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Digital divide – the new form of social inequality

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Abstract This study examines the relationship between digital divide metrics and income inequality across the 27 EU member states from 2015 to 2024, with particular attention to changes before, during, and after the COVID-19 pandemic. Using correlation analysis, OLS regression, and cluster analysis, we investigate how internet access, digital skills, digital economy development (DESI), ICT investment, and broadband prices affect the GINI coefficient. Our findings reveal that while internet access and digital skills demonstrate consistently negative relationships with inequality, broadband prices, ICT investment, and overall digital advancement (DESI) show positive associations with income inequality, especially during the post-pandemic period. These complex relationships suggest that digital transformation can both reduce and exacerbate inequality depending on implementation context. Cluster analysis reveals three distinct country groupings based on digital skills development and inequality dynamics, with some nations achieving notable inequality reduction alongside digital advancement while others experienced widening disparities despite similar digital progress. Predictive modeling indicates that a 10% improvement in digital indicators would reduce inequality in most EU countries, with Eastern European nations showing the greatest potential benefits, while seven countries would experience increased inequality despite digital improvements. This research demonstrates that the digital divide represents not merely a technological gap but a multifaceted social challenge requiring targeted policy interventions that prioritize equitable access, skills development, and complementary measures to ensure digital transformation benefits are shared across society.

Keywords Digital Divide, GINI, EU, Digital Skills.

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Introduction

Today, people depend on the digital world's development in many areas of their daily lives. Fields such as healthcare, education, banking, public administration, and libraries use ICT, thus making them necessary tools for citizens when using the respective services. To do this, they must know how to access the internet, email, blogs, or social networks. Even many economic entities, small and medium-sized enterprises, use various forms of ICT, which makes knowledge in this area a prerequisite for acquiring a new job. However, not everyone possesses this knowledge. This is how the digital divide or "digital gap" emerges.

Inequality is one of the world's biggest challenges, and there are significant concerns about the contribution of digital technologies to inequality. So far, the dominant

hypothesis for understanding the relationship between digital technologies and inequality is that of the digital divide: nations, regions, groups, individuals, etc., who are absolutely or relatively excluded from the benefits of digital technologies (Van Dijk, 2020).

1. Theoretical approach

The interrelationship between digitalization and inequality was initially viewed as follows: computers, mobile devices, radio, and television media, as elements of the more general contribution of technologies and information flows, reduce global inequality between "third world" countries. This thread, stemming from the modernization perspective of development, persists today. Initially, the digital divide was explained as a dualism of "haves" versus "have-nots," related to access to technologies, be it devices such as personal computers or services such as internet connectivity. The multidimensional digital divide theory includes analysis of several complex issues, such as social exclusion and inclusion, approaches and measurements of social exclusion, standard means of reducing inequality, and the role of digital technologies in society.

According to the Digital Divide Network, digital inequality refers to the "gap" between those who can effectively use new information and communication tools, such as the internet, and those who cannot. Warschauer (2002) considers that the digital divide is characterized not only by physical access to computers and connectivity but also by access to additional resources that allow people to use technology well, such as content and language, literacy and education, and community and institutional structures. Although several interesting factors are mentioned, the tools are again emphasized.

Hargittai (2002) goes even further and argues that we must also consider a second level of digital divide, which accounts for differences in people's online skills. She defines online skills as effectively and efficiently finding online information. She sees countless ways in which people search for information on the internet, and significant differences in how long it takes them to complete online tasks. She does not find a connection between age and search skills, but claims that there is a connection between experience with technologies and online skills. Gender differences also do not appear to have an impact. Although the author goes beyond access to focus on skills, there is still no reference to the actual use of information.

