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An inverted digital divide during Covid-19 pandemic? Evidence from a panel of EU countries

Grishchenko Natalia

Institute of Social Policy, National Research University Higher School of Economics, Moscow, Russia

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ABSTRACT

The extension of remote forms of employment, education and communication during the Covid-19 pandemic was expected to bridge the digital divide in 2020. However, more digitally developed countries have shown a reduction of Internet use. This article examines the changes in Internet use in 2020 as the first year of the Covid-19 pandemic focused on cross-country digital development. We use a random effects regression model to assess the relationship between Internet use as an indicator of digital divide and digital development on the macro, business, infrastructural, and individual levels in EU countries. Panel data from Eurostat for 2014–2020 are applied. We found that more digitally developed EU countries, including Estonia, the Netherlands, Denmark and Norway, show a higher relationship between Internet usage and digital performance than other EU countries. These countries saw a decrease in Internet use during 2020, which is contrary to the general trend of either increasing or unchanging Internet use in the case of social distancing restrictions and lockdowns. High digital dependence in more digitally developed countries, and in some other EU countries in the context of a pandemic as a crisis, has led to a reduction in Internet use due to the vulnerability of digitalized industries, enterprises, jobs and personal patterns that may identify the new challenge as inverted digital divide.

1. Introduction

With the introduction of social distancing measures in the EU to fight the coronavirus pandemic, the demand for Internet has increased for remote work, learning, communication and entertainment. The European Commission’s Digital Strategy highlights the importance of digital solutions such as using digital tools to monitor the spread of the coronavirus, research and develop diagnostics, treatments and vaccines and to ensure that Europeans can stay connected (European Commission, 2020). EU operators also point to increased demand for connectivity. According to an OECD report, the Spain telecommunication company Telefonica reported an almost 40% increase in bandwidth in the country in 2020, with mobile traffic growing 50% and 25% for voice and data, respectively. In Italy, Telecom Italia experienced growth in fixed and mobile network traffic by 63% and 36%, respectively. In France, Orange reports that its international infrastructure has been in high demand: 80% of the traffic generated by users in France was directed to the US in 2020 during the lockdowns, where much of the entertainment content is concentrated (OECD, 2020). Internet traffic in some countries increased by up to 60% shortly after the outbreak, highlighting the digital acceleration fueled by the pandemic (OECD, 2020).

Despite the demand for Internet use, there was an opposite trend due to the growth of digital inequality. The pandemic as a crisis has exposed and even exacerbated the existing inequalities in the digital divide despite the increased use of ICT for social distancing.
and with restrictions in offline life. Those who were unable to communicate online before the pandemic were in a worse position with no access or skills to adapt to life by distance. In the ongoing Covid-19 crisis, certain groups of people were identified as vulnerable, such as older people, less educated people, and people with physical health problems, low literacy or low Internet skills. Generally, people who are already in a relatively advantaged position are more likely to use the opportunities provided by the Internet to their benefit in a health pandemic, while less advantaged individuals are less likely to benefit (Van Deursen, 2020). Those who can afford Internet access during job layoffs and who have the skills and support to quickly embrace new digital habits were able to avoid some of the repercussions of the crisis (Nguyen et al., 2021). The individual digital divide has driven the decline in Internet use during the pandemic.

Changes in the use of the Internet as an indicator of the digital divide, however, are also under pressure from the level of countries’ digital development. The studies emphasize that the digital development of the country is one of the main factors determining the digital divide, including macro, business and infrastructural levels (Lamberti et al., 2021; Appiah-Otoo and Song, 2021; Su et al., 2020). In addition, different levels of digital development generate different marginal effects on changing the digital divide (Emara and Zhang, 2021; Maneeluk and Yamaka, 2020). In this article, we examine the changes in Internet use as an indicator of the digital divide in relation with digital development in countries on macro, business, infrastructural and individual levels. We assume that digitalization might have both positive and negative impacts on the digital divide. This is especially important in crises such as the Covid-19 pandemic due to the potential negative impact of digitalization on society and the economy, people, their employment, education and communications. The research question in our study is: How and to what extent is the Internet use dependent on the digital development of EU countries during the Covid-19 pandemic? We contribute to the development of the theory of the digital divide by describing and evaluating indicators that reflect the digital development in a country and can influence the use of the Internet.

