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Digital Competitiveness Gap between the US and EU Member States in the 21st Century

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Abstract:

Purpose: *The aim of the article is to assess the gap between EU member states and the United States in terms of digital competitiveness of the ex-ante and the ex-post type in the 21st century.*
Design/methodology/approach: *To assess the ex-ante digital competitiveness the ICT Development Index (IDI) was used, and the ex-post competitiveness was measured with the original Outcome Digital Competitiveness Index (ODCI). The study takes into account a broader approach to digital competitiveness than previously discussed in the literature and includes the "outcome" component, regarding the implementation effects of ICT. A measure of this competitiveness type is also introduced.*
Findings: *The conducted study provides evidence confirming the hypothesis that the digital competitiveness gap between the EU and the US is widening, especially in terms of ICT patent activity, ICT impact on new business and organisational models, intensity of high-tech trade and the importance of the ICT sector in value added creation.*
Practical implications: *The results provides evidence to confirm the hypothesis that the digital competitiveness gap between the EU and the US is widening especially in its output dimension, related to the channels transforming the country's digital potential into economic results.*
Originality/Value: *The study can be the source for the examination of the degree of EU internal differentiation both in the levels and dynamics of digital competitiveness. These issues, however, require an in-depth analysis that may be the subject of another study.*

Keywords: *European Union, US, ex-ante digital competitiveness, ex-post digital competitiveness*

JEL codes: *O30, O57, Q55.*

Paper Type: *Research article.*

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1. Introduction

Changes in economic processes due to information and communication technologies (ICT) brought the transformation of economies towards (initially-called) knowledge-based, then internet, mobile and new economies. In turn, the 4th technological revolution (based mainly on data and networking), caused economies to evolve towards (new) digital economies. The progressive development of the ICT sector has led not only to the creation of the entire digital sector, but also to the use of data and networking in the traditional sectors of the economy like services and manufacturing (Bukht and Heeks, 2017; Śledziewska and Włoch, 2020).

The intensification and extension of digitalization processes to the new areas is an opportunity for business and society (Kamalipour and Friedrichsen, 2017), and in a broader perspective, it is a determinant of the international competitiveness of the economy (European Commission, 2019; Yousefi, 2011; Meijers, 2014). The literature increasingly indicated a need to define the competitiveness of economies in the context of their digital transformation and to adjust its measures (Coyle, 2015; Pearson and Theofilou, 2016; Lacy *et al.*, 2016; Ahmad and Schreyer, 2016).

The first definition of digital competitiveness appeared in 2017. IMD defined it as "…the capacity of an economy to adopt and explore digital technologies leading to the transformation in government practices, business models and society in general" (IMD, 2017). Digital competitiveness is identified by digital innovations and the improvement of digital skills of the society, thus putting emphasis on its input component. Thus, it can be described as ex-ante digital competitiveness.

This definition seems to disregard the fact that (as mentioned above) the ICT sector has a wide spectrum of impact on the economy, its GDP growth and productivity, and not only by generating and using technological innovations, but also by investing in ICT (including changes in business models), human capital accumulation, changes in the trade patterns, etc., (Aiginger, 2013; Weresa, 2017, Śledziewska and Włoch, 2020). For that reason, the outcome component, understood as a range of results of ICT usage, i.e., ex-post digital competitiveness, should be also discussed both in theoretical and empirical studies (Aiginger, 2006, Bosak and Bieńkowski, 2004).

In this paper the concept of digital competitiveness is extended and includes the economic implications of the ICT sector development, i.e., various transmission channels from "digital causes" to "final results" for the economy (ITU, 2010; Ketels, 2016; G20, 2018). It is defined as country's ability and readiness to create and use digital technologies and benefit from the development of the ICT sector. However, measuring the outcome component of digital competitiveness still remains a major challenge. (Młynarzewska-Borowiec, 2021).

