Research Article

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Digital Gender Divide and Convergence in the European Union Countries

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Abstract: The aim of this study is to examine the digital gender divide in the European Union (EU) countries by applying two widely used indicators: percentage of the population who has used the Internet in the last 3 months (ICT-USE indicator) and percentage of the population who has made an online purchase in the last 3 months (ICT-PURCHASE indicator). With these indicators, the digital gender gaps are shown in absolute and relative terms. In addition, the European convergence beta and sigma, between the years 2007 and 2019, is also analyzed. The results among European countries show that the ICT-USE indicator has a lower dispersion than the ICT-PURCHASE indicator; hence, in general, the digital gender divide or gap is usually lower when ICT-USE is used in comparison with ICT-PURCHASE. The highest values of the digital gender gap in the EU, regardless of the indicator used, are found in Croatia and Italy, reflecting an unfavorable position for women. Ireland is also in this group, but in its case, the results show an unfavorable position for men. Additionally, Cyprus does not register gender differences in either of the two indicators analyzed. Finally, the convergence between European countries is corroborated, both in the indicators analyzed and in the different gender digital gaps built.

Keywords: digital economy, ICT indicators, digital gender divide, convergence, European Union

JEL code: J16, O33, O52

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1 Introduction

The digital economy is based on the digital goods and services sectors production and is related to the Information and Communication Technologies (ICTs), including electronic commerce (OECD, 2014) *or online shopping*. ICTs are tools that allow us to manipulate, organize, transmit, and store information in a digital form. This amplifies the intellectual capacity, in a way comparable to the extension of the muscular power achieved by the technologies in the industrial revolution (Cohen, DeLong, & Zysman, 2000). In a pioneering study, Autor, Levy, and Murnane (2003), who developed an estimated model for the United States, pointed out that ICTs can replace everyday work tasks and assist workers in other tasks that require communication, flexibility, and creativity. Thus, the digital economy has transformed the production processes, increasing productivity. The nature of work and the model of labor relations have also changed (Acemoğlu & Restrepo, 2019; Autor, 2015; Eurofound, 2020; World Bank, 2019). New forms of commerce and work have emerged in such a way that consumers have an immediate and easy access to products they demand on digital platforms (UNCTAD, 2019; WEF, 2018). In fact, some companies do not need a specific physical space anymore, as a service that connects products, workers, and customers can be provided by computer applications and online services (Degryse, 2019).

The growing use of ICTs in the production and consumption processes can have positive and negative effects on society, as well as on the different agents involved (OECD, 2019; Tourpe, 2021). This phenomenon has different repercussions on workers, generating both winners and losers, which could further exacerbate inequality (Acemoğlu, 2021). This is the approach taken by the concept of digital gap (Park, Choi, & Hong, 2015), which seeks to identify the inequality in the access and use of ICTs between different territories or population groups, such as men and women.

Consequently, the term digital gender gap or divide is used when comparing the situation of men and women in this area. The growing digitalization of the economy can

cause or increase the risk of exclusion of vulnerable groups: those with scarce resources, advanced age, poor social and family relationships, etc. (OECD, 2020; UNCTAD, 2019). Furthermore, the risk of exclusion can be aggravated in the case of women (OECD, 2018). This may be due to the fact that female participation in jobs and studies related to science and technology (STEM[1]) is considerably lower than men, as it is their presence in the most demanding ICT jobs.

According to OECD (2019), significant gender gaps are emerging with the digital transformation in some specific dimensions of well-being, as work–life balance, social connections, governance, and digital security. Digitalization offers women greater opportunities compared to men, regarding both, the health (where the Internet is vastly used to make medical appointments and look for medical information) and the labor market (higher use of the Internet to search for work and also, women obtain larger returns of their digital skills when accessing to more demanding ICT jobs). However, the proportion of women is lower when using government digital services, working from home (teleworking) or expressing their opinion online. In addition, young girls are more probable to suffer from cyber-bullying than boys.

Equality between men and women is not only a fundamental right but also an essential requirement to achieve inclusive and sustainable growth, as dictated by the United Nations (2015). For this reason, increasing female presence in the digital world is one of the measures to enhance productivity and promote equality and social progress (Mariscal, Mayne, Aneja, & Sorgner, 2019; OECD, 2018).

The aim of this study is to analyze the digital gender divide or gap in the European Union (EU). The gap has been constructed in absolute and relative terms by means of two common indicators of Internet usage, examining the existence of beta and sigma convergence among EU countries during the 2007–2019 period. These indicators have been used for the adult population (16–74 years old) who has recently used (ICT-USE) or has made a purchase (ICT-PURCHASE) online. This sample complied with a long-term usage of the Internet, at least decade, so we could easily identify beta and sigma convergence. Therefore, we have used two simple ICT indicators, whose data is segregated by gender and available in all EU countries during the study period (2007–2019).

The convergence analysis, beta and sigma, is widely recognized in economy, and it is mainly focused on the population's average income in different regions and countries. However, in the last few years, it has also been related with the well-being of the population, for instance, in areas like education (Murtin & Viarengo, 2011) and health (Jaworska, 2014), as well as referring to gender inequality. In an innovative way, the present study applies this methodology to contrast the convergence on the digital participation between men and women in the EU countries, so it offers answers and empirical evidence in this respect. The analysis allows us to know, not only if a convergence of the values of the ICT indicators selected by gender exists, but also it shows whether there has been a decrease on the digital gender gaps of the different EU countries.

The study is organized as follows. First, the concept of the digital gender gap is examined, featuring the different approaches taken when measuring it, as well as the European policy context that prioritizes its reduction. Second, the methodological aspects related to the analysis carried out are detailed, and the results obtained are presented later. Finally, the main conclusions are drawn.

2 Background and Context

As noted above, the digital divide or digital gap is defined as the disparity in the access and use of ICTs, either between people or countries. It can be measured in terms of digital availability and the skills or knowledge related to the use of computer technology or the Internet. The OECD (2019, p. 24) points out that "the digital gap can refer to both horizontal (i.e. across groups) and vertical inequalities and be related to both access to digital technologies and to the ability to use them (the so-called second digital gap)."

The Economic Commission for Latin America and the Caribbean acknowledges that the digital divide can increase preexisting socioeconomic inequalities, and concludes that the differences between men and women in the technological field is a reflection of the social gender gap itself (ECLAC, 2013). Antonio and Tuffley (2014) consider that digital technologies can provide women with job opportunities, increased income levels, and better access to health and educational services. Additionally, Caridad Sebastian and Ayuso García (2011) consider that the digital gap can reinforce other social, cultural, economic, generational, and geographical disparities, as well as aggravate gender inequalities.

The study of the digital gender gap can take different perspectives. For instance, Castaño Collado (2008) considers the inequality between men and women in the

1 STEM stands for Science, Technology, Engineering, and Mathematics.

access to ICTs as the first digital gender gap, whereas the one related to the skills necessary to obtain all the benefits of access is considered as the second gender digital gap. Hargittai and Shaw (2015) also insist on that the importance of ICT skills to continue reducing the gender digital gap.

One of the pioneer's studies introducing the second digital gender gap is Hargittai (2002). Since then, it has been proved that the digital inequality is now linked to people's technological skills and the benefits obtained from these online activities, rather than their accessibility to the Internet (OECD, 2020). However, this does not mean that access difficulties have disappeared and the first digital divide has been solved. Thus, Van Deursen and van Dijk (2019) verify that even in rich and technologically advanced countries, such as the Netherlands, where they focus their analysis, there continues to be a first-rate digital gap.