We begin the study by reviewing the literature on the digital development factors that define the digital divide in the context of the Covid-19 pandemic. We then describe our data and method for evaluating the relationship between Internet use and different levels of a country’s digital development. After analyzing the results of the study, we discuss the implications of our findings.

2. Literature review

2.1. The digital divide and digital development on the individual and household level

The digital divide is one of the main technological, economic and social policy challenges associated with combating the Covid-19 pandemic and adapting to the new socially distancing reality. The use of the Internet by individuals or households according to their socioeconomic status, such as income, education, gender, place of residence, and others was presented in pre-pandemic studies (Van Deursen and Helsper, 2018; Van Deursen and Van Dijk, 2014; Blank and Groselj, 2014; Helsper and Gerber, 2012). During the pandemic in 2020, there are studies that evaluate the impact of the Covid-19 on the digital divide in which arguing for the amplification of the digital inequality and the importance of access to the Internet as well as skills and outcomes. The digital divide is proved during the pandemic, based on survey data from the Netherlands that make the digital inequality worse (Van Deursen, 2020). Using survey data from a national sample of US participants collected during the early months of the pandemic, a study argues that people privileged in their socioeconomic status, their Internet skills and online experiences are more likely to increase and less likely to decrease digital communication during the pandemic (Nguyen et al., 2021). Other studies also show the greater risk of already disadvantaged groups during the pandemic with social distancing restrictions (Bonacini et al., 2021; Esteban-Navarro et al., 2020; Wallinheimo and Evans, 2021; Moore and Hancock, 2020; Nguyen et al., 2020; Ranchordas, 2020). Thus, there is no bridging the gap in Internet use during lockdowns, distance learning, employment, communications, etc. The digital gap not only remains during pandemic, but widened due to pandemic (Grishchenko, 2020; Hilbert, 2016).

Considering the task of assessing differences in digital inequalities by country comparison, there are studies that focus on differences in Internet access and different households and individual characteristics on country and cross-country levels. The level of digital development of countries is seen as one of the primary determinants of the digital divide in a study conducted in the EU and the UK. Moreover, the level of a country’s digital development is more important than motivation, access, and digital skills for tackling the digital divide, as socially disadvantaged Europeans benefit more from living in more digitally developed countries (Lamberti et al., 2021). This thesis is supported by the example of Mediterranean countries with the highest connectivity of the human development index with the production of the digital divide than with the ICT development index (Perez-Castro et al., 2021). Differences in the most influential variables were also found in Chilean and Korean models in ICT literacy: personal indicators, such as parental education, are more essential for Chile, while Internet connection is more important for Korea (Aydin, 2021). The divergence in ICT development in 47 developed and emerging countries according to data from 2000 to 2012 were related to two factors: the growth of per capita income and the ratio of urban to rural population (Rath, 2016). These papers provide evidence that Internet use is associated with (1) a country’s level of digital development, (2) the influence of personal characteristics on Internet use is stronger with low incomes and less digital development.

2.2. Digital development on the macro and business levels

R&D, science and technology (S&T) are among the most macro predictors of ICT use, including the use of the Internet in a country. A study evaluating the macroeconomic performance of technological innovation in the G7 countries from 1996 to 2017 suggests that the reason for the more efficient innovative activities of G7 countries lies in their high R&D expenditures. The development of human capital, accompanied by the accumulation of knowledge and R&D, are important factors explaining technological innovation in G7
countries (Wang et al., 2020). Research findings suggest that ICT maturity is associated with a 1–3.8% increase in economic development in OECD countries (Ali et al., 2020). Similar empirical results were obtained studying the endogenous relationships between R&D, ICT infrastructure development and long-term economic growth in OECD countries during 1961–2018 (Nair et al., 2020). Other effects of Internet penetration are related to the research output. Using a country-level panel dataset, it was found that higher Internet penetration increases the volume of research output in the economy and the impact of Internet penetration on research output quantity decreases as the number of fixed broadband users increase in an economy (Xu and Reed, 2021). Interesting results relate to the positive role of corporate training and digital skills, which were found in a study of digital competences in the EU between 2015 and 2017. A significant relationship was found between the level of digital knowledge and the level of unemployment: a strong positive correlation exists between levels of digital competence and corporates training, which differs between underdeveloped, developing and developed countries not only in the number of digitally educated people but also in the distribution of digitally qualified groups (Csordás, 2020).