The European Union countries as well as the US, are experiencing intensive digital transformation. It turns out, however, that the US has so far benefited the most from the 3rd technological revolution based on computers, automation and the Internet. Furthermore, the US is also becoming a leader in the implementation of the latest digital technologies of the next technological wave e.g., Artificial Intelligence (AI), Internet of Things (IoT), 5G, etc., (Castro *et al.*, 2019).

As research show, although EU countries experienced a positive impact of the ICT sector on the living standards and labour productivity, after 2000 it became much less significant compared to the US (Welsum *et al.*, 2012; van Ark, 2016; Atkinson, 2018; OECD, 2019b). It can, therefore, be hypothesised that the digital competitiveness gap between the EU and the US is widening over time, especially in its output component.

The aim of the article is to verify the above hypothesis by assessing the changes in the distance between EU member states and the United States in terms of digital competitiveness, both in its ex-ante and ex-post dimension in the last two decades. The first part of the article discusses the issue of digital competitiveness measures, in particular the method of the ex-post digital competitiveness measure calculation.

The second part of the article covers the analysis of the EU-US gap in the field of the input digital competitiveness (based on the ICT Development Index –IDI). In the third part of the study, an attempt to examine the position of the European Union member states against the US in terms of output digital competitiveness (measured by Author's Outcome Digital Competitiveness Index) was made.

2. Ex-ante and Ex-post Digital Competitiveness Measurement

A digital transformation process in individual countries is regularly monitored and compared by international institutions creating composite indicators and digital competitiveness rankings. Most of the research on digital competitiveness focuses on its input component (digital infrastructure, digital skills of individuals and business and ICT governance aspects). The output pillar is either not included or significantly limited.

Since 2009 the International Telecommunication Union provided the ICT Development Index (IDI) to analyse the performance of countries in networked infrastructure and access to ICTs (access sub-index), the level of intensity and use of ICT in society (use sub-index) and inhabitants' capabilities and skills important for ICTs development (skills sub-index)[2].

[2]*Access sub-index includes five infrastructure and access indicators (fixed-telephone subscriptions, mobile-cellular telephone subscriptions, international Internet bandwidth per Internet user, households with a computer, and households with Internet access. Use sub-index includes three intensity and usage indicators (individuals using the Internet, fixed-*

The economic implications of the ICT sector development are not taken into account, so IDI can be regarded as a pure measure of the ex-ante digital competitiveness (ITU, 2010; 2017).

The European Commission has developed the Digital Economy and Society Index and International Digital Economy Index (since 2013). DESI/I-DESI dimensions, i.e. connectivity (the development and quality of broadband infrastructure), human capital (skills of digital society), use of the Internet (activities performed by citizens online), business technology integration (digitisation of businesses and the development of online sales channels) and digital public services (digitisation of public services, e-Government) reflect mainly input digital competitiveness drivers (European Commission, 2018).

Since 2015 the International Institute for Management Development (IMD) has calculated the Digital Competitiveness Index (DCI) with three main digital competitiveness drivers: knowledge (talent, training and education, scientific concentration), technology (regulatory framework, capital, technological framework) and future readiness (adaptive attitudes, business agility, IT integrations).

Although these digital subfactors provide a more detailed examination of specific aspects of the digital transformation, among over 50 digital competitiveness criteria only a few of them concerned the impact of ICT on the economy (e.g., scientific and technical employment, high-tech patent grants, IT and media stock market capitalisation, investment in telecommunications, knowledge transfer). They were, however, components of various sub-indexes, not just one, illustrating the ex-ante aspect of economies' digital competitiveness (IMD, 2022).

The World Economic Forum (from 2002 to 2018) and Portulans Institute (since 2019) have published the Networked Readiness Index (NRI), and as the only ones, distinguished ICT impact subindex. It includes (in the latest version) the data on high-tech manufacturing, trade and services, prevalence of gig economy, patent activity and labour productivity growth. It is worth adding that the mentioned sub-index takes into account the overall level of labour productivity without focusing on the ICT/ digital sectors and the patent activity in general, not in the ICT and related sectors (WEF, 2016; Portulans Institute, 2022).