In addition, Martín Fernández and Martínez Cantos (2009) introduced a third gender digital gap regarding the use of the most advanced ICTs. However, Sáinz, Arroyo, and Castaño (2020) refer to three gender digital gaps: the differences between men and women in the access to ICTs, the disparities in the level of competencies in ICT management, and the benefits acquired through the use of ICTs. These three aspects of the digital gender gap are contemplated in OECD (2018), where the digital financial inclusion is incorporated.

Furthermore, prejudice and stereotypes play a key role in explaining women's digital gap (European Commission, 2018). Beliefs about women's technological or leadership capabilities or the lack of role models for young girls can create a vicious circle rather difficult to overcome. The importance of the psychological factor has also been analyzed by Larsson and Viitaoja (2020), who consider it crucial to introduce changes in attitudes, behaviors and habits by launching informative campaigns that show female role models in STEM. Such measures would inspire and encourage girls and women to start academic and professional careers in these areas, and would also help eradicate gender stereotypes or prejudices. Another important issue, pointed out by Fernández-Morante, Cebreiro, and Casal (2020), is that the digital gender gap is present and persistent from a very early age, so only the actions taken on the initial educational stages will correct this problem.

Moreover, the EU has been preparing its digital transformation since the beginning of the twenty-first century through different objectives embodied in the successive economic growth strategies. The flagship initiative within the Europe 2020 Strategy, the *Digital Agenda for Europe*, has orientated community action toward the construction of a digital single market; that is, a common regulatory framework at European level to promote the public administration and electronic commerce (European Commission, 2015).

Despite the progress made in the digitalization of the EU's economy, the 2008 crisis has truncated the European aspirations to lead an innovation system based on the knowledge economy. In fact, the competitive position of the EU has worsened and its technological dependence has increased in recent years. The COVID-19 pandemic has only highlighted this vulnerability. In addition, the loss of opportunities in areas, such as education, labor, or relationships, created by the digital gap in different social groups or territories, have been a heavy burden for the economic recovery and social cohesion.

In March 2021, the EU has presented its roadmap for the so-called Europe's Digital Decade with the horizon in 2030. Twelve goals have been established. They evolve around four basic areas of action, or cardinal points, which make up the EU's Digital Compass to guide the course of its digitalization process. Gender convergence is part of the objectives included in the first cardinal point, relative to digital skills, which it proposes for 2030 (European Commission, 2021a, p. 5): "In addition to the target on basic digital skills established in the European Pillar of Social Rights Action Plan, there are 20 million employed ICT specialists (2019 baseline: 7.8 million), with convergence between women and men"[2].

Despite the advance of digital changes, there are important conceptual and statistical gaps to measure the scope of the economy's digital transformation, making its analysis and international comparability of data difficult (OECD, 2020; UNCTAD, 2019). Measuring the digital gender gap increases these difficulties as a good part of the ICT indicators are not always disaggregated by sex. Furthermore, comparability problems are exacerbated when a relatively broad time perspective is required, as reflected in this study. The continuity of the indicators is scarce, being modified or replaced by new ones due to the speed of the digital transformation process and the technological advances that are intended to be captured.

The Organisation for Economic Cooperation and Development (OECD) and the EU have built their own indicators system to improve the degree of digitalization in the economy and society. In the case of the OECD, it is a

2 The share of women among the employed ICT specialist is around 19%. The target on basic digital skills established in the European Pillar of Social Rights Action Plan that 80% of citizens aged 16–79 years have at least basic digital skills (2020 baseline: 58.3%).

set of 33 key variables structured in seven dimensions, which make up a tool called Going Digital[3]. Its objective is to serve as a guide for analysts and politicians. This tool gives an account of gender equity in the digital sphere through seven indicators. Among those, the disparity in Internet use between men and women indicator provides a measure of potential room for improvement in the overall level of Internet uptake of the female population.

The EU produces a mixed index, the Digital Economy and Society Index (DESI), which provides a synthetic and comparable figure on the degree of digitalization of the different members and the Union as a whole. In 2021, the DESI structure was modified to adapt it to the Digital Compass objectives, from five to four of the dimensions contemplated (Human capital, Connectivity, Integration of digital technology and Digital public services), and reducing the number of incorporated indicators (33) compared to earlier editions (European Commission, 2021b). Linked to this general measurement, the EU publishes Women in Digital (WiD) Scoreboard, also preparing another synthetic index, the WiD index. Its objective is to publicize the degree of female integration in three dimensions (Internet use, Internet user skills and specialist skills, and employment) based on 12 indicators. The main drawback of the WiD scoreboard is that most of the data is only offered for a few years, and the WiD index has been available only for the last 2 years, which makes it impossible to use it in this study. Similarly, the database of the European Institute for Gender Equality (EIGE) does not include female indicators on digital skills beyond those published in EIGE (2020), which are only available for 2018 or 2019.

The study of digital inequality in the EU has several earlier references, with different methodological approaches, from the multivariate analysis (Vicente Cuervo & López Menéndez, 2006) to the most common one, and the comparative analysis generally takes a short period of time (Negreiro, 2015). The descriptive examination of some indicators predominates in the studies dealing with the gender digital gap, also evaluating numerous proposals aimed at the empowerment of women (Perifanou & Economides, 2020). Before the existence of the WiD index, the construction of a synthetic index to measure the digital gender gap in the EU had already been proposed (Martín Fernández & Martínez Cantos, 2012). In contrast, no study has been found that performs a convergence beta and sigma analysis similar to the one presented here.

3 OECD Going Digital Toolkit allows users to consult the digital development for each OECD country interactively (https://goingdigital.oecd.org/).

3 Methodological Aspects

As mentioned above, the main objective of this study is to analyze the digital gender gap in the EU, by addressing its calculation in absolute and relative terms. The International Telecommunication Union (ITU) has been used and states: "The gender gap represents the difference between the Internet user penetration rates for males and females relative to the Internet user penetration rate for males, expressed as a percentage" (ITU, 2019, p. 3). This same estimation approach, the difference between the percentage of men and women users, it is also applied in OECD (2020, p. 24) and EIGE (2020, p. 169).

First, this calculation, expressed as $(M - W)$, quantifies the gap in absolute terms. Second, the ratio between men and women has also been determined in a way similar to the procedure used by Martín Fernández and Martínez Cantos (2009). Therefore, the gender gap in relative terms is obtained by calculating $(M - W)/W$, expressed as a percentage. In both cases, the sign of the gap consistently shows the group in disadvantage: the female population when the sign is positive, and the male population when the sign is negative.

The indicators used to calculate the digital gender gap refer to two areas of ICT usage included in the Digital Economy & Society Database elaborated by Eurostat. These are the percentage of the population aged 16–74 years that has used the Internet in the last 3 months, which we call the ICT-USE indicator, and the percentage of the population aged 16–74 years that has made an online purchase in the last 3 months, which we call the ICT-PURCHASE indicator. The results in absolute and relative terms of the digital gender gap, as well as the values of the ICT indicators for the years 2007 and 2019, are shown in the Tables 1 and 2.

Finally, we examine the evolution of the digital indicators and the absolute and relative digital gender gap to identify the approximation or distance of these variables across the EU-28 countries. As González, López, and Martínez (2019) highlight, the analysis of economic convergence across countries has incorporated other social magnitudes in recent years, such as gender equality. This study addresses the study of beta and sigma convergence, verifying whether the countries that start with lower ICT indicators achieve higher growth over time (there is β-convergence), and whether the dispersion across countries is reduced (there is σ convergence). The β-convergence is necessary, but not solely responsible, for σ-convergence to occur.