Recognizing the issues with the divide leads to the understanding that digital inequality is not just a narrow and unilateral concept. The concept of relative inequality (categorical differences between groups of people) is used by Van Dijk (2005) to explain the current digital gap. The author shows how dominant groups appropriate resources and social norms and how this affects the uneven adoption of new technologies, increasing categorical inequalities. He also highlights the different positions on the spectrum of inequalities: from absolute exclusion of access to digital media to differences in economic and social benefits obtained through skillful and informed use of digital technology. The application of technologies depends on different types of access and is based on the motivation for

the frequency of their use. According to Van Dijk (2012), motivation is crucial to the digital divide. Motivation tends to grow as technology spreads through society. This increase can be attributed to various social and cultural factors, such as income and education levels, as well as psychological elements like individual personality types or specific fears.

Additionally, the expanding development of digital skills and usage contributes to this motivation. Therefore, we can interpret motivation as a potential outcome of efforts to either diminish or exacerbate digital inequality. The second level of the digital divide consists of disparities in a wide range of digital skills. Van Deursen and Van Dijk (2010) develop six types of internet skills and the inequalities that can exist in each of these types. Van Deursen et al. (2017) examine the links between different aspects of the digital divide. Forms of "digital inequality of connection" and "digital inequality of sequence" among Dutch internet users are revealed. Connected forms of inequality mean that a lack of offline capital in one area (e.g., economic) will reduce the benefits of using the internet. Still, they will not affect benefits in another (e.g., cultural) way. Sequential forms of inequality arise when a lack of technical or information-seeking skills affects different types of internet applications in multiple areas and reduces the benefits received. These findings indicate that digital inequality is highly diverse.

Since the mid-1990s, digital inequality has been a problem for researchers and policymakers who are aware of the negatives of limited or no access to technologies such as home computers and the internet. Over time, computers and internet connections have become cheaper and more widespread, but differences in access continue. The focus on the divide between those who have regular internet access and those who do not - later known as the "first-level digital divide" - is considered too simplistic to capture the complexity of digital inequality. As a result, alternative explanations for digital inequalities emerge.

Contemporary academic studies of the digital divide no longer focus on access to technological infrastructure and high-speed internet connection, but also on barriers to acquiring the necessary skills and knowledge for effective engagement in an increasingly digitalized world (Alam and Imran, 2015).

Several studies and public policies find that certain demographic groups, including older people (Powel, Bryne, and Dailey, 2010), people with limited English literacy (Nguyen, Mosadeghi, and Almario, 2017), and people with low incomes (Hinton, 2021), experience more difficulties acquiring or maintaining these skills in the face of advancing technologies. They emphasize that people positioned in more than one of these demographic characteristics experience cumulative effects of exclusion. Inequality related to internet access and use is a key issue for those living in public housing, who often have low incomes, speak languages other than English at home, and are statistically more likely to have disabilities. For example, a study in Melbourne public housing shows that some tenants with migrant

backgrounds face financial and language barriers when accessing the internet (Fairlie, 2017).

The digital divide represents a serious challenge in education as it creates disparities in student access to and use of technology. The consequences of this divide are far-reaching, as it affects students' ability to engage with digital resources and participate in online learning platforms. Schools can contribute by creating well-equipped computer labs and adopting blended learning models. By addressing the digital divide, we can create an inclusive and empowering educational environment that enables all students to access the benefits of technology. It is critical to recognize that bridging the digital divide is a matter of improving educational opportunities and a step towards building a more equal and fair society. By working together, we can ensure that every student has the opportunity to thrive in the digital era and contribute to their full potential.