2.3. Digital development on the infrastructural level

Similar tendencies in the impact of macro and business digital development on ICT use were observed in the cross-country comparison presented by the assessment of ICT infrastructure. The important role of the quality of ICT infrastructure was highlighted in several studies, including the future demand for higher bandwidths (fixed broadband access) of at least 500 Mbit/s from residential customers in Germany, the UK, and the Flemish region (Martins and Wernick, 2021). Using a panel of 123 countries, including high,
middle and low-income countries from 2002 to 2017, and using the ICT index for mobile, Internet and fixed broadband, evidence was found that overall ICT infrastructure accelerates economic growth in all countries, however, poor countries tend to benefit more from the ICT revolution (Appiah-Otoo and Song, 2021). What is also important is that different levels of national digitalization should be considered in terms of digitalization on individual and infrastructural levels (Su et al., 2020). Examining the Internet consumption for different purposes between indicators, which reflect macro, infrastructural and micro, individual digitalization on the example of European countries, China, and the US, the study argued that while digitalization at the individual level is the most important factor and has a significant impact on all aspects of Internet use, digitalization at the infrastructural level contributes to only two aspects of Internet use: news consumption on the Internet and use at work. Thus, in a crisis, in more digitalized economies, businesses and human resources are potentially more negatively impacted. This may be reflected in a decline in the use of ICT and the Internet.

2.4. Marginal effects of digital development on Internet and ICT use

On the whole, differences in Internet use between countries due to their digital development reflect marginal effects depending on the degree of this development. This thesis was proved in the evaluation of ICT in relation to global trade using an example of 122 countries from 1995 to 2008 (Abeliansky and Hilbert, 2017). By assessing of trade transaction costs in relation to the effects of telecommunication quantity (data subscriptions per capita) and quality (bandwidth data speed per subscription) of fixed and mobile telephony and Internet services on countries’ bilateral exports of goods, data speed quality for developing countries was the most important, while the quantity of subscriptions is more relevant for developed ones (Abeliansky and Hilbert, 2017). This conclusion is supported by research on the relationship between improved digitization and the flow of remittances in order to fill the void caused by staying at home and being quarantined due to Covid-19 (Emara and Zhang, 2021). This analysis compares Brazil, Russia, India, China and South Africa on the Digital Ecosystem Development Index and proves that an initial improvement in digitization may lead to an
increase in remittance inflows, however, once the digitization index reaches a threshold, further improvement in digitization tends to decrease. This result, which has been presented in related studies, means that the marginal effects of digital development are greater when this development begins at a lower level (Appiah-Otoo and Song, 2021; Lamberti et al., 2021; Maneejuk and Yamaka, 2020). Thus, marginal effects reflect different countries' digital development; different levels of infrastructural digitalization lead to different amounts of Internet use.

2.5. Between-country differences in the digital divide and digital development

In light of the evaluation of ICT use as an indicator of the digital divide and its relationship to digital development across countries, only a limited number of studies use a multi-level indicator approach (Appiah-Otoo and Song, 2021; Xu and Reed, 2021; Habibi and Zabardast, 2020; Ali et al., 2020). However, the use of the indicators on macro, business, infrastructural and individual levels, which are mentioned above, reflects the digital development of the country and digital inequality in Internet use in terms of its frequency, activity, use in the cloud more informatively. In this study, we use digital development and digitalization interchangeably.

The literature on the determinants of changes in Internet use does not consider how this use has changed during the pandemic crisis, taking into account the levels of digital development and cross-country comparisons. To fill this gap, we assess changes in Internet use for the EU countries during the Covid-19 pandemic in 2020 across macro, business, infrastructural and individual levels. Based on prior evidence, it might be predicted that the determinants of changes in Internet use are potentially related to the level of the digital development in a country, which has been turbulent during the Covid-19 crisis. We assume that a higher level of digitalization
and a higher penetration of ICT into the economy, society, infrastructure, employment and personal lifestyle leads to a higher
dependence, which, in a crisis, can reduce Internet usage. The following hypotheses are identified in the study.

**H1.** There is a relationship between reduced Internet use and the digital development of a country. H1 will be supported if there is a
significant relationship between high digitalization and reduced Internet use.

**H2.** There are differences in the strength and direction of the relationship between Internet use and digital development on the
macro, business, infrastructural and individual levels. H2 will be supported if there are significant differences between countries in the
use of the Internet with respect to the different indicated levels of digitalization.