In this article, to verify the hypothesis and track the changes of EU member states' position towards the US in terms of ex-ante digital competitiveness, the ICT Development Index (IDI) was chosen. First, it measures only the input component of countries' digital competitiveness. Secondly, unlike other synthetic indicators, it

broadband subscriptions and mobile-broadband subscriptions). Skills sub-index includes three proxy indicators (mean years of schooling, gross secondary enrolment, and gross tertiary enrolment)

enables to conduct studies for a relatively wide time range 2010-2017. Its drawback, however, is the fact that it was published until 2017. The ex-ante digital competitiveness gap assessment is carried out for the US and 28 EU Member States (including the EU-15 and EU-13 groups)[3].

The study on the EU countries' position compared to the US in terms of the ex-post competitiveness turns out to be more problematic. The only usable sub-index seems to be quite general, therefore the article uses a new, proprietary index that takes into account several important aspects of the ICT's impact on economic processes in the analysed countries. The synthetic index of ex-post digital competitiveness was constructed for the longest possible period (allowing for the tracking of relevant changes).

Due to missing statistical data the group of analysed EU countries was limited to 23 countries – the "former fifteen" (EU-15) and selected "new" member states from Central and Eastern Europe, i.e., Estonia, the Czech Republic, Lithuania, Latvia, Poland, Slovenia, Slovakia and Hungary (EU-8/CEE). The methodological approach is based on the calculation of individual sub-indices reflecting different dimensions of the ICT's impact on economy and using them to calculate the overall Output Digital Competitiveness Index (ODCI).

The individual indicators of interest showed large variations in the frequency of their sharing in databases, which created the problem of developing synthetic sub-indices for particular years. For this reason particular sub-indices were calculated for two periods, i.e., 2006-2010 and 2015-2019, using (depending on the availability of data) the averaged values of the respective individual indicators[4]. 12 indicators grouped into 6 dimensions of the outcome digital competitiveness are shown in Table 1.

Table 1. *Dimensions of the Outcome Digital Competitiveness Index (ODCI)*

Dimension	Indicator	Source
D1: ICT employment	1.Employment in information industries[1] (as % of total employment) 2. Knowledge-intensive jobs[2] (as % workforce)	OECD STAN Database; OECD, Measuring the Digital Transformation. A Roadmap for the Future (2019) ILOStat (2021)
D2: ICT trade in goods	3. ICT exports (ICT goods as a percentage of total exports) 4. ICT imports (ICT goods as a percentage of total imports)	The World Development Indicators (WDI) database 2022
D3: ICT services	5. ICT services as a percentage of	The World Development

[3]*The study covers the 27 countries of the current EU and the United Kingdom. UE-15 includes the so-called „old" member states, and the EU-13 a group of countries whose accession took place in 2004 and later.*

[4]*For example, if data for the whole period 2006-2010 was available a five-year average was calculated, if for two years – a two-year average, etc.*

trade	services total exports 6. ICT services as a percentage of services total imports	Indicators (WDI) database 2022 The WTO Data portal 2022; own calculations
D4: ICT patents	7. ICT PCT patents[3], applications/million pop. 8. Patents in ICT-related technologies[4] (as a percentage of total IP5 patent families)	World Intellectual Property Organization (WIPO), OECD Stat (2022)
D5: ICT impact on business and new organisational models	9. Impact of ICTs on business models, 1-7 (best) 10. Impact of ICTs on new organisational models, 1-7 (best)	World Economic Forum, Executive Opinion Survey(2020)
D6: ICT value added	11. Value added in information industries[1] (as a percentage of total value added) 12. ICT-related domestic value added[5] (% of total value added)	OECD STAN Database 2022; OECD, Measuring the Digital Transformation. A Roadmap for the Future (2019)

