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Digitalisation and income inequality in Central and Eastern European countries

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Abstract

The COVID-19 pandemic has highlighted the importance of digital technologies in business and daily life. The paper aims to explore the theoretical and empirical aspects of the relation between digitalisation and income inequality in Central and Eastern European (CEE) countries between the years 2000–2020. It contributes to existing research on determinants of income inequality, focussing on the potential negative role of digitalisation as an unnoticeable driver of income inequality in CEE countries. To investigate the potential impact of digitalisation on income inequality, empirical analysis was performed for a sample of 10 CEE countries, namely Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Slovak Republic and Slovenia. The results of the canonical correlation analysis indicated that the sets of variables related to digitalisation and inequality as a group are significantly related to each other and a strong correlation exists between them. The relative contribution of each indicator to each standardised function showed that the highest values of significant standardised coefficients were observed for income inequality indicators such as the top 10% share, the Gini coefficient and the top 1% share, while in digitalisation measures, the highest value was observed for Internet users as well as fixed and mobile broadband subscriptions.

Keywords

- income inequality
- digitalisation
- canonical correlation
- Central and Eastern European countries

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Introduction

The years of the COVID-19 pandemic have shown how important and irreplaceable digital technologies are in our business and daily life. The growing importance of digital technologies or the so-called digital transformation (sometimes referred to as revolution) began to reshape the world of business and work in profound ways even before the pandemic, which, however, has significantly accelerated these processes (Götz et al, 2018; Kraus et al., 2021; Verhoef et al., 2021; Vial, 2019). Some commentators argue that digitalisation can become a new engine of economic growth by increasing capital and labour productivity, lowering transaction costs and facilitating access to global markets (Arendt, 2015; Dahlman et al., 2016; Myovellaet al., 2020). But with new opportunities come new challenges. As digitalisation is impacting many areas of our lives, the gains from it seem to not spread evenly across economies. In the last two decades, together with the rapid adaptation of new digital technologies, income inequality has increased in practically all advanced economies. Are these megatrends of our time connected? This question seems to be particularly important in the case of Central and Eastern European (CEE) countries in which digitisation is considered one of the key drivers of economic growth. Furthermore, a growing number of recent empirical analyses show that income and wealth inequalities in Eastern Europe since the fall of socialism have increased significantly more than previously suggested (Brzeziński & Sałach, 2022).

Taking this into account, the main goal of the presented study is to explore the theoretical and empirical aspects of the relation between digitalisation and income inequality in CEE countries between the years 2000–2020. We hope that such stated goal will allow us to address the research question: How does digitalisation influence income inequality in Central and Eastern European (CEE) countries between 2000 and 2020, and what are the underlying theoretical mechanisms driving this relationship? The choice to analyse this relation in the years 2000–2020 stems primarily from data availability constraints, particularly regarding digitalisation metrics. During this period, data collection and reporting on digitalisation-related indicators in CEE countries gradually improved, albeit from a relatively low starting point. The level of digitalisation in these countries was notably limited during this timeframe, characterised by slower adoption rates compared to more developed regions. Furthermore, it is essential to note that several countries within the CEE region joined the European Union during this timeframe, influencing their economic and policy landscapes, including their approach to digitalisation and its implications for income distribution.

This article hopes to contribute to existing extensive research on determinants of income inequality, focussing on the potential negative role of digitalisation as an unnoticeable driver of income inequality in CEE countries. This group of countries seems to be especially interesting not only because comparative evidence on the relation between digitalisation and inequality in this group is scant but also because this geographical region has distinct cross-country patterns in digitalisation and income inequality trends.

To investigate the potential impact of digitalisation on income inequality in the studied countries, two main data sources have been used. Indicators related to the level of digitalisation indicated by data on access to and use of ICT by households and individuals have been obtained from the International Telecommunications Union (ITU), a specialised United Nations agency for information and communication technologies. Income inequality estimates were received from the World Inequality Database (WID.world). Empirical analysis was performed for a sample of 10 CEE countries, namely Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the Slovak Republic and Slovenia over the period 2000–2020. The selection of specific variables was sometimes limited due to the availability of the data.

The remainder of this paper is structured as follows. Section 2 describes the key theoretical findings on the potential relation between digitalisation and income inequality, focussing on channels through which digital transformation is affecting income inequality. Section 3 discusses general trends in income inequality and digitalisation trends in CEE countries. Consequently, section 4 aims to study the empirical relation between the digitalisation and income inequality in CEE with the method of hierarchical canonical correlation analysis. Finally, the last section concludes the article.

