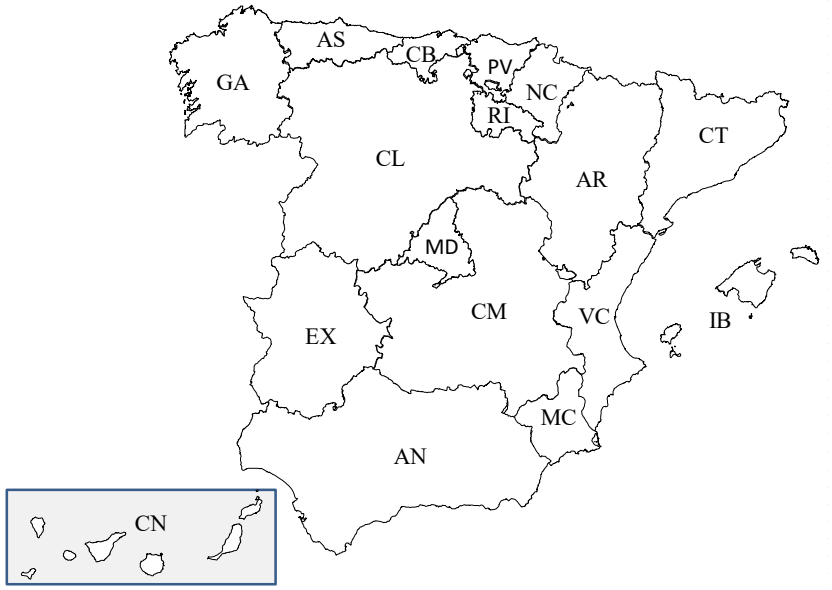
ANNEX 1. Codes for the names of the 17 autonomous communities of Spain



AN	Andalusia	Andalucía
AR	Aragon	Aragón
AS	Asturias	Asturias, Principado de
CB	Cantabria	Cantabria
CL	Castile and Leon	Castilla y León
CM	Castilla-La Mancha	Castilla-La Mancha
CN	Canary Islands	Canarias
CT	Catalonia	Cataluña
EX	Extremadura	Extremadura
GA	Galicia	Galicia
IB	Balearic Islands	Islas Baleares
MC	Region of Murcia	Murcia, Región de
MD	Community of Madrid	Madrid, Comunidad de
NC	Navarre	Navarra, Comunidad Foral de
PV	Basque Country	País Vasco
RI	La Rioja	Rioja, La
VC	Valencian Community	Valenciana, Comunidad
ES	Spain	España

Note: The autonomous cities of Ceuta and Melilla are not included, as their small sample yields insignificant data.

ANNEX 2. Summary statistics of the cluster analysis solution

Cluster	Measure	Connectivity	Human capital	Use internet services	Integration digital technology	Digital public services
Cluster 1 (N=1)	Mean	57.1	72.0	61.8	52.7	62.0
Cluster 2 (N=5)	Mean	52.2	59.0	59.8	47.8	70.4
	Min	45.5	56.1	57.5	46.2	68.2
	Max	59.8	64.2	64.8	49.9	72.6
	Range	14.3	8.1	7.3	3.7	4.4
	SD	5.5	3.2	3.0	1.5	1.8
	Var	30.7	10.2	9.0	2.2	3.2
Cluster 3 (N=2)	Mean	46.1	53.9	58.1	44.0	55.5
	Min	44.1	53.1	56.3	41.3	54.9
	Max	48.1	54.6	59.8	46.7	56.0
	Range	4.0	1.5	3.5	5.4	1.1
	SD	2.8	1.1	2.5	3.8	0.8
	Var	8.0	1.1	6.1	14.6	0.6
Cluster 4 (N=6)	Mean	42.7	53.9	54.0	43.6	69.5
	Min	38.8	51.7	51.8	41.0	67.7
	Max	44.5	55.2	56.4	45.8	71.2
	Range	5.7	3.5	4.6	4.8	3.5
	SD	2.1	1.3	1.8	2.1	1.5
	Var	4.5	1.6	3.3	4.6	2.1
Cluster 5 (N=3)	Mean	50.6	52.0	53.5	44.3	70.4
	Min	49.1	50.8	52.9	43.5	69.0
	Max	52.5	54.2	54.4	44.9	71.7
	Range	3.4	3.4	1.5	1.4	2.7
	SD	1.7	1.9	0.8	0.7	1.4
	Var	3.0	3.7	0.7	0.5	1.8
Total (N=17)	Mean	48.1	56.1	56.5	45.5	67.8
	Min	38.8	50.8	51.8	41.0	54.9
	Max	59.8	72.0	64.8	52.7	72.6
	Range	21.0	21.2	13.0	11.7	17.7
	SD	5.8	5.3	3.6	3.1	5.2
	Var	33.1	27.7	13.3	9.7	27.4

Note: Minimum (Min); Maximum (Max); Range (Max-Min); Standard deviation (SD); Variance (Var).
Source: Own elaboration from Riojastat, IRIS data.