### 3. Data and method

#### 3.1. Data

We employ indicators of Internet use and digital development from the Eurostat database for 31 European countries from 2014 to
2020. The reason for choosing Eurostat as the data source is related to the possibility of observing the period before the pandemic, from
2014 and includes data for 2020 with the first and second waves of the coronavirus. We use two groups of countries to evaluate
hypotheses on dependence of Internet use on digital development. Group A includes four countries that have more than one negative
change for the four observed dependent indicators on Internet use for 2018–2020. These are Denmark, Norway, the Netherlands, and
Estonia. Group B includes 24 other EU countries and Iceland, Switzerland, and the UK. All countries form 31 observation units. The
panel data is balanced, time-series and cross-section. The missing values are less than 5% on average for the study’s variables.

![Figure 3. Change in frequency of Internet use in EU countries, 2018–2020, % Source: Eurostat Notes: France, Italy and Switzerland have no data for 2020; Denmark, Finland has zero changes for 2019/2018; Estonia, Austria, Sweden has no changes for 2020/2019.](image-url)
3.2. Method

The study employs the generalized least square (GLS) random-effects estimation that is the appropriate choice if the focus is on the effects of country-level predictors or the variance component structure (Green, 2003). The GLS random-effects model fits a panel-based regression with its capability of controlling for missing data and serial correlation. The GLS model also follows the assumptions of a normal distribution, linearity, homogeneity of variance, and independence. This approach allows us to evaluate the presence or not the relationships between dependent/independent variables according to H1, H2 with potentially smaller variance of country effect.

The dependent variables include four indicators of information society that relates to different sides of Internet use by individuals: (1) Internet use, (2) Internet activities, (3) the frequency of Internet use, and (4) use of cloud service (Table 1). These indicators reflect the digital divide in Internet use and have been used as explanatory variables in other studies (e.g., Van Deursen, 2020; Su et al., 2020; Blank and Groselj, 2014; Helsper and Gerber, 2012).

The independent variables include indicators, which reflect the country’s digital development on four levels (Table 1). The first level includes macro indicators such as an expenditure and budget allocations for R&D, human resources in S&T. The second level refers to the digital development of corporations and includes indicators of business expenditure on R&D, and employment and training related to ICT. The third level refers to digital infrastructure and contains indicators of Internet access, broadband, and mobile Internet access. The fourth level reflects the Internet use of individuals for online purchases, using e-government services, and financial activities. The independent variables were included in the study taking into account research on the topic of digital development and ICT use (e.g., Wang et al., 2020; Nair et al., 2020; Csordás, 2020).

The empirical specification used is expressed as:

$$ y_{it} = \beta x_{it} + \eta_i + \epsilon_{it} $$

Fig. 4. Change in use of cloud services in EU countries, 2018–2020, % Source: Eurostat Notes: France, Italy and Switzerland have no data for 2020; Portugal has no changes for 2020/2019; Croatia, Bulgaria has zero changes for 2019/2018.
where $i$ is the number of countries, $t$ is the number of time periods, $y_{it}$ is the dependent variable, $\beta_i$ is the country-specific random effect, $x_{it}$ is the independent variable, $\eta_i$ is the individual (sample) residual, which is the random characteristics of the unit observation the $i$-th and remain at all times, $\epsilon_{it}$ is the model residual as a whole where the residual is a combination of cross-section and times series.

The equation is used for a comparison of the countries in group A and B for the 4 dependent variables within 4 levels.

A pre-estimation analysis of the data reveals that GLS with random effects is the correct estimation procedure. The choice of the approach was between independently pooled panel and random between/within effects model, and between fixed and random effects models. We apply the Breusch-Pagan test (Lagrange multiplier test) and Durbin-Wu-Hausman test. The results, given in Table 2, indicate that the variability between countries is random and uncorrelated with the independent variable and a further regression analysis with random effects should be performed. Since the random effects approach may reflect cross-sectional heterogeneity and temporal variation in the dependent variable that may have variance on the country level, we estimate the correlation between individual and model residuals, which indicates their low association (Green, 2003) (Table 2). All of them prove the fitness of the method used and data for further analysis.

4. Analysis and results

4.1. Descriptive analysis

The descriptive analysis shows an emerging decline in Internet use that occurred across EU countries in 2020 (Figs. 1-4). Despite an increase in Internet use on average in the EU and the euro area in 2019–2020, some countries show a one-off decline in Internet use, while others show more stable trends. This tendency in various forms of Internet use appeared in 2019 in the EU, that is, before the pandemic, however it became more pronounced in 2020.