1. Digital transformation and inequalities – literature review

The matter of increasing income inequality is publicly debated in most developed countries. Books such as Deaton (2013) or Piketty (2014) have spurred worldwide interest in income and wealth inequality, making this topic one of the most popular topics in both empirical and theoretical analyses. In the cauldron of scientific as well as socio-political debate, much of the blame for the rise in income inequality is heaped on factors such as globalisation, liberalisation, financialisation, inefficient labour market institutions, education, etc. (Roine & Waldenström, 2015). However, current developments related to the COVID-19 pandemic and the connected and rapid acceleration in the implementation of new digital technologies force us to focus on another traditional and well-studied driver of income inequality, that is, technological change. As indicated, an especially interesting and important element of contemporary technological change is the ongoing transformation of the economy toward a digitalised production and work environment, a phenomenon called digitalisation (Butryn, 2020).

It seems that concerns related to the impact of technology on the working population and its possible negative consequences on the labour market, including income distribution, have been one of the core concerns of economists for as long as economics has been considered a distinct field of study. For example, Berg (1980) has gone so far as to argue that the debate on the machinery question that emerged in the wake of the Industrial Revolution was instrumental in the birth of the new science of economics during the mid-19th century. Almost a hundred years later, in 1933, John Maynard Keynes made a frequently cited prediction of widespread technological unemployment, arguing that "due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour" (Keynes, 1963, p. 364). Although contemporary economists no longer use terms such as "machinery question" or "intellectual machinery" to frame the debate over new technology and the labour market, current concerns about the effects of technology are remarkably similar to those of the past. Although there is a broad consensus on the positive impact of digital transformation on productivity and its effect on economic growth (Gal et al., 2019), the impact on the labour market and its different elements, including expected income inequalities and wage polarisation, remain a matter of debate.

In general, there is a consensus among researchers that digitisation contributes to the exacerbation of inequalities. This effect can be analogised to the phenomenon described by Simon Kuznets (1955) in his famous Kuznets curve, where sectors or job locations experiencing digitisation yield higher incomes. The transition from an industrial to a digital economy is at play here. However, there remains no consensus regarding the specific mechanisms through which this phenomenon occurs. Various factors are involved in this process. For example, Qureshi (2021) argues that the uneven diffusion of new digital technologies between firms is of great importance both for productivity dynamics and income distribution. The fact that new digital technologies have been captured for the most part by a relatively small number of larger firms in which productivity growth has been relatively strong while it has slowed considerably in the vast majority of other, typically smaller firms. This process has resulted not only in the growth of inequalities in productivity performance between firms, but also caused income disparities to rise. For the author of this paper, much of the blame for the ongoing increase in income inequality is attributable to increased wage differences between firms. A similar argument is presented by Song et al. (2019); these authors used a massive, matched employer-employee database for the United States and found that one third of the rise in the variance of earnings occurred within firms, whereas two-thirds of the rise occurred due to a rise in the dispersion of average earnings between firms. However, this rising between-firm variance is not accounted for by the firms themselves, but by a widening gap between firms in the composition of their workers. Furthermore, the results obtained indicate that two-thirds of the rise in the within-firm earnings inequalities occurred within mega firms (10,000+ employees), which saw a particularly large increase in the variance of earnings compared to smaller firms. However, in a study aimed at analysing wage inequality patterns and their firm dimension in Central and Eastern European countries, they found that, unlike many other advanced economies, wage inequality levels have decreased in CEE countries during the 2000–2014 period and particularly in those countries that previously had the highest wage inequality levels (Magda et al., 2021). Furthermore, the relative size of the between-firm component of wage inequalities varied substantially between countries and was highest in countries with the highest levels of wage inequality. However, the authors revealed that, as in the case of previous studies, firms played an important role in shaping wage inequality in both the early 2000s and 2014, as wage inequality in CEE was greater between firms than within them.