[1]*Information industries cover the following ISIC Rev.4 Divisions: computer, electronic and optical products (26); publishing, audiovisual and broadcasting (58 to 60); telecommunications (61) and IT and other information services (62, 63).*
[2]*Knowledge-intensive jobs correspond to the International Labour Organization (ILO) aggregate category "Managers, professionals, technicians and associate Professional".*
[3]*Number of applications for information and communication technology-related patents filed under the Patent Cooperation Treaty (PCT) per million population.*
[4]*Data refer to IP5 families (patents that have been filed in at least two IP offices worldwide – the European Patent Office, the Japan Patent Office, the Korean Intellectual Property Office, the US Patent and Trademark Office). Patents in ICT are identified using the list of IPC codes in Inaba and Squicciarini (2017).*
[5]*Information industries' value added and non-information industries' value added content of global demand for information industry products. Value added of domestic ICT industries is embodied in a wide range of final goods and services meeting final demand both at home and abroad. Similarly, domestic value added (DVA) from other industries ("non-ICT") can be embodied in final ICT goods and services consumed globally. Information and communication technology (ICT) industries are defined according to ISIC Rev.3 and consist of Computer, electronic and optical products (Divisions 30, 32 and 33), post and telecommunications services (Division 64), and computer and related activities (Division 72).*
Source: *Own elaboration.*

For the two selected periods and for each country *i* (US and EU members), the particular sub-indices (reflecting dimensions from D1 to D6) were calculated on the basis of the methodology proposed by Hellwig (1968). Under this method the Euclidean distance of each country from the development pattern (reference country) is determined. The calculated composite sub-index takes values in the range from 0 to 1, but sometimes the value may be negative, which means that country is definitely worse than others. The following procedure was applied:

a) The indicators (*j*) used as proxies of the selected dimension were assessed as stimulants
b) Normalisation of values of the above indicators with the use of the following formula was carried out:

$$z_{ij} = \frac{x_{ij} - \overline{x_j}}{s_j} \quad (i = 1,2,\dots,n; j = 1,2,\dots,m), \tag{1}$$

where: x_{ij}- *i*-th value of *j*-th indicator,$\overline{x_j}$- mean of *j*-th indicator, s_j- standard deviation of *j*-th indicator

c) Development pattern $z_0 = [z_{01}, z_{02}, \dots, z_{0j}]$ was determined, where:

$$z_{0j} = max_i\,(z_{ij}) \tag{2}$$

d) Calculation of the Euclidean distance of *i*-th country from the development pattern was conducted:
e)

$$d_{io} = \sqrt{\sum_{j=1}^{m}(z_{ij} - z_{0j})^2} \quad (i=1,2,\dots,n) \tag{3}$$

f) The value of the sub-index (D1.....D6) for country *i* was calculated:

$$SGSI_i = 1 - \frac{d_{io}}{d_o} \quad (i=1,2,\dots,n), \tag{4}$$

where:

$$d_0 = \overline{d_0} + 2s_0, \tag{5}$$

$$\overline{d_0} = \frac{1}{n}\sum_{i=1}^{n} d_{i0}, \tag{6}$$

$$s_0 = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(d_{i0} - \overline{d_0}\right)^2}. \tag{7}$$

The *Outcome Digital Competitiveness Index* (*ODCI*) for each country (*i*) in two periods concerned was calculated as the arithmetic average of the six sub-indices' values.

3. Ex-ante Digital Competitiveness of European Union Member States in Relation to the US

Taking into account the ICT Development Index (IDI) as a measure of ex-ante digital competitiveness, it can be concluded that the position of the European Union (EU-28) was slightly weaker than that of the US. The average IDI value for the EU-

28 in 2010 was 6.4 and for the US 7.1. In the next decade, it increased to 7.7 and 8.2, respectively (Table 2).

However, EU member states showed a clear differentiation in terms of distance to the US. Denmark, Finland, France, Germany, the Netherlands, Luxembourg, Sweden and the United Kingdom had a higher level of digital economy development than the US. All (except France), both in 2010 and 2017, were ranked higher than the US (which was 16th in the group of 159 and 176 economies) in the ITU ranking.