Such techniques are also applied to the digital gender gap, and the convergence is examined among European countries. It should be specified that, in this case, the gap

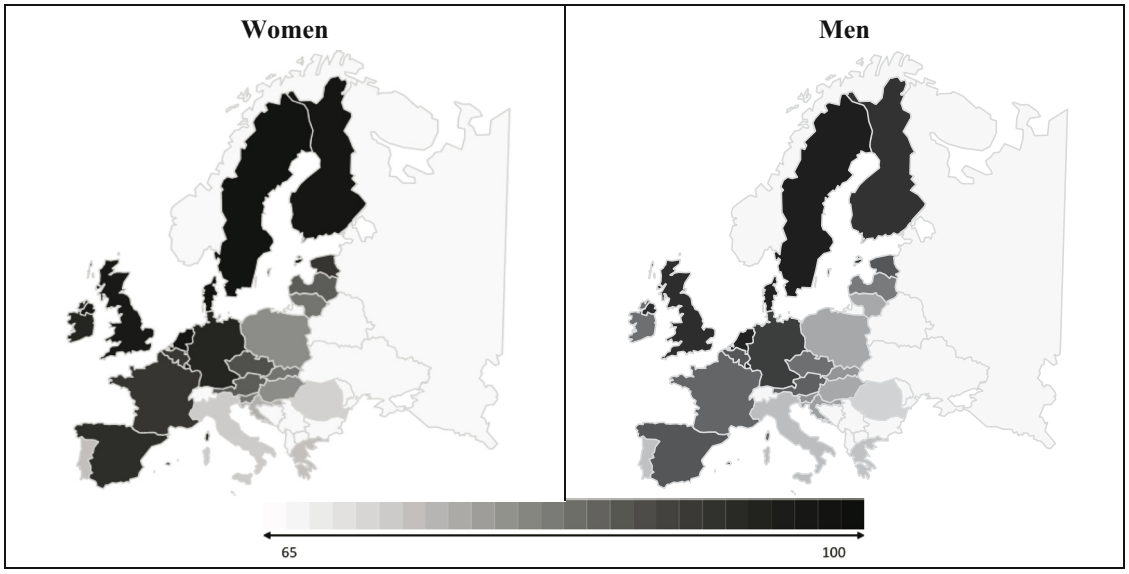

Figure 1: ICT-USE indicator in the EU-28, 2019 (%) Note: Cyprus has the same color as Malta, both for men and women. Source: Own elaboration based on the Digital Economy & Society Database (Eurostat) and using Clearly and Simply (https://www.clearlyandsimply.com/clearly_and_simply/2009/06/choropleth-maps-with-excel.html).

is considered by taking only its numerical value into account, that is, omitting its sign. Otherwise, the analysis would not be possible. This means that it is not distinguished whether the indicator is higher in men or in women, as the treatment of the gender disparity is the same regardless of the sex in disadvantage. Obviously, this distinction is important, so it will be determined when comparing the levels of the digital gender gap for the year 2019.

It should be remembered that, for the population as a whole, it is possible to use a greater variety of digital indicators available for a long period of time. However, when disaggregated by sex, the variables and their time coverage are reduced. It is proved that an increasingly complete set of indicators on digital skills is emerging, although if the gender perspective is introduced, this availability decreases. This prevents the study of convergence or divergence processes that require a long period of time. This circumstance has motivated the need to use two basic ICT indicators in the analysis implemented.

However, its exploration has allowed us to face the following research questions: Has there been convergence between the EU countries in the use and purchases through the Internet for each sex? Does the digital gender gap converge on Internet usage and shopping online in the EU? Regarding the first question, the convergence of ICT indicators for men and women separately means a decrease in territorial inequality between the EU countries. In the second case, the convergence of the digital gender gap would show a reduction in inequalities between both sexes in most EU countries.

4 Analysis of the Digital Gender Gap in the EU

The convergence study is implemented starting from a comparative analysis of the ICT indicators and the digital gender gap referred to the year 2019. For β-convergence, the situation in 2007 and the variation experienced between 2007 and 2019 are taken as a reference point. When examining the σ-convergence, we observe the evolution of the standard deviation of each year during the period considered. Finally, it should be noted that, although Cyprus is not represented in the maps, it has been included in all the analyses carried out. Furthermore, the same color as Cyprus has been identified for other countries on every map.

4.1 ICT Indicators in the EU-28: Disparities and Convergence

In 2019, the EU-28 countries had a very high percentage of the population, both women and men, who used the Internet in the last 3 months. As can be seen in Figure 1 (data in Table 1), except for Bulgaria, Romania, Greece, Italy and Portugal, the rest of the EU-28 countries reach ICT-USE values above 80%; near 100% in Denmark, Sweden, Luxembourg, the Netherlands, Finland, and the United Kingdom.

The differences between the EU-28 countries have narrowed since 2007. As shown in Figure 2, there is a

Table 1: ICT indicators and the digital gender, 2019

Countries		ICT-USE indicator				ICT-PURCHASE indicator			
		Women (%)	Men (%)	Digital gender divide		Women (%)	Men (%)	Digital gender divide	
				$M - W$ (p.p.)	$(M - W)/W$ (%)			$M - W$ (p.p.)	$(M - W)/W$ (%)
European Union-28	**EU-28**	**86**	**88**	**2**	**2.3**	**52**	**54**	**2**	**3.8**
Belgium	BE	89	91	2	2.2	53	56	3	5.7
Bulgaria	BG	67	69	2	3.0	15	13	−2	−13.3
Czechia	CZ	86	88	2	2.3	45	40	−5	−11.1
Denmark	DK	97	97	0	0.0	76	72	−4	−5.3
Germany	DE	92	94	2	2.2	70	72	2	2.9
Estonia	EE	90	91	1	1.1	58	54	−4	−6.9
Ireland	IE	92	88	−4	−4.3	63	55	−8	−12.7
Greece	EL	74	77	3	4.1	31	34	3	9.7
Spain	ES	91	91	0	0.0	46	48	2	4.3
France	FR	90	89	−1	−1.1	59	57	−2	−3.4
Croatia	HR	76	82	6	7.9	31	39	8	25.8
Italy	IT	73	78	5	6.8	25	31	6	24.0
Cyprus	CY	86	86	0	0.0	31	31	0	0.0
Latvia	LV	85	87	2	2.4	34	34	0	0.0
Lithuania	LT	82	81	−1	−1.2	39	37	−2	−5.1
Luxembourg	LU	96	97	1	1.0	60	65	5	8.3
Hungary	HU	80	81	1	1.3	33	37	4	12.1
Malta	MT	86	86	0	0.0	50	49	−1	−2.0
The Netherlands	NL	96	97	1	1.0	69	71	2	2.9
Austria	AT	85	90	5	5.9	52	57	5	9.6
Poland	PL	80	81	1	1.3	42	41	−1	−2.4
Portugal	PT	74	77	3	4.1	26	30	4	15.4
Romania	RO	72	75	3	4.2	14	15	1	7.1
Slovenia	SI	82	84	2	2.4	44	45	1	2.3
Slovakia	SK	82	83	1	1.2	45	48	3	6.7
Finland	FI	96	95	−1	−1.0	55	55	0	0.0
Sweden	SE	97	98	1	1.0	71	69	−2	−2.8
United Kingdom	UK	95	96	1	1.1	80	80	0	0.0

Source: Own elaboration based on the Digital Economy & Society Database (Eurostat).

clear process of β-convergence between countries for the two sexes. Thus, those countries that started in 2007 from levels higher than the European average are those that have grown less than the EU average between 2007 and 2019 (located in the lower right quadrant). However, those that started from lower levels have grown more intensely (upper left quadrant). That is why the equation shows a negative regression coefficient, the coefficient of determination R^2 being very close to unity.