2. Methodology

We aim to explore the effects of the digital divide on the GINI coefficient in the 27 EU member states for the period 2015-1014. The explored period is divided into three subperiods: pre-COVID-19 pandemic (2015-2019), COVID-19 pandemic (2020-1022), and post-COVID-19 pandemic (2023-2024). In the study, we apply correlation analysis, OLS regression, and cluster analysis estimated by Python. To assess the effects of the digital divide on income inequality, we use the following variables:

Table 1. Explored variables

Variable	Abbreviation	Source
GINI coefficient	GINI	https://data.worldbank.org/indicator/SI.POV.GINI
Individuals using Internet	Internet access	https://data.worldbank.org/indicator/IT.NET.USER.ZS
Individuals' level of digital skill	Digital skills	https://ec.europa.eu/eurostat/web/main/data/database
Digital economy and society	DESI	https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets
Investment in ICT with private participation	ICT investment	https://data.worldbank.org/indicator/IE.PPI.ICTI.CD
Broadband price index	Broadband prices	https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets

To estimate the impact of the digital divide on the GINI coefficient, we apply the following regression model:

$$GINI = f(Internet\ access, Digital\ skills, DESI, ICT\ investment, Broadband\ prices) \quad (1)$$

Where GINI is the dependent variable, and based on the theoretical approach, we apply the variables – Internet access, Digital skills, DESI, ICT investment, and Broadband prices as proxies for the digital divide.

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3. Results and Discussion

This correlation matrix heatmap reveals that digital development generally corresponded with lower income inequality, with digital skills and internet access showing the strongest equalizing relationships. Broadband affordability emerged as a critical factor - high prices were strongly linked to higher inequality, suggesting that cost barriers to connectivity may have been a significant driver of economic disparities. The tight correlations among positive digital indicators suggest digital development occurred as an integrated process rather than through isolated improvements. The matrix supports the view that digital development generally had equalizing effects, but highlights the importance of affordable access as a prerequisite for these benefits to be broadly shared.

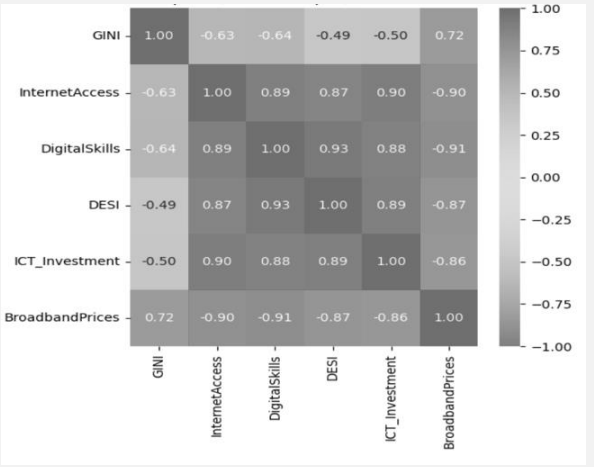

Fig. 1. Heatmap of correlation coefficients (Source: author's estimation)

Fig. 2 represents the results from the applied OLS regression. The consistently negative coefficients for InternetAccess across all periods indicate that greater internet penetration is associated with reduced income inequality. This relationship strengthened during the pandemic and has remained stronger post-pandemic. This suggests that internet access functions as an equalizing force in society, potentially by democratizing opportunities for education, employment, and entrepreneurship. The intensification of this effect during and after COVID-19 likely reflects how digital connectivity became even more crucial for economic participation when physical interactions were limited, making those without access more vulnerable to financial exclusion.

OLS regression: pre-COVID-19 (2015-2019):

	coef	std err	t	P>|t|	[0.025	0.975]
const	23.4218	8.529	2.746	0.007	6.547	40.296
InternetAccess	−0.2215	0.072	−3.064	0.003	−0.365	−0.078
DigitalSkills	−0.4362	0.087	−4.986	0.000	−0.609	−0.263
DESI	0.4050	0.080	5.060	0.000	0.247	0.563
ICT_Investment	3.4652	1.022	3.392	0.001	1.444	5.487
BroadbandPrices	0.2518	0.062	4.079	0.000	0.130	0.374