The rest of the EU-15 group showed the level of the IDI index constituting from 82 to 98% of its value for the US. In turn, the new EU member states (except Estonia with 17th position in 2017) took places in the 3rd or 4th ten in the ranking and showed a gap to the USA within 8-32 percentage points in 2010 and 0.5-16 pp. in 2017.

Table 2. *Ex-ante digital competitiveness gap between the EU and US (IDI) in 2010 and 2017*

Countries	2010		2017	
	IDI	EU-US gap (USA=100)	IDI	EU- US gap (USA=100)
Austria	6.74	94.80	8.02	98.04
Belgium	6.60	92.83	7.81	95.48
Denmark	8.01	112.66	8.71	106.48
France	7.08	99.58	8.24	100.73
Finland	7.89	110.97	7.88	96.33
Germany	7.18	100.98	8.39	102.57
Greece	5.88	82.70	7.23	88.39
Ireland	6.99	98.31	8.02	98.04
Italy	6.13	86.22	7.04	86.06
Luxembourg	7.64	107.45	8.47	103.55
Netherlands	7.60	106.89	8.49	103.79
Portugal	5.86	82.42	7.13	87.16
Spain	6.31	88.75	7.79	95.23
Sweden	8.21	115.47	8.41	102.81
United Kingdom	7.35	103.38	8.65	105.75
Bulgaria	4.87	68.50	6.86	83.86
Cyprus	5.64	79.32	7.77	94.99
Croatia	5.54	77.92	7.24	88.51
Czech Republic	5.89	82.84	7.16	87.53
Estonia	6.36	89.45	8.14	99.51
Hungary	5.53	77.78	6.93	84.72
Latvia	5.80	81.58	7.26	88.75
Lithuania	5.88	82.70	7.19	87.90

Malta	6.30	88.61	7.86	96.09
Poland	6.09	85.65	6.89	84.23
Rumania	4.89	68.78	6.48	79.22
Slovenia	6.54	91.98	7.38	90.22
Slovakia	5.63	79.18	7.06	86.31
EU-28	6.44	90.63	7.66	93.65
EU-15	7.03	98.89	8.02	98.03
EU-13	5.77	81.10	7.25	88.60
USA	7.11	100.00	8.18	100.00

Source: *Own elaboration based on ITU 2010; 2017.*

Looking at the changes in the IDI index and the EU-US gap over the analysed period, it can be concluded that EU members have slightly "approached" the US (in 2010, the IDI value for the EU accounted for approx. 91% of its value for the US, and about 94% in 2017).

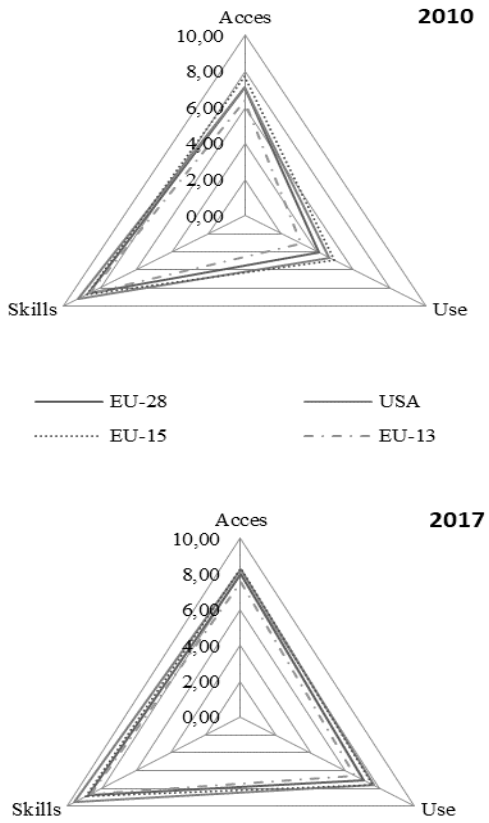
However, the reduction of the gap resulted only from the new Member States' performance (for which the gap decreased by approx. 7.5 pp.). On average, the EU-15 countries did not reduce their gap to the US, and most of the above-mentioned leaders even showed a decline in their relative position to the US. The discrepancy between the EU and the US should also be discussed in the context of the changes in individual components of the IDI indicator (Figure 1).