Specifically, in the ICT-USE indicator the smallest advance occurs in the Netherlands, Denmark, Finland, and Sweden, both in men and women. However, the highest growth takes place, in general, in the countries that started with the lowest levels of digitalization: Bulgaria, Croatia, Cyprus, Greece, and Romania (Tables 1 and 2).

The values decrease notably in the percentage of the population who have made an online purchase in the last 3 months (ICT-PURCHASE), and the differentials between countries widen. At the lower end are Bulgaria and Romania, with figures that do not exceed 15% for both sexes (Table 1). However, in the United Kingdom, Denmark, Germany, Sweden, and the Netherlands, the percentages exceed 70% generally (Figure 3).

However, Figure 4 shows that such differences have decreased since 2007, as the worst-situated countries at the beginning of the period have increased their

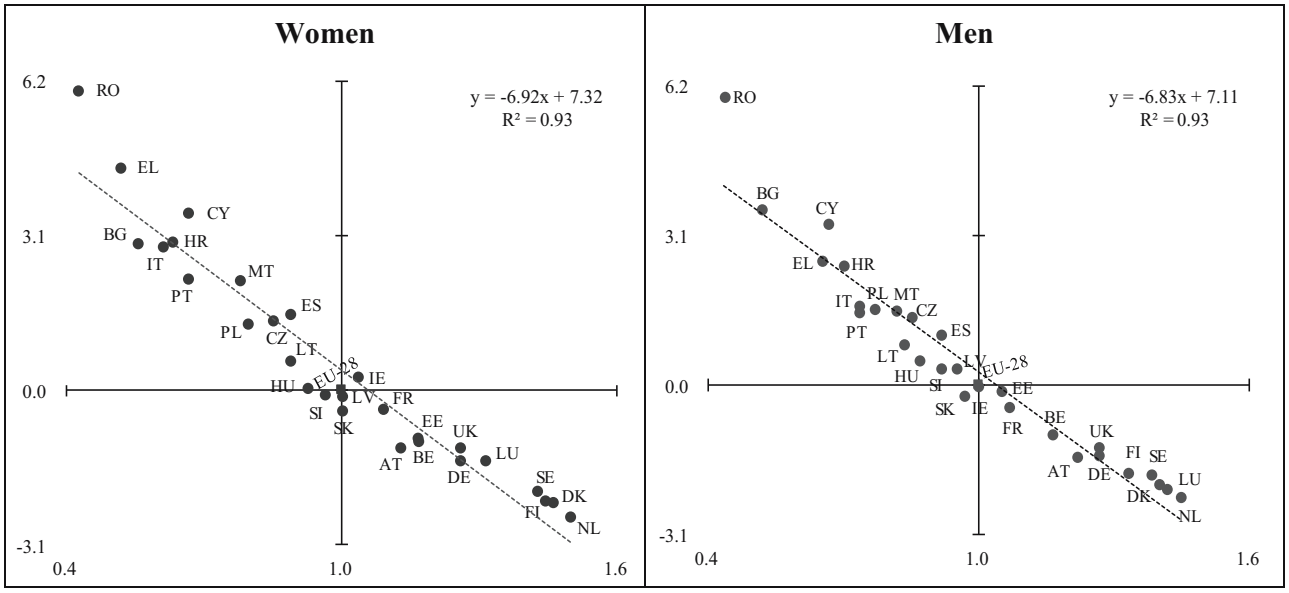

Figure 2: β-convergence in Internet use in the EU-28, 2007–2019. Note: The abscissa represents the relative situation of women and men with respect to the EU-28 (which represents the unit) in the 2007 ICT-USE indicator. The average annual growth differential with the EU between 2007 and 2019 is represented on the ordinate. Source: Own elaboration from Digital Economy & Society Database (Eurostat).

percentage much more (upper left quadrant) than the better situated ones (lower right quadrant). Therefore, the existence of β-convergence in the evolution of the ICT-PURCHASE indicator for both sexes is verified. Again, the equation shows a negative regression coefficient, with R^2 reaching a fairly high value.

Furthermore, as Figure 5 shows, the dispersion between countries is greater in online purchases than in Internet use, both in men and women. Between 2007 and 2019, there has been a continuous process of convergence, with the standard deviation falling by more than 67% in the indicators of Internet use (men and women), and around 50% in those of online shopping.

Therefore, there is a clear approximation across European countries in the use of ICTs, not only between extreme years (β-convergence) but throughout the years of the entire period (σ-convergence). The existence of σ-convergence validates the previous analysis, as β-convergence is necessary but it is not a sufficient condition to confirm the convergence process of the ICT indicators in the EU.

4.2 Gender Digital Gap in the EU-28: Narrow and Convergent

As indicated above, the digital gender gap has been calculated in absolute terms, difference in percentage points between the indicators for men and women ($M - W$), and in relative terms, $(M - W)/W$, expressing the difference as the percentage of the indicator corresponding to women.

Regarding Internet usage, there are hardly any differences between the proportion of men and women in the EU-28 in 2019 (Figure 6). The greatest gender digital gap, with women in disadvantage, corresponds to Croatia, with 6 percentage points, which is 7.9% in relative terms. It is followed by Italy and Austria, with the same gender digital gap in percentage points (5), and percentage values of 6.8 and 7.9%, respectively (Table 1). It is important to note that, for the most part, the ICT-USE indicator is higher for men and, therefore, the positive sign of the gender gap indicates less female integration in the digital world. Only four countries register negative figures for the gender gap, three of them (Slovakia, Lithuania, and France) with identical low values (–1 point), whereas Ireland (–4 points) is the fourth country in the EU-28 with the largest gender gap, with men in disadvantage[4].

No differences between the two sexes are found in the ICT-USE indicator for Denmark, Cyprus, Spain, and Malta. However, it should be noted that the most significant differences take place between countries. The proportion of women who use the Internet in Denmark and Sweden reaches 97%, 30 points more than in Bulgaria, with a similar distance occurring also for men. Considering such