Another strand of literature concentrates on the role of digital transformation in the shaping of individual wage inequality (wage differentials that arise within firms). The long history of these analyses has its roots in the literature on skill-biased technological change (SBTC) (Acemoglu, 2002; Autor et al., 1998; Card & DiNardo, 2002; Griliches, 1969; Katz & Murphy, 1992). This approach explains the growing wage inequality due to changing occupational tasks or skill requirements as a result of the fact that technology increases the demand for educated workers, thus allowing them to command higher wages. In more recent studies, the observed increase in wage inequality is usually attributed to SBTC, associated with new computer technologies. For example, Frey and Osborne (2017) focus on the effects of digitalisation on the occupational composition of the labour market and argue that digitalisation will primarily hit low-skill and low-wage jobs. According to their estimates, about 47% of the total US employment is at risk, causing a potential increase in the level of income inequality. Fiedler et al. (2021) analysing the impact of industrial robots, as well as investments in computing equipment and digital technologies on different indicators of income distribution, found that robot density is positively associated with income inequality, while no robust evidence was found for computing equipment and digital technologies. Their results indicate that the income shares of the bottom 20% and 50% decrease with automation, while the income shares of the top 10% and 1% increase, which supports the job and wage polarisation hypothesis. Acemoglu and Restrepo (2022) documented that between 50% and 70% of changes in the US wage structure over the last four decades are accounted for by relative wage declines of worker groups specialised in routine tasks in industries experiencing rapid automation. Moll et al. (2022) showed that automation can increase inequality not only by increasing high-skilled labour wages but also by raising returns to wealth. The benefits of new technologies accrue to owners of capital in the form of higher capital incomes and to most qualified workers in the form of higher wages. Mönnig et al. (2019) in a future-orientated study using a macroeconometric input-output model, which accounts for circular flow in the economy and feedback loops, predict that digital transformation increases wage inequality especially at the upper end of the distribution, although to a low extent. The authors emphasise that the mechanism through which digital transformation is impacting wage inequality refers to the fact that digitalisation strengthens the unequalising role of structural change. In an earlier study by Antonczyk et al. (2009), in which changes in the German wage structure for full-time working males were investigated from 1999 to 2006, the authors concluded that only wage dispersion at the top of the wage distribution can be observed. Keister and Lewandowski (2017) studied the shift from manual to cognitive work in 10 Central and Eastern European economies and found that in all countries routine cognitive tasks were most common in the middle of wage distribution but increasingly rare among the top earners. They concluded that if technological progress reduces demand for routine work, a large proportion of workers would be affected and wage inequality would rise.

Summing up this short review of studies related to the impact of technological change, including processes of digital transformation on wage inequality, it is interesting to note that most authors assume that digital transformation plays an important role as a driver of income inequalities; however, there is no agreement on the main channels and the scale of this relation.

2. Inequality levels and digital transformation in CEE countries

Before transformations, income inequalities were relatively low in socialist countries, primarily stemming from ideological motives that aimed to flatten the pay structure (Bukowski & Novokmet, 2017; Novokmet, 2017). Additional contributing factors included low registered unemployment, measures to prevent intergenerational transfer of private assets, price subsidies, rationing and non-wage remuneration. Moreover, socialist states boasted a higher percentage of working women compared to western countries (Flemming & Micklewright, 2000). However, it is essential to note that despite low-income inequalities, there were pronounced consumption disparities due to the scarce and regulated access to commodities. Obtaining rare products relied on personal connections, party membership and hierarchies within the communist party (e.g. exclusive stores accessible only to party activists, security personnel and high-ranking officials). In the 1990s, income inequality underwent significant transformations – it not only increased but also became more diverse, which is a phenomenon unprecedented in other regions (Milanovic, 2001). Over a decade, the average Gini coefficient, a measure of income inequality, increased by 0.10 points, indicating a rapid shift towards greater inequality in these countries compared to western counterparts. This rise was particularly marked within former Soviet Union countries, while countries that later joined the European Union (that is, our study group) experienced a milder change in this area (Alvaredo & Gasparini, 2015).