Changes in Internet use in the EU show that despite the growth in 2019–2020 and 2018–2019 for most countries, there was a decrease in a number of countries that revealed in 2018–2019: in Denmark by $-1.02\%$, in Estonia by $-1.10\%$, in the Netherlands by $-1.04\%$ and in Norway by $-1.01\%$. This tendency in 2019 compared to 2018 intensified in 2020 (Fig. 1).

Changes in the percentage of individuals making voice and video calls via the Internet show partly the same tendency. The decline

### Table 3

GLS regression results with random effects in the countries in Group A.

|                      | Internet use | Internet activity | Frequency of Internet use | Use of cloud service |
|----------------------|-------------|-------------------|---------------------------|----------------------|
| (1) Macro            |             |                   |                           |                      |
| Gross domestic expenditure on R&D | 0.0090 (0.0014) | 0.0246 (0.0077) | 0.0111 (0.0014) | 0.0316 (0.0054) |
| Government budget allocation on R&D | −32.3534 (14.5582) |
| Human resources in S&T | 0.36059 (0.0804) | 3.3067 (1.0753) | 0.6773 (0.0704) | 2.8882 (0.7365) |
| R-sq.                | 0.9562 (0.0016) | 0.6359 (0.0074) | 0.8946 (0.0097) | 0.9726 (0.0097) |
| Enterprises that employ ICT specialists | −1.4451 (0.4121) |
| R-sq.                | 0.1741 (0.0145) | 0.2757 (0.0291) |
| (3) Infrastructural  |             |                   |                           |                      |
| Level of Internet access – households | 0.9333 (0.1807) | 0.8818 (0.1386) |
| Broadband and connectivity – households | −0.4438 (0.1186) | −0.2938 (0.1033) |
| Individuals – mobile Internet access | 0.1377 (0.0420) | 0.1771 (0.0556) | 0.5236 (0.2071) |
| R-sq.                | 0.9549 (0.0113) | 0.9652 (0.0715) |
| (4) Individual      |             |                   |                           |                      |
| Internet purchases by individuals | 0.1517 (0.0296) | 0.2310 (0.1014) | 0.1775 (0.0279) | 0.6262 (0.0177) |
| E-government activities of individuals via websites | 0.0739 (0.0184) | 0.8345 (0.2430) | 0.6687 (0.0475) |
| Financial activities over the Internet | 0.5266 (0.0545) | 0.7295 (0.0477) | 0.2503 (0.1160) |
| R-sq.                | 0.9929 (0.0175) | 0.9962 (0.0992) | 0.9239 (0.0475) |
| Mean                 | 94.75        | 52.29             | 92.39                     | 45.19                |
| Obs.                 | 28           | 28                | 28                        | 27                   |

Notes: confidence level – $p > 0.05$, robust standard errors in parenthesis, Obs. – number of observations, Mean – the average of a dependent variable.
in such Internet activities was in Denmark by –16.42% and in Croatia by –7.69% in 2019 compared to 2018, and a slight decrease in the UK by –3.70% in 2020 (Fig. 2). However, all other EU countries are showing growth in 2020 associated with an increase in remote and online communications via online video calls.

The change in the frequency of Internet use more than once a week (including every day) shows that, along with a single example of a decrease in such Internet use in Iceland by –1.01% in 2019 compared to 2018, in more ‘frequent’ 2020, there were two examples of declining Internet activities. In the Netherlands, the decline was –2.11% and in Norway –2.04% (Fig. 3).

Changes in the use of cloud services shows two cases of decrease: in Hungary by –3.03% and Finland by –6.52% in 2019 compared to 2018 (Fig. 4). This trend continued in 2020. Despite the need for more cloud services with remote employment, communication and education, in Estonia this service decreased by –7.15%, in Ireland by –10.00%, in Latvia by –3.23%, in Luxembourg by –6.25%, in the Netherlands by –7.69% and in Norway by –3.57%. As a rule, such tendencies concern the EU countries that are most developed in the field of digital technologies. Among the EU countries showing such a decline in Internet use in 2019/2020 are the Netherlands, Norway, Estonia and Denmark. These countries are leaders in some ICT rankings. By the Global connectivity index, Denmark, the Netherlands, Norway, and Estonia were 5th, 7th, 10th, and 24th, respectively, in the world in 2020 (Global connectivity index, 2020).