4 Obviously, although the sign of this difference is provided, it is considered a gap both in one sense and the other.

Table 2: ICT indicators and the digital gender, 2007

Countries		ICT-USE Indicator				ICT-PURCHASE Indicator			
		Women (%)	Men (%)	Digital gender divide		Women (%)	Men (%)	Digital gender divide	
				$M - W$ (p.p.)	$(M - W)/W$ (%)			$M - W$ (p.p.)	$(M - W)/W$ (%)
European Union-28	**EU-28**	**54**	**60**	**6**	**11.1**	**20**	**25**	**5**	**25.0**
Belgium	BE	63	70	7	11.1	12	17	5	41.7
Bulgaria	BG	30	31	1	3.3	1	2	1	100.0
Czechia	CZ	46	51	5	10.9	7	9	2	28.6
Denmark	DK	79	84	5	6.3	39	47	8	20.5
Germany	DE	68	76	8	11.8	37	45	8	21.6
Estonia	EE	63	63	0	0.0	7	5	−2	−28.6
Ireland	IE	56	60	4	7.1	22	29	7	31.8
Greece	EL	28	39	11	39.3	3	7	4	133.3
Spain	ES	48	55	7	14.6	10	15	5	50.0
France	FR	59	64	5	8.5	25	26	1	4.0
Croatia	HR	34	42	8	23.5	4	6	2	50.0
Italy	IT	33	44	11	33.3	4	9	5	125.0
Cyprus	CY	36	40	4	11.1	5	11	6	120.0
Latvia	LV	54	57	3	5.6	5	6	1	20.0
Lithuania	LT	48	50	2	4.2	4	4	0	0.0
Luxembourg	LU	71	85	14	19.7	29	45	16	55.2
Hungary	HU	50	52	2	4.0	6	8	2	33.3
Malta	MT	42	49	7	16.7	10	21	11	110.0
The Netherlands	NL	81	87	6	7.4	39	47	8	20.5
Austria	AT	61	73	12	19.7	23	30	7	30.4
Poland	PL	43	46	3	7.0	9	13	4	44.4
Portugal	PT	36	44	8	22.2	4	7	3	75.0
Romania	RO	23	26	3	13.0	1	2	1	100.0
Slovenia	SI	52	55	3	5.8	8	11	3	37.5
Slovakia	SK	54	58	4	7.4	9	10	1	11.1
Finland	FI	78	80	2	2.6	31	34	3	9.7
Sweden	SE	77	83	6	7.8	36	41	5	13.9
United Kingdom	UK	68	76	8	11.8	40	49	9	22.5

Source: Own elaboration based on the Digital Economy & Society Database (Eurostat).

disparity, the gap has been calculated in both absolute and relative terms as the same difference in percentage points can result in a different percentage.

Our results agree with those obtained by Martínez Cantos and Castaño Collado (2017), referring to a previous period, confirming that the Spanish digital gender gap is lower than those of the EU counties. However, they differ from those offered by Martínez Cantos (2013), who obtains a more intense gender digital gap in countries with high digitalization, such as the Nordic countries. Such disparities may be due to the fact that that study was carried out some years before our period of analysis (2007 and 2011), and it also included non-EU countries, such as Norway and Iceland. Furthermore, an indicator of more complex and specialized digital skills was used to define the gender gap.

In any case, the results obtained for 2019 (Table 1) show a clear advance in the digital integration of women compared to 2007 (Table 2), when the rest of the EU-28 countries presented unfavorable gaps for women in the digital sphere (except for Estonia, which registered gender equality in Internet use). However, Estonia is the only country that increases its gap between 2007 and 2019 in ICT-USE, both in relative and absolute terms and, in the latter case, also Bulgaria increases its gap.

However, Figure 7 shows the results of the β-convergence analysis. As can be seen, the digital gender gap converges in the EU-28 countries between 2007 and

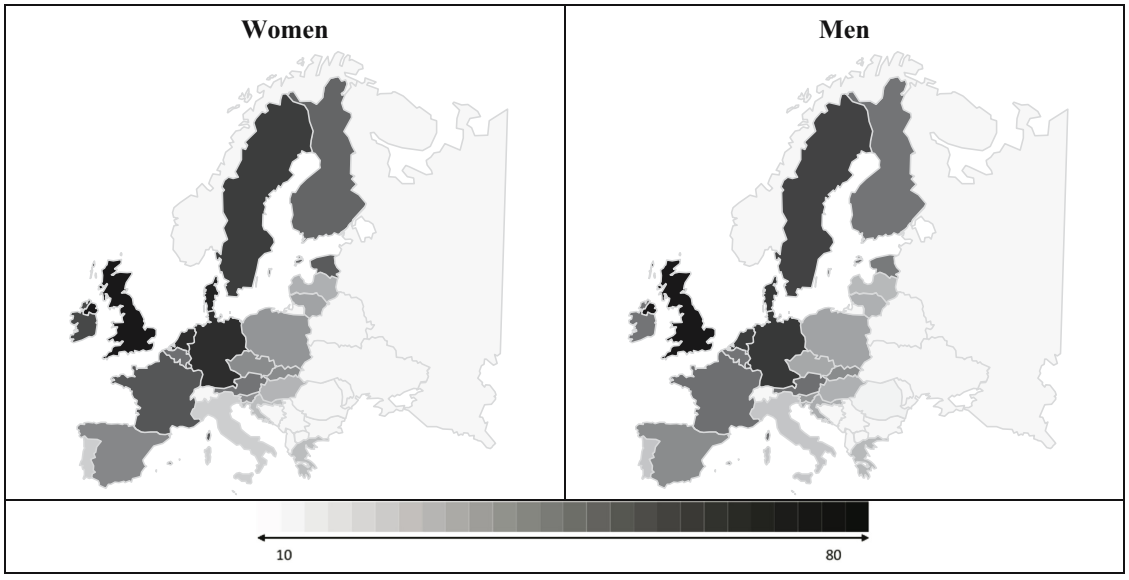

Figure 3: ICT-PURCHASE indicator in the EU-28, 2019 (%). Note: Cyprus has the same color than Croatia's women and Italy's men. Source: Own elaboration based on the Digital Economy & Society Database (Eurostat) and using Clearly and Simply (https://www.clearlyandsimply.com/clearly_and_simply/2009/06/choropleth-maps-with-excel.html).

2019, regardless of how it is expressed, in percentage points or as a percentage. Two negative regression coefficients are obtained and a lower R^2 is obtained in the digital gender gap calculated as the difference in the percentages of Internet use by men and women.

Figure 8 contains information on the digital gender gap in online shopping, through the ICT-PURCHASE indicator. An increase in the number of countries, up to ten, with a negative gender digital divide, unfavorable to men, is identified (Table 1) in Ireland (–8 points), Czechia (–5), Denmark (–4), Estonia (–4), Bulgaria (–2), France (–2), Lithuania (–2), Sweden (–2), Malta (–1), and Poland (–1).

Except for the last three and Denmark, the digital gender gap has increased in the rest of the countries

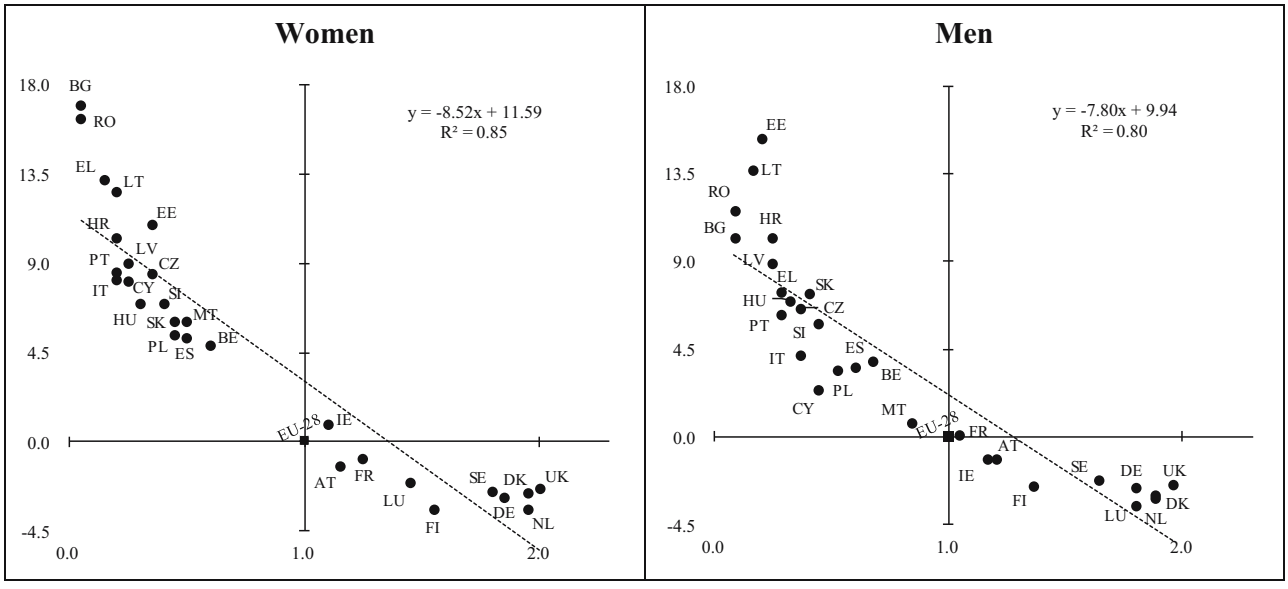

Figure 4: β-convergence in online shopping in the EU-28, 2007–2019. Note: The abscissa represents the relative situation of women and men with respect to the EU-28 (which represents the unit) in the 2007 ICT-PURCHASE indicator. The average annual growth differential with the EU between 2007 and 2019 is represented on the ordinate. Source: Own elaboration from Digital Economy & Society Database (Eurostat).