The natural starting point of the analysis of the distributional consequences of digitalisation and the possible role of digital transformation in the process of polarisation of income in CEE countries is the analysis of the indicators related to the inequality levels. In this analysis, measures such as Top 1%, Top 10%, Top 10% to Bottom 50% ratios and values of the Gini index of pre-tax income for years 2000–2020 obtained from the World Inequality Database were used (see Figure 1 and Figure 2). As Figure 1 indicates, the countries differ significantly both in terms of the levels of observed inequalities and the trends and dynamics of income disparities. Countries such as the Czech Republic, Hungary, Poland, the Slovak Republic and Slovenia exhibited stabilisation or even a small decrease in the range of indicators analysed even after initial growth in inequalities indicated by an increase in income shares and the Gini index in the early 21st century. However, in countries such as Bulgaria, Estonia, Latvia, Lithuania and Romania, a much greater variation can be observed. It is important to note that the highest level of income inequality was observed between the countries studied in Bulgaria and Romania. The Gini index reached as high as 0.55 in 2020 for these countries. The share of income going to the top 10% was 43.5% in Bulgaria and 41.4% in Romania and the top 1% shares were 18.3% and 14.4%, respectively. The lowest levels of inequalities were observed in the Czech Republic and the Slovak Republic, where the Gini index value in 2020 amounted to 0.37; the share of the top 10% was 28.6% in the Czech Republic and 26.5% in the Slovak Republic, and the top 1% shares were 10.1% and 7% respectively. While analysing income inequality trends in this group of countries, it is also worth spotting the rapid increase of all measures related to inequalities in Bulgaria in the last few years and the significant decrease of inequalities in Estonia since 2004.

In verifying the potential relationship between digitalisation and inequality levels in CEE countries, indicators such as the proportion of individuals using the Internet, data on fixed and mobile subscriptions to high-speed access to the public Internet (a TCP/IP connection), and the indicator related to international Internet bandwidth (bits/s) per Internet user were used. Data availability in the case of the last two indicators is limited. Looking at one of the most natural, as

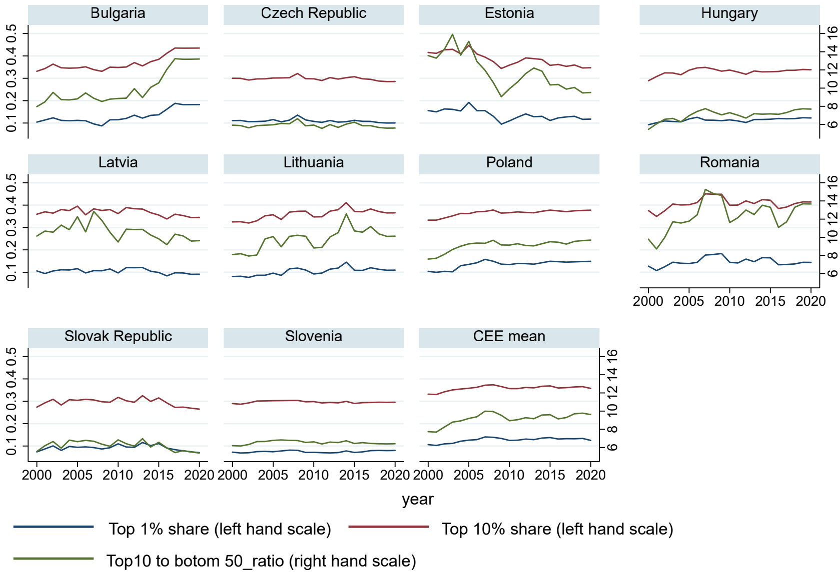

Figure 1. Income inequalities in 2000–2020 in CEE countries

Note: The CEE mean was calculated as population weighted average.

Source: own elaboration based on data from the World Inequality Database (https://wid.world/)