The decline in Internet use occurred in these countries during 2020, the first year of the Covid-19 pandemic, which may be a response to the need for more cloud services with remote employment, communication and education, in Estonia this service decreased by –7.15%, in Ireland by –10.00%, in Latvia by –3.23%, in Luxembourg by –6.25%, in the Netherlands by –7.69% and in Norway by –3.57%. As a rule, such tendencies concern the EU countries that are most developed in the field of digital technologies. Among the EU countries showing such a decline in Internet use in 2019/2020 are the Netherlands, Norway, Estonia and Denmark. These countries are leaders in some ICT rankings. By the Global connectivity index, Denmark, the Netherlands, Norway, and Estonia were 5th, 7th, 10th, and 24th, respectively, in the world in 2020 (Global connectivity index, 2020).

The decline in Internet use during the crisis. This reflects the greater impact of the crisis and the emergence of a possible inverted digital divide in the most digitally advanced countries.

### 4.2. Regression analysis and results

The regression results of the relationship between Internet use and digital development on four levels in the countries in groups A and B show the significance of such a relationship (Tables 3, 4).

Group A demonstrates a higher dependency between the indicators of Internet use and the indicators of four digital-characterized levels as a more significant relationship and by the number of related indicators. Group A show the higher relationship between all of digitally-based indicators and indicators of Internet use in five cases between: (1) use of cloud service and digital indicators on macro level, (2,3) Internet use (frequency of Internet use) and digital indicators on the infrastructural level, (4,5) Internet use (use of cloud services) and digital indicators on micro level. In group B, there is a weaker relationship between Internet use and all digital indicators, only the frequency of Internet use depends on all infrastructural characteristics.

To compare the results of the two regressions, we graph two trends by the two groups of countries, which reflect the significance
and direction of the bivariate relationship between indicators of Internet use and indicators of digital development (Fig. 5).

We chose only those indicators that have statistical significance in all groups of countries and can be compared. In Fig. 5, we can see similar tendencies between the two groups of countries, even with different slopes; some of them demonstrate opposite directions of the relationship between Internet use and the indicators of digital development. These include (1) the frequency of Internet use and human resources in S&T, (2) the use of cloud services and human resources in S&T, (3, 4, 5) Internet activity (the frequency of Internet use, the use of cloud service) and e-purchases by individuals, (6) Internet use and e-government activities of individuals via websites. For other indicators of Internet use versus indicators of digital development, opposite trends are already visible between the two groups of countries.

The marginal effects for the two groups of countries according to the regression are presented graphically (Fig. 6, Appendix). We have identified variables for which both groups of countries have a statistically significant relationship between the indicators of
Internet use and the indicators of digital development. The results show considerable marginal effects on comparable variables between the two groups of countries. The most marginal effects are present at the micro level of digitalization when comparing Internet use (Internet activity, use of cloud services) and types of e-services (e-purchases, e-government, e-finance) and comparing Internet activity and digital development in business (business enterprise expenditure on R&D, enterprises that employ ICT specialists and provide ICT training).

5. Discussion

In this article, we assess the impact of different levels of digital development on Internet use as an indicator of the digital divide during the Covid-19 pandemic in EU countries. We examine the relationship between indicators that reflect digital development into a country on the macro, business, infrastructural, and individual levels, and indicators of Internet use, Internet activity, frequency of
Internet use and use of cloud service. We prove the emergence of an inverted digital divide, based on the decline in Internet use during the pandemic, primarily in countries with a high digital development in the EU.

The findings show that the most digitally developed countries reduced their Internet use during the Covid-19 pandemic in 2020. The regression results indicate that there is a significant relationship between Internet use and digital development indicators in a country, and this relationship is stronger in countries with higher digital development. Countries with high digitalization demonstrate a higher dependence between the indicators of Internet use and digital indicators with a more significant relationship and, by the number of related indicators. This partially confirms our H1, proving the relationship between the changes in Internet use and most indicators of digital development on the macro, business, infrastructural and individual levels. The partial confirmation of H1 lies in the selective nature of this relationship not for all observed indicators. H2 was confirmed as we obtained evidence of differences in the

Fig. 5. (continued).
significance and directions of the relationship between Internet use and digital indicators in the two groups of countries, which differ in digital development. Our main conclusion is that the greater development of digital technologies in a country means higher digital dependence in the economy, employment, services, which, in a crisis as the Covid-19 pandemic, can lead to a decrease in the use of the Internet and ICT on the whole.