In 2010 the position of the European Union and the US and in terms of citizen's access to mobile phones, computers and the Internet was similar (ICT access score was 7.08 for EU-28 and in the US 7.11). The ICT access in the majority of EU-15 countries (except Greece, Spain and Portugal) was assessed much higher than in the US (the EU-15's average access sub-index was 7.70). In 2017 compared to 2010 the average value of the access sub-index for the EU increased by 12% (8% for the EU-15 and 19% for the EU-13), while for the US by 16%.

The greatest progress among EU members was observed in Romania, Malta, Poland and Hungary (over 25% increase). The US thus strengthened its advantage over the EU in terms of ICT infrastructure development mainly due to the relatively lower rating of EU-15 countries in this field. The new EU members (with an average sub-index value of 7.58), despite a clear catching-up, were still ranked lower than the US (except Malta and Estonia).

Both in 2010 and 2017 the European Union (EU-28) was rated lower than the US in intensity of using the Internet, fixed-broadband and mobile-broadband subscriptions. (EU's use sub-index amounted to 4.09 and 7.10 while for the US 4.64 and 7.67, respectively). The exceptions were Denmark, France, Finland, Germany, the Netherlands, Luxembourg, Sweden or the UK which maintained the advantage over the US in this respect.

Figure 1. *IDI by dimension in 2010 and 2017 (EU vs. US)*



Source: *Own elaboration based on ITU 2010; 2017.*

Despite this, in 2017 the EU-15 group lost its leadership position to the US (in 2017 the use sub-index value for this group was lower than for the US and amounted to 7.58). In 2017 compared to 2010 the value of the use sub-index for the EU-28 increased by 74% (by 54% in the EU-15 and over 100% in the EU-13) and for the US by 65%.

Among the highest-performing European countries were Ireland, Portugal, France, Romania, Bulgaria, Cyprus, Latvia and Lithuania. The European Union has only slightly reduced its distance to the US in this dimension of ex-ante digital competitiveness, and this is only due to dynamic changes in new EU countries.

The European Union (not only UE-28 but also the EU-15 group) lagged behind the US in terms of the third dimension of digital competitiveness connected with educational outcomes. In 2010 and 2017 only Denmark, Finland, Greece, Lithuania and Slovenia showed a higher level of ITC human skills than the US. In 2017 compared to 2010 the skills sub-index improved by 4.1% for the US and by 1.5% for EU-28 (the EU-15 group experienced a 2.6% increase while the EU-13 group only 0.4%).

Generally speaking, in each of the aspects of ex-ante digital competitiveness discussed in the IDI framework, the gap between the European Union (EU-28) and the US tended to widen. The drop in the EU's digital competitiveness relative to the US concerned mainly the "old" member states.

4. Ex-post Digital Competitiveness of European Union Member States in Relation to the USA

In the light of the research on output digital competitiveness measured by the ODCI, in the period 2006-2010 the US dominated over the European Union (as a whole). The average ODCI value for the EU-23 group was 0.39, while for the US it was 0.47. The CEE countries, in particular, showed the distance from the US, as their average level of ex-post digital competitiveness was approx. 30% lower. The gap between the EU-15 group and the US was rather small. The performance scores of Finland, Sweden, Ireland, the Netherlands, Luxembourg and the United Kingdom were even better.

However, the gap between the EU and the US widened by around 7 percentage points in the period 2015-2019. The EU ex-post digital competitiveness index decreased to the value of 0.37 (accounted for approx. 77% of the US index). Almost all members of the EU-15 group were weaker compared to the US. Only Sweden, the Netherlands, Ireland and Finland managed to maintain a higher position, although their advantage also decreased.