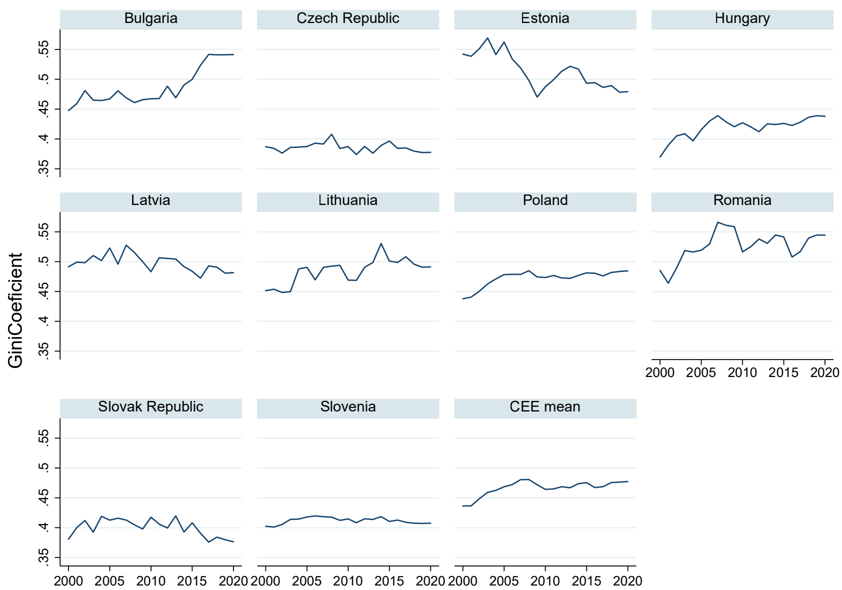

Figure 2. Gini coefficient in 2000–2020 in CEE countries

Note: The index ranges from 0 to 1; the higher the index the more unequal the income distribution. The CEE mean was calculated as population weighted average.

Source: own elaboration based on data from the World Inequality Database (https://wid.world/)

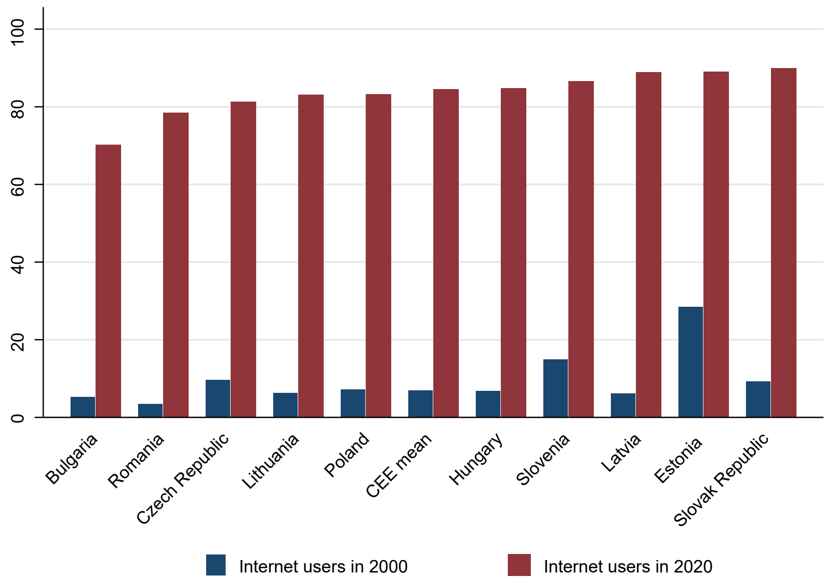

Figure 3. Internet users in 2000 and 2020 in CEE countries (% of population)

Note: The CEE mean was calculated as population weighted average.

Source: own elaboration based on data from The International Telecommunication Union (ITU) (https://www.itu.int/en/Pages/default.aspx)

well as the broadest, indicator of the level of societal digitalisation, namely the share of the population using the Internet (presented in Figure 3), an immense growth in the popularity of the Internet can be observed. In 2000 only the share of Internet users in Estonia was higher than 20%. Compare that with 2020, where the indicator exceeded 80% in most countries. The lowest shares were observed in Bulgaria and Romania, where the shares of internet users reached 70.16% and 78.45% in 2020, respectively, while the highest values – almost 90% – were observed in Latvia, Estonia and the Slovak Republic.

After analysing the next two indicators (see Figure 4) related to the digitalisation, namely the number of active fixed- and mobile-broadband subscriptions per 100 inhabitants, two main trends can be observed. First, the level and dynamics of fixed broadband subscriptions were similar among the entire studied group. The number of fixed subscriptions increased steadily from almost nil in 2000 to around 30 subscriptions per 100 inhabitants in 2020. The change in mobile broadband subscriptions was much more rapid and diverse. In the last ten years there has been a doubling in subscriptions and, in some countries, even a tripling in countries such as Latvia, Estonia and Poland in 2020 to the levels of 141, 165, and 197 subscriptions, respectively. These data indicate that, for example, in Poland in 2020 on average there were two devices connected to the broadband Internet per person.