The following findings are partially in line with previous studies and develop them. First, while we justify the dependence of Internet use on the development of digital technologies in the country (Abeliansky and Hilbert, 2017), we also obtain the variability of this dependence on different levels of digitalization: macro, business, infrastructural, and individual (Su et al., 2020). One of the interesting findings is the significant relationship between all indicators of Internet use applied in the study and such macro indicator as human resources in S&T, and this is typical for all EU countries, regardless of their level of digital development. This supports the thesis about the importance of human capital, its skills and education in the use of information technologies (Emara and Zhang, 2021; Wang et al., 2020). At the same time, the relationship between expenditures on R&D and Internet use is characteristic only for countries with high digital development.

Second, the close relationship between the use of the Internet and educational/ training programs in ICT once again confirms the influence of a person’s technological competence on the use of information technology, which is consistent in all observed EU countries (Csordás, 2020). However, in countries with a high digital development, there is a negative relationship between Internet activity and ICT workers in enterprises, reflecting a strong correlation during the pandemic between digital employment and its decline during lockdowns, despite the introduction of some remote work opportunities. This highlights the possible vulnerability of the ICT industries and their employees to the decline in ICT employment during crises for highly digitalized economies.

Third, we found a closer relationship between the Internet use and two levels of digitalization: infrastructural and individual for all EU countries. The regression analysis of the relationship between digitalization and Internet use confirmed both the importance of applying such levels and, above all, the individual level of digital development, which can better explain the use of the Internet (Su et al., 2020). Individual characteristics, such as possible reasons of changes in Internet use during the Covid-19 pandemic, may include the different ways in which the Internet is used for information, communication and entertainment, which change during the pandemic (Van Deursen, 2020), as well as a decrease in personal digital communications with family and friends; and in limiting places with free Internet access due to isolation measures (Nguyen et al., 2020).

Fourth, we obtained pronounced marginal effects, represented by graphically comparable indicators of Internet use and indicators of digital development between the two groups of EU countries, depending on their digitalization (Appiah-OOoo and Song, 2021; Lamberti et al., 2021; Maneejuk and Yamaka, 2020; Abeliansky and Hilbert, 2017). The most marginal effects are present on the individual level of digitalization when comparing Internet use and types of e-services and comparing Internet activity and digital development in business. Since we are comparing only two groups of countries with high digital development and the rest of the countries, which can be different from each other, the comparison with a more detailed division into groups can be considered as a direction for future research. We assume that the current reduction of Internet use during the crisis due to greater digital dependence in countries with high digitalization may further manifest in other countries as their digital development continues and its marginal effects are achieved.

6. Conclusions

The findings of this study allow us to make the following conclusions. The theory of digital inequality may be augmented with a new dimension: an inverted digital divide caused by a decline in Internet use in countries with high digital development, and in an empirical explanation for this digital divide, which manifested in a crisis and leads to an unequal reduction in the use of ICT in the economy, business, employment, etc.

We also assume that more research and policy focus should be given to assessing digital dependence in economies, employment and
services due to the potentially high risks of such dependence in countries with a high digital penetration and the manifestation of digital dependence during a crisis.

Given the general nature of the initial conceptual approach used in our study, our results might be considered a forerunner of the inverted digital divide trend in other countries with fast-growing digital development. Therefore, it would be worthwhile to use this approach with additional digital indicators in future international studies and longitudinal surveys.

Since we use certain indicators of both Internet usage and digital development in this study, there may be some limitations when comparing other similar indicators. These indicators can be complemented by others that reflect the qualitative characteristics of Internet use, for example, bandwidth, and digital development, for example, the quality of digital infrastructure: 5G/6G, Wi-Fi, wireless and broadband, etc.

Fig. 6. The relationship between Internet use and digital development in the 2 groups of EU countries.
The empirical results of our study used a random effects model. Future studies could consider the possibility of cluster analysis across countries with different levels of digital development. In addition, given that we have obtained evidence of the influence of human resources employed in S&T, R&D, as well as business on the use of the Internet, it would be interesting to assess the relationship between employment indicators, including remote employment and the use of various information technologies.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
Data availability

Data will be made available on request.

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Fig. 6. (continued).
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