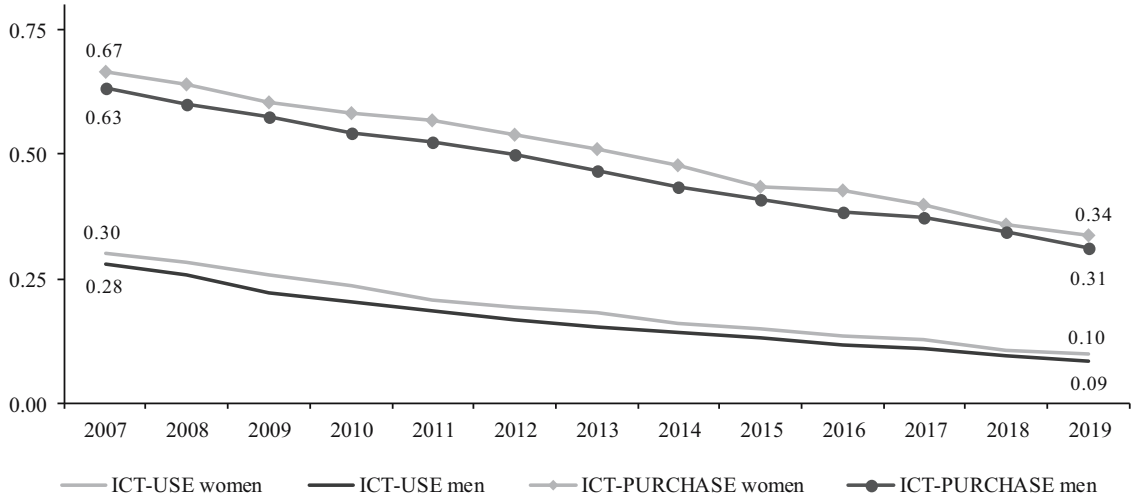

Figure 5: σ-convergence of ICT indicators in the EU-28, 2007–2019. Note: Evolution of the standard deviation. Source: Own elaboration from Digital Economy & Society Database (Eurostat).

according to the absolute indicator of ICT-PURCHASE, which has also happened in Croatia, Hungary, Italy, Portugal, and Slovakia. As it is shown in Table 2, most of the countries that increased their gap were those that started from the lowest levels in 2007, so convergence can be expected to predominate.

It would be interesting to investigate the causes that explain why the digital divide is favorable to women. This would require having additional data on the type of purchase made, the ages of the men and women who buy online, their educational level, etc., aspects that, as indicated, are not yet offered disaggregated for men and women.

Once again, Croatia has the highest positive gender digital divide, 8 percentage points, followed by Italy. As indicated, the same difference between men and women in the ICT-PURCHASE indicator, which happens for Croatia and Ireland (8 points), has a very different relative importance as this difference in points represents 25.8% of the female indicator in Croatia and only 12.7% in Ireland. Similarly, Portugal and Hungary have one of the highest

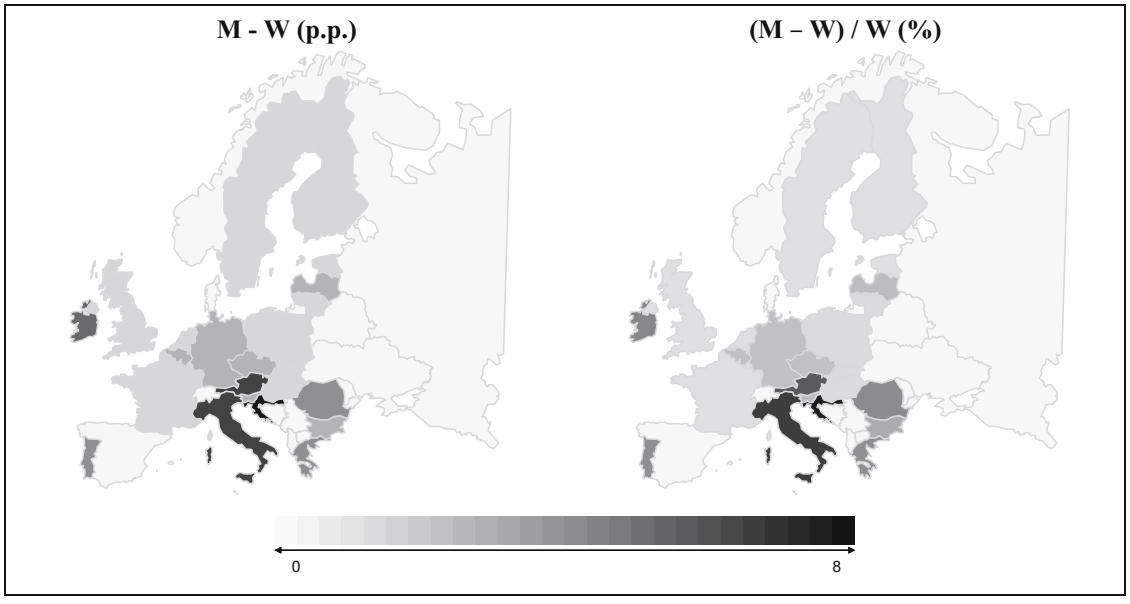

Figure 6: Digital gender gap in the ICT-USE indicator in the EU-28, 2019. Note: Cyprus has the same color than Denmark. Source: Own elaboration based on the Digital Economy & Society Database (Eurostat) and using Clearly and Simply (https://www.clearlyandsimply.com/clearly_and_simply/2009/06/choropleth-maps-with-excel.html).