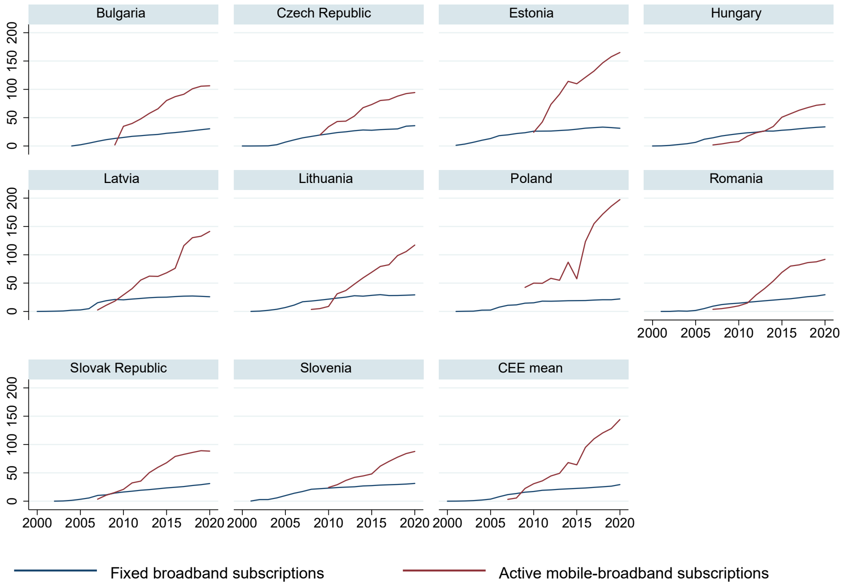

Figure 4. Fixed and mobile broadband subscriptions in CEE countries (per 100 inhabitants)

Source: own elaboration based on data from The International Telecommunication Union (ITU) (https://www.itu.int/en/Pages/default.aspx)

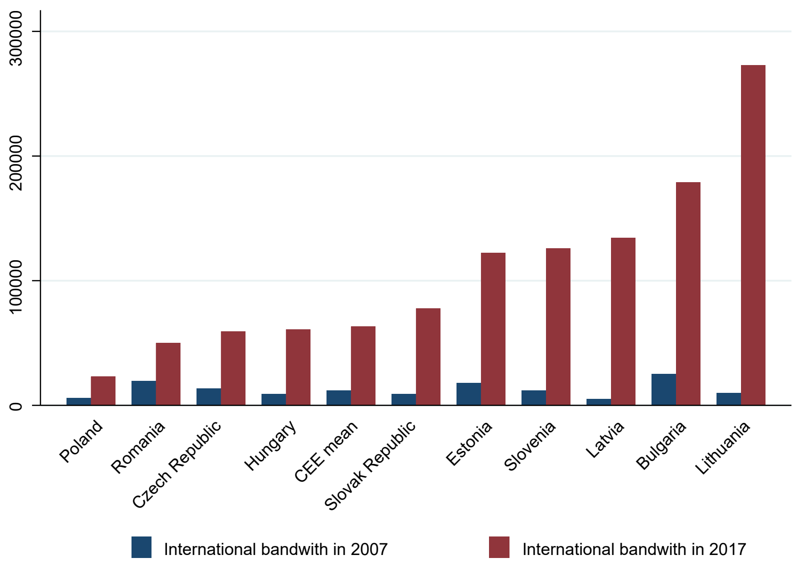

Figure 5. Fixed and mobile broadband subscriptions in CEE countries (per 100 inhabitants)

Note: International Internet bandwidth (bit/s) per Internet user is calculated by converting to bits per second and dividing by the total number of Internet users. Due to data availability analysis covers the years 2007-2017.

Source: own elaboration based on data from The International Telecommunication Union (ITU) (https://www.itu.int/en/Pages/default.aspx)

The last indicator related to the level of digitalisation, that is, international bandwidth per Internet user, is an indicator showing the maximum quantity of data transmission (rate) from a country to the rest of the world. It is worth underlining that this indicator is sometimes used to measure the level of development of digital infrastructure in a country (Di et al., 2022). As the data in Figure 5 indicate, CEE countries differ significantly in terms of the speed of international Internet bandwidth, which has increased significantly since 2007. The lowest level of these indicators was observed in Poland, with an average value of 22k (bits/s), while the highest value was observed in Lithuania of 272k (bits/s). However, assessing data related to International Internet bandwidth, we have to remember that since 2017 (the last year with reliable data), a rapid growth in the quality of international bandwidth has been observed in most CEE countries. Therefore, the presented data should be seen as an indication of the dynamics rather than a measure of the levels of the studied phenomenon.

3. Relation between digitalisation and income inequality in CEE countries – empirical verification

To study the empirical relation between digitalisation and income inequality in CEE, canonical correlation analysis (