OLS regression - during COVID-19 (2020-2022):

	coef	std err	t	P>|t|	[0.025	0.975]
const	33.8930	11.038	3.070	0.003	11.904	55.882
InternetAccess	−0.3256	0.097	−3.372	0.001	−0.518	−0.133
DigitalSkills	−0.3741	0.117	−3.201	0.002	−0.607	−0.141
DESI	0.3204	0.103	3.118	0.003	0.116	0.525
ICT_Investment	4.0556	1.147	3.536	0.001	1.771	6.340
BroadbandPrices	0.2318	0.077	3.020	0.003	0.079	0.385

OLS Regression - post-COVID-19 (2023-2024):

	coef	std err	t	P>|t|	[0.025	0.975]
const	32.8859	13.086	2.513	0.015	6.575	59.197
InternetAccess	−0.3448	0.116	−2.965	0.005	−0.579	−0.111
DigitalSkills	−0.4408	0.141	−3.128	0.003	−0.724	−0.157
DESI	0.5052	0.138	3.654	0.001	0.227	0.783
ICT_Investment	2.9068	1.491	1.950	0.057	−0.091	5.905
BroadbandPrices	0.2317	0.091	2.552	0.014	0.049	0.414

Fig. 2. OLS regression results (Source: author's estimation)

Similarly, the negative relationship between DigitalSkills and the GINI coefficient demonstrates that higher digital literacy in a population corresponds with lower income inequality. Digital skills serve as a pathway to economic opportunity that can help bridge income gaps. The slight weakening of this effect during COVID might reflect temporary labor market disruptions that overwhelmed the equalizing benefits of digital skills. Still, the return to pre-pandemic levels suggests this relationship has stabilized.

The positive coefficient for DESI across all periods reveals a concerning trend: greater overall digital advancement correlates with higher income inequality. This counterintuitive finding suggests digital transformation may disproportionately benefit those disadvantaged. The significant increase in this coefficient post-COVID-19 indicates this inequality-enhancing effect has intensified, possibly because digital advancement increasingly rewards technological capital owners and highly-skilled workers while leaving others behind.

ICT_Investment shows a consistently positive relationship with inequality (3.47 pre-COVID-19, 4.06 during COVID-19), suggesting that technology investments may exacerbate income gaps rather than narrow them. This could reflect the nature of returns on technology investment, which often accrue disproportionately to capital owners and highly skilled workers. Notably, the diminished significance of this variable post-COVID-19 (p=0.057) indicates this relationship may evolve, perhaps as technology becomes more democratized or as policy interventions begin addressing technological inequality.

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The positive association between BroadbandPrices and inequality suggests that higher connectivity costs may reinforce socioeconomic divisions. When broadband is more expensive, it creates barriers to digital inclusion that disproportionately affect lower-income households, potentially widening economic disparities. The persistence of this relationship across all periods indicates that affordability remains a crucial factor in digital equity.

The increasing constant term from pre-COVID-19 (23.42) to during and post-COVID periods (33.89 and 32.89) suggests a concerning baseline rise in inequality independent of the measured digital factors. This may reflect broader structural economic changes that have intensified inequality, with the pandemic potentially accelerating these trends.

These findings collectively paint a complex picture of digital transformation's relationship with inequality. While some aspects, like internet access and digital skills, appear to reduce inequality, overall digital advancement and technology investment may simultaneously drive greater economic disparities. This suggests that digital policies must prioritize inclusive access and skills development while implementing complementary measures to ensure the benefits of digital transformation are shared equitably across society.

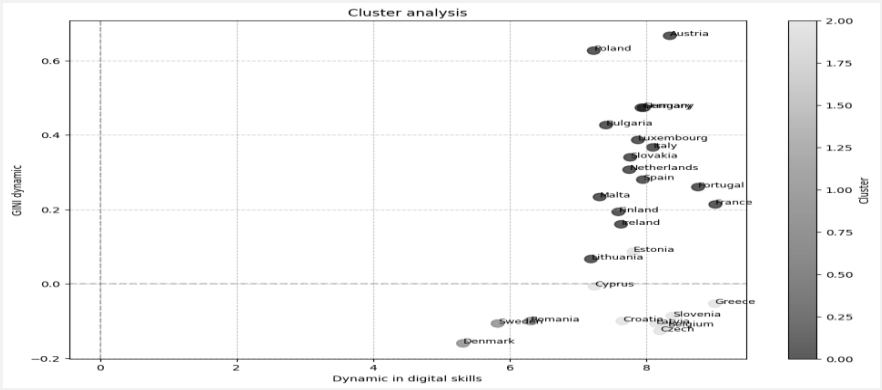

Fig. 3. Cluster analysis (Source: author's estimation)