The position of the new EU countries (EU-8) in relation to the US has not changed and the average level of ex-post digital competitiveness of this group still accounted for about 70% of the level estimated for the US. Progress was only observed in the Czech Republic, Estonia, Latvia and Poland (Table 3).

Table 3. *Ex- post digital competitiveness gap between the EU and US (ODCI) in the periods 2006- 2010 and 2015- 2019*

	2006-2010		2015-2019	
	ODCI	EU-US gap (USA=100)	ODCI	EU-US gap (USA=100)
Austria	0.35	74.70	0.33	68.07
Belgium	0.35	75.74	0.35	71.79
Denmark	0.43	91.21	0.38	77.84

France	0.43	92.64	0.36	73.63
Finland	0.68	145.81	0.63	129.94
Germany	0.43	91.80	0.42	86.45
Greece	0.16	33.97	0.10	19.66
Ireland	0.65	138.15	0.58	119.33
Italy	0.27	56.88	0.18	38.14
Luxembourg	0.49	104.87	0.47	96.11
Netherlands	0.54	115.97	0.49	101.58
Portugal	0.26	56.48	0.25	51.80
Spain	0.26	56.04	0.24	50.20
Sweden	0.64	137.33	0.63	129.58
United Kingdom	0.51	108.83	0.47	97.52
Czech Republic	0.37	78.08	0.42	86.32
Estonia	0.44	93.46	0.47	96.96
Hungary	0.39	83.97	0.34	71.08
Latvia	0.29	60.95	0.35	71.31
Lithuania	0.29	62.74	0.27	56.50
Poland	0.22	46.46	0.25	51.38
Slovenia	0.27	57.38	0.26	53.59
Slovakia	0.34	71.72	0.35	71.90
EU-23	0.39	84.14	0.37	76.99
EU-15	0.43	92.03	0.39	80.78
EU-8/CEE	0.32	69.34	0.34	69.88
USA	0.47	100.00	0.48	100.00

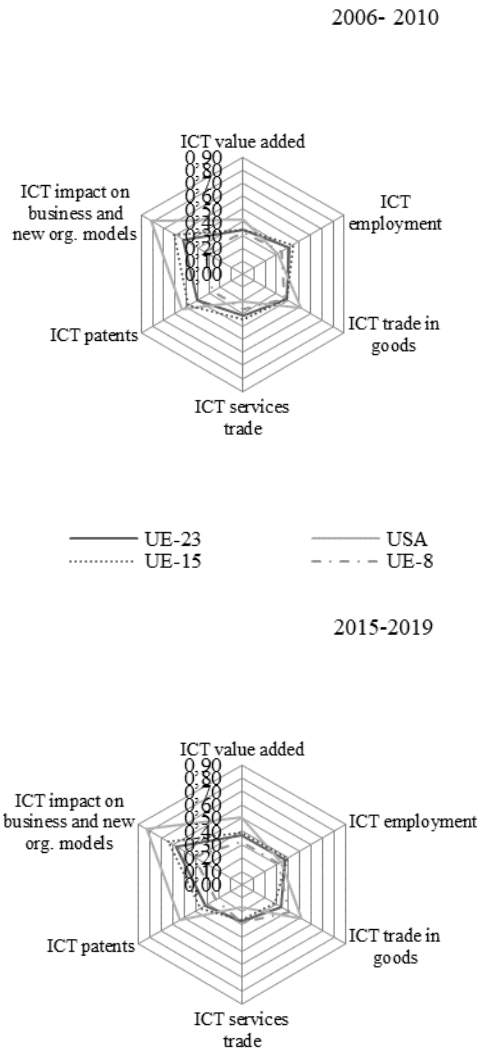
Source: *Own elaboration based on data defined in Table 1.*

Figure 2 shows the changes in individual components of the discussed composite indicator. The analysis of the sub-index approximating the degree of countries' involvement in high-tech trade (computers, communication equipment, electronic components, etc.) confirms the advantage of the US over the EU in both analysed periods.