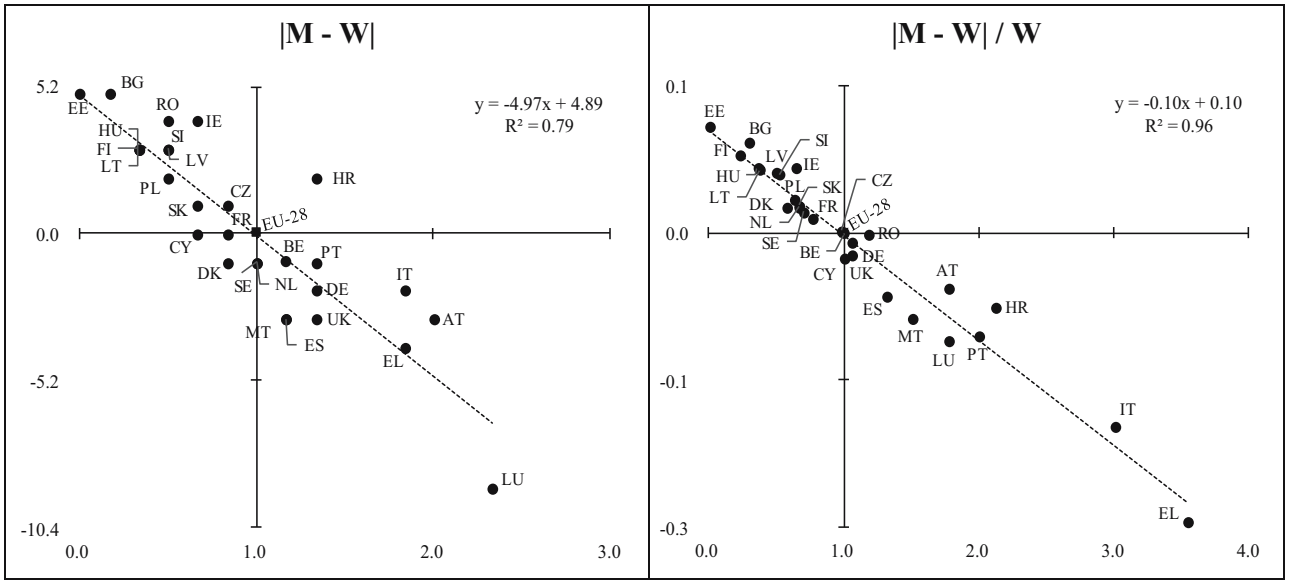

Figure 7: β-convergence of the digital gender gap (ICT-USE) in the EU-28, 2007–2019. Note: The digital gender gap is defined as the disparity between men and women in Internet use (ICT-USE indicator), expressed in absolute terms, as a $M - W$ difference, and in relative terms, as a ratio $(M - W)/W$, taking the numerical value and omitting the sign. In each case, the abscissa represents the relative situation of the digital gender gap (without considering the sign) compared to the EU-28 (which represents the unit) in the 2007 gap. The variation differential of the gender gap with the EU is represented on the ordinate. Source: Own elaboration from the Digital Economy & Society Database (Eurostat).

digital gender gaps, both in percentage points and as a percentage. In contrast, there is no gender disparity in Internet purchases in Cyprus, Finland, Latvia, Lithuania, and the United Kingdom. With respect to the situation in 2007, an improvement in the gap is also observed, a reduction in the relative indicator, except in Lithuania, whereas in the absolute indicator there are several countries where it increases or is maintained, as indicated before.

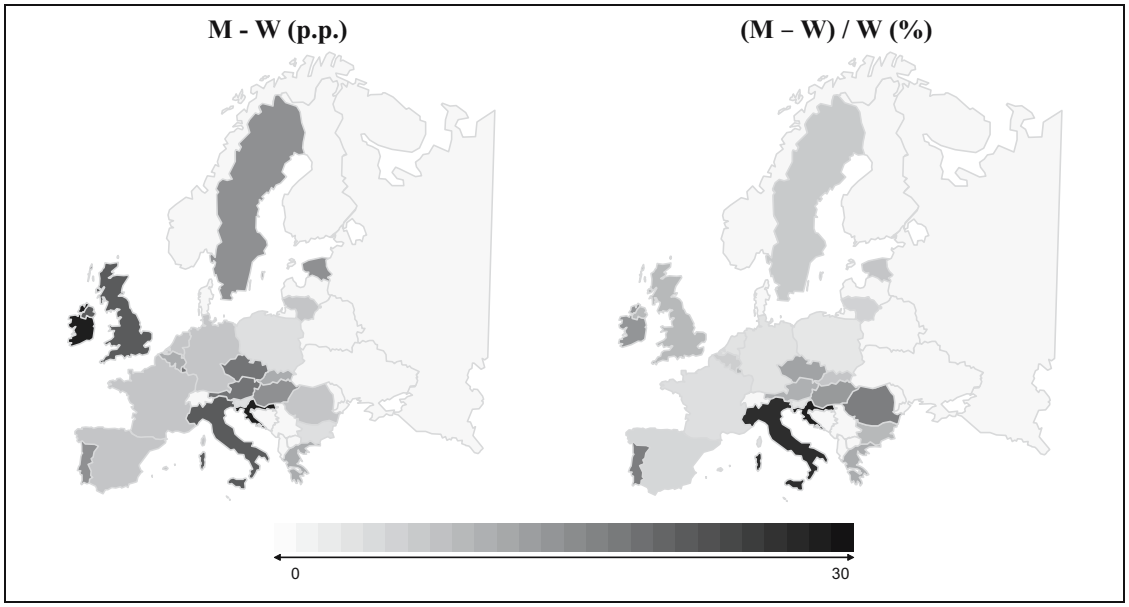

Figure 8: Digital gender gap in the ICT-PURCHASE indicator in the EU-28, 2019. Nota: A Chipre le corresponde el mismo color que a Finlandia. Note: Cyprus has the same color than Finland. Source: Own elaboration based on the Digital Economy & Society Database (Eurostat) and using Clearly and Simply (https://www.clearlyandsimply.com/clearly_and_simply/2009/06/choropleth-maps-with-excel.html).

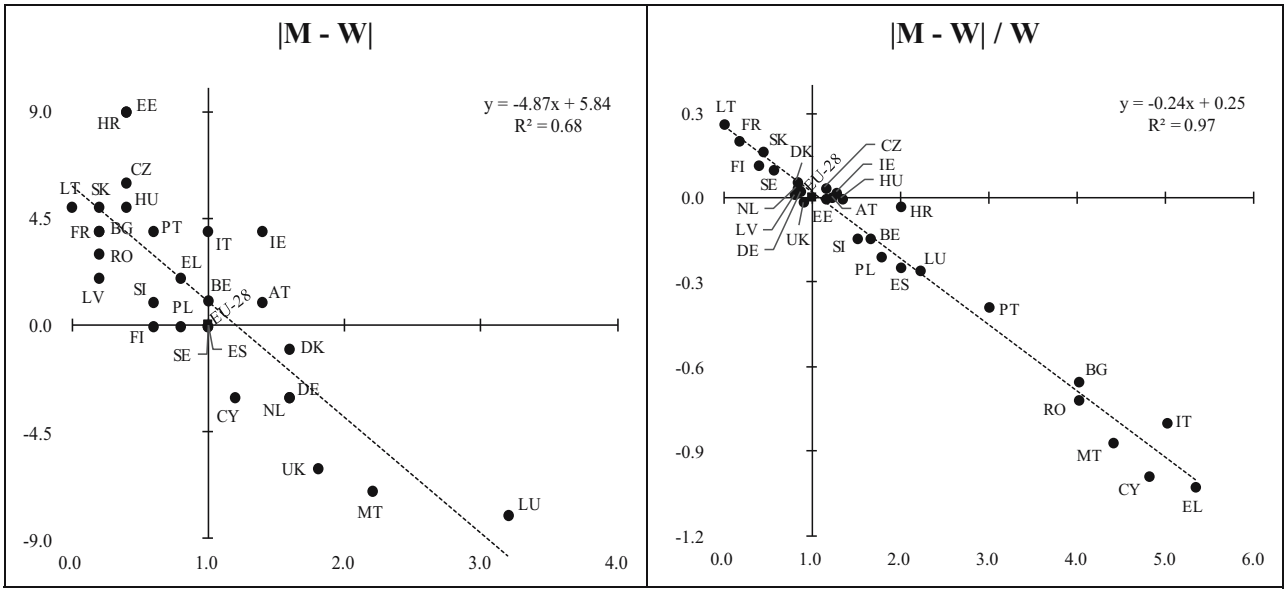

Figure 9: β-convergence of the digital gender gap (ICT-PURCHASE) in the EU-28, 2007–2019. Note: The digital gender gap is defined as the disparity between men and women in Internet purchases (ICT-PURCHASE indicator), expressed in absolute terms, as a $M - W$ difference, and in relative terms, as a ratio $(M - W)/W$, taking the numerical value and omitting the sign. In each case, the abscissa represents the relative situation of the digital gender gap (without considering the sign) with respect to the EU-28 (which represents the unit) in the 2007 gap. The variation differential of the gender digital gap with the EU is represented on the ordinate. Source: Own elaboration from the Digital Economy & Society Database (Eurostat).