Fig. 3 reveals distinct groupings of European countries based on their digital skills development and changes in income inequality (GINI dynamics). The x-axis measures improvements in digital skills, while the y-axis shows changes in income inequality, where positive values likely indicate increasing inequality and negative values represent decreasing inequality. Cluster 1 —Upper right quadrant: This is the largest cluster, including countries like Austria, Poland, Germany, Bulgaria, Luxembourg, Italy, Slovakia, the Netherlands, Spain, Portugal, France, Malta, Finland, Ireland, and Lithuania. These nations show moderate to high digital skills improvement combined with increasing income inequality. Austria and Poland show the highest increases in inequality within this group. Cluster 2— Lower right quadrant: Greece, Slovenia, Croatia, Belgium, the Czech Republic, Cyprus, and Estonia. These countries have highly developed digital skills while experiencing stable or

slightly decreasing inequality, suggesting they've managed digital transformation more equitably. Cluster 3 - Middle-lower area: Sweden, Romania, and Denmark form a distinct cluster showing moderate digital skills improvement while achieving notable decreases in income inequality. These countries have implemented the most successful policies for equitable digital transformation.

There are noticeable patterns. Most countries with high digital skills improvements (x-axis values 6-8) show varying inequality outcomes, suggesting that digital advancement alone doesn't determine inequality trends. The countries achieving inequality reduction (negative y-values) all show moderate digital skills improvement, potentially indicating these countries found an optimal balance in their digital transformation approach. The countries with the highest increases in inequality (Austria, Poland) also show substantial improvement in digital skills, possibly reflecting an unequal distribution of digital transformation benefits. The visualization highlights that digital transformation can have varied distributional effects and that policy, institutional factors, and implementation approaches mediate the relationship between digital skills development and inequality.

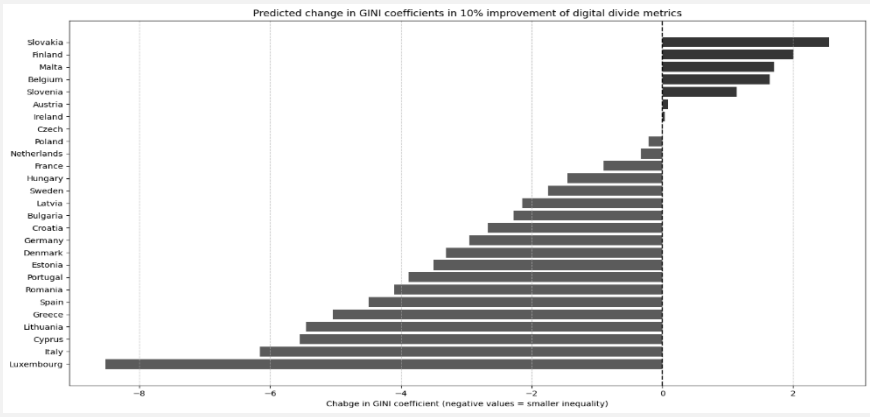

Fig. 4. Predicted change in GINI coeff. in 10% improvement of digital divide metrics. Source: author's estimation