The USA's position in this dimension of ex-post digital competitiveness has not changed much over the analysed years, while the EU's has weakened. The deepening distance between the EU and the US was mainly the result of the weakening position of the "former fifteen" (especially Finland, Ireland and the United Kingdom), whose results dropped by approx. 26%. During this time, the new member states recorded a 9 percent rise in their relative position to the US. The greatest progress was observed in Latvia and Slovakia.

EU countries showed relatively high and growing intensity of trade in ICT services (telecommunications, computer and information services, etc.). The average value of the sub-index approximating trade in ICT services in the EU was 50-60% higher than that calculated for the US. Among leaders there were Finland, Sweden and Ireland.

Figure 2. *ODCI by dimension in 2006- 2010 and 2015- 2019 (EU vs. US)*



Source: *Own elaboration based on data defined in Table 1.*

In the period 2015-2019, compared to 2006-2010, the advantage of the EU over the United States strengthened (the value of the sub-index for the EU-23 improved in relation to the US by approx. 7.8%). The improving position of the EU resulted mainly from the high dynamics of trade in the CEE countries, especially in Estonia and Poland.

In both periods 2006-2010 and 2015-2019, the European Union (EU-23) showed an advantage over the US in terms of employment in the ICT sector (people employed in the ICT and ICT-related sectors), which was maintained thanks to the high position of the EU-15 (in particular Finland, the Netherlands, Luxembourg, Sweden and the UK). The results of the new member states (with the exception of Estonia with a relatively better position) were similar to those of the US. Despite the domination of the EU over the US in this dimension, its position seems to be weakening. In 2006-2010, the ICT employment sub-index for the EU was higher by 31% than that for the USA, while in the period 2015-2019 only by 9%.

However, the European Union (EU-23) showed a much weaker position versus the US in terms of patent activity in the ICT sector. The exceptions were the Scandinavian countries – Finland and Sweden. Comparing the two analysed periods, it can be concluded that the relative position of the EU (especially the group of the new members) in terms of the number of ICT patents has decreased on average by approx. 20%.

The US advantage can be also confirmed in the sub-index reflecting the impact of information and communication technologies on business and organisational models. Among EU member states, the greatest digital transformation in enterprises took place in France, Finland, the Netherlands, Sweden, the UK and Estonia. These countries showed a similar or even higher position in this dimension than the US. However, the position of the EU vs. the US seems to be improving as the negative disproportion has narrowed by around 8%.

The European Union second to the US in terms of the ICT sector's share in value added in the economy. When assessing the position of individual countries in this dimension it can be concluded that only Finland, the Netherlands and Sweden were better than the US. In 2015-2018, compared to the previous period, the EU-23 group recorded a decrease in the value of the discussed sub-index in relation to the US by approximately 10%. This drop was particularly strong in the CEE countries and amounted to about 19%.

5. Conclusions

The conducted study provides evidence to confirm the hypothesis that the digital competitiveness gap between the EU and the US is widening especially in its output dimension, related to the channels transforming the country's digital potential into economic results. The US maintained its advantage over the EU in terms of ICT patent activity, ICT impact on new business and organisational models, intensity of high-tech trade and the importance of the ICT sector in value added creation.

The high level of employment in the ICT and related sectors as well as high intensity of IT services trade remained the strengths of the EU, which undoubtedly resulted

from a relatively rich human capital resources. However, the position of the EU countries seemed to be slightly weakening also in this respect.

From the economic policy point of view an important issue is, to identify the causes of this phenomenon. On the one hand, they may be related to the differences between the EU and the US in the size of ICT investments, and, on the other hand, to different system solutions shaping the flexibility of the labour market, diffusion of technologies, organisation of work and business systems, investment in human capital or institutional environment for innovation and entrepreneurship.

The above explanations probably can also be the sources of a high degree of EU internal differentiation both in the levels and dynamics of digital competitiveness. These issues, however, require an in-depth analysis that may be the subject of another study.

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