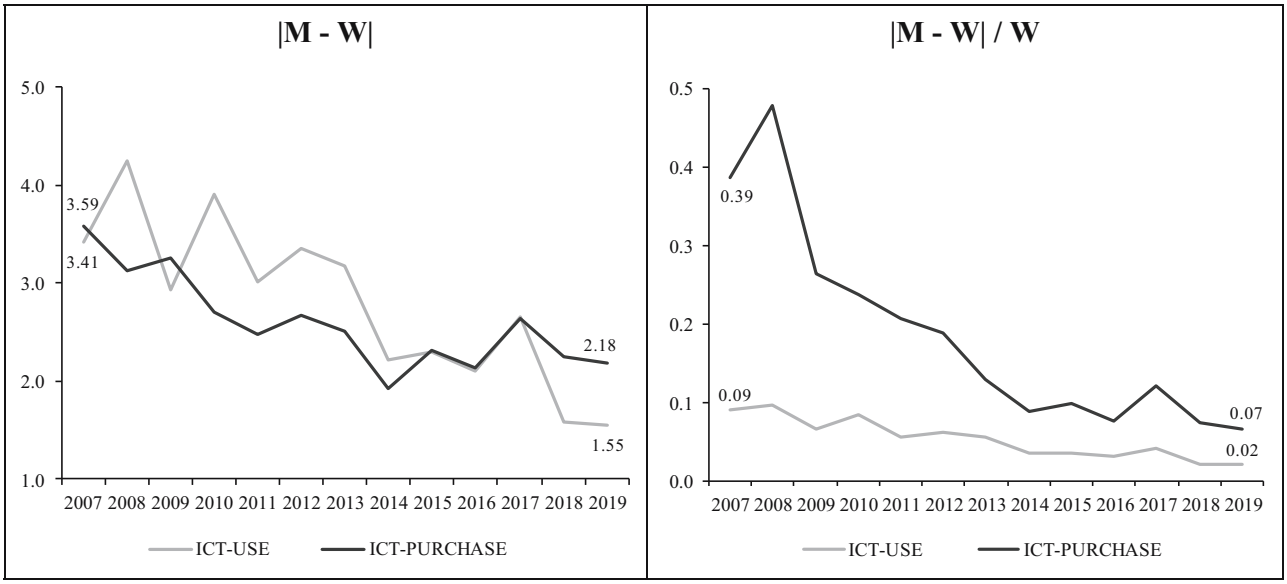

Figure 10: σ-convergence of the digital gender gap in the EU-28, 2007–2019. Note: Evolution of the standard deviation. Source: Own elaboration from the Digital Economy & Society Database (Eurostat).

However, Figure 9 shows the results of the study of β-convergence for the gender digital gap, constructed from the ICT-PURCHASE indicator. As in all the previous cases, a clear convergence is observed in the digital gender gap. The R^2 is much higher if the difference between both sexes is used to define the gender gap than if it is done in percentage terms, as previously mentioned, in this indicator the gap reduction has not been generalized.

Finally, when studying the evolution of the dispersion of the digital gender gap, a gradual process of convergence is also observed, as shown in Figure 10. As shown, this dispersion between countries is much higher

when using the relative gap, than if it is calculated as a difference. In comparison with the observed evolution of the degree of dispersion of the ICT indicators, already commented on in Figure 5, the σ-convergence analysis of the digital gender gap shows a less linear downward evolution, with greater variability, especially in the case of the gap calculated in absolute terms.

In general, there is a greater disparity in the digital gender gap between countries when it is calculated from the ICT-USE using the absolute gap, although the dispersion in the gap built with ICT-PURCHASE is more intense at some points. However, if the relative gap is considered, then the dispersion is greater when analyzing the digital gender gap for online shopping, although the amount of the standard deviation of each indicator has been approached.

5 Conclusion

The process of propagation and use of ICTs has been heterogeneous from a geographical viewpoint and also affects people and groups differently. Thus, the digital divide refers to the disparity in the access and use of ICTs between different territories or population groups. When the situation between men and women in this area is compared, the term digital gender gap is used, the analysis of which has been carried out in the EU-28 countries during the period 2007–2019.

In this study, two ICT-USE indicators offered by Eurostat have been used, in both cases, referring to the percentage of the adult population (women and men, aged 16–74 years) who, in the last 3 months, have used the Internet (ICT-USE) and have made an online purchase (TIC-PURCHASE). The gender gap has been calculated in absolute and relative terms and, in addition to analyzing the current situation of men and women, the existence of territorial convergence has also been studied, both in the indicators themselves and in the digital gender gap.

The countries that lead the exploitation of digital resources, both in the ICT-USE indicator and in the ICT-PURCHASE indicator are Denmark, the Netherlands, Sweden, and the United Kingdom, whereas Bulgaria, Portugal, Romania, Greece, and Italy are at the opposite end. Although there are important differences between one group of countries and another in 2019, the convergence analysis carried out shows that the dispersion has decreased since 2007. It seems that the geographical and economic distribution North-West (higher income per inhabitant) compared to South-East (lower income per inhabitant), with some exceptions, accounts for a good part of the differences.

In relation to the digital gender gap, it has been found that it is relatively low when the ICT-USE indicator is used, whereas it reaches somewhat higher values in the case of the ICT-PURCHASE indicator. The highest gaps in ICT-USE are found in Croatia, Italy, Austria, and Ireland, although in the latter, it is favorable to women. No digital gender gap can be seen in Denmark, Cyprus, Spain, and Malta. Regarding ICT-PURCHASE, the largest gender gaps are also found in Croatia, Ireland and Italy. No gap is identified in Cyprus, Finland, Latvia, or the United Kingdom. Spain stands out in the ICT-USE indicator because, as has been pointed out, it coincides in men and women. However, in ICT-PURCHASE, Spain is located in a central position, with a digital gender gap that is unfavorable to women.

Our analysis of the digital divide in 2019 reveals a clear advance for women in their digital integration compared to 2007. However, as mentioned, there are still countries with a clearly unfavorable situation for women, especially in the indicator relating to Internet purchases. In addition, the convergence analysis allows us to affirm that the differences between countries have narrowed since 2007. Specifically, from the perspective of the gender gap, the countries with the greatest digital gap have generally managed to reduce it more intensely than those that started with a smaller gap, hence existing β-convergence. In addition, this dynamic has occurred gradually throughout the period, hence existing σ-convergence.

In short, and, although the empirical analysis may be conditioned by the indicators used, it has been found that there has been a continuous convergence between the EU countries in the digital sphere, for men and women, which has made it possible to reduce gender inequality, both in the use of the Internet and in online commerce. Similarly, the digital gender disparity has been gradually reduced.

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