Countries with Projected Inequality Reduction (left side of the figure): The majority of countries (23) are projected to experience reduced inequality (improved GINI coefficients) with a 10% improvement in digital indicators: The most substantial inequality reductions are projected for Latvia, Romania, and Portugal (around -6 to -5 points). Lithuania, Poland, Croatia, Estonia, and Luxembourg show substantial projected improvements (-5 to -4 points). Mediterranean countries (Greece, Spain, Italy) all show moderate inequality reductions. Western European nations (France, Germany, Denmark) show smaller but meaningful reductions. Belgium and Ireland show minimal projected reductions in inequality. Countries with Projected Inequality Increase (right side of the figure): Seven countries are projected to experience increased inequality despite digital improvements. Slovakia and Finland show the most dramatic projected increases in inequality (approximately +4

points). Slovenia shows a substantial projected increase (about +2 points). Austria and Hungary show moderate projected increases. The Czech Republic and Malta show minimal projected increases.

The stark contrast between countries suggests that digital transformation's effects on inequality are highly context-dependent and not universally positive. Eastern European countries (Latvia, Romania, Lithuania, and Poland) generally show the most substantial projected inequality reductions. Nordic results are mixed: Sweden shows moderate inequality reduction, while Finland shows significant inequality increase. Central European outcomes vary considerably between neighboring countries. The differing outcomes likely reflect varying starting levels of inequality and digital development, labor market structures and educational systems, social safety nets and redistributive policies, and Industry compositions and vulnerabilities to digital disruption. This analysis demonstrates that while digital improvement generally correlates with reduced inequality across Europe, specific national contexts and implementation approaches significantly influence distributional outcomes. Countries facing projected inequality increases should examine policies in nations with substantial projected reductions to identify potential complementary measures.

Conclusion

This study provides substantial evidence that the digital divide is emerging as a new form of social inequality across the European Union, with its effects intensifying in the wake of the COVID-19 pandemic. Our analysis has uncovered several critical insights into the complex relationship between digital advancement and income inequality.

First, our findings demonstrate that certain aspects of digital development—notably internet access and digital skills—consistently correlate with reduced income inequality across all explored periods. This suggests that basic connectivity and digital literacy function as equalizing forces in modern economies, potentially by democratizing access to information, education, and economic opportunities. The strengthening of the negative relationship between internet access and inequality during and after the pandemic underscores how digital connectivity has become increasingly crucial for financial participation in the post-pandemic world.

We also reveal trends concerning how other aspects of digital development may exacerbate inequality. The positive association between overall digital advancement (DESI) and income inequality, which significantly increased post-pandemic, suggests that digital transformation may disproportionately benefit already-advantaged populations. Similarly, the persistent positive relationship between broadband prices and inequality highlights how cost barriers to connectivity can reinforce socioeconomic divisions.

The clustering of EU countries based on digital skills development and inequality dynamics reveals no universal pattern linking digital advancement to equality outcomes. While

some nations (particularly in Eastern Europe) show potential for substantial inequality reduction through digital improvement, others (notably Finland and Slovakia) face projected increases in inequality despite digital progress. This variability likely reflects differences in starting conditions, labor market structures, social safety nets, and implementation approaches. These findings have significant policy implications. First, they highlight the importance of targeted interventions to ensure equitable access to digital resources, particularly through affordability measures and skills development programs. Second, they suggest that digital transformation strategies must be accompanied by complementary policies addressing structural inequalities to prevent technological advancement from widening economic gaps. Finally, they indicate the value of cross-national policy learning, as countries facing projected inequality increases could benefit from examining approaches in nations successfully leveraging digital advancement for more equitable outcomes.

As we advance deeper into the digital era, especially following the accelerated digital transformation triggered by the COVID-19 pandemic, policymakers must recognize that bridging the digital divide is not merely a technological challenge but a critical social equity imperative. By ensuring that digital advancement is inclusive and its benefits are widely shared, we can harness technology's potential to create more equitable societies rather than exacerbating existing disparities. Future research should focus on identifying specific policy mechanisms and institutional arrangements that enable some countries to achieve digital advancement while reducing inequality, providing concrete guidance for creating more inclusive digital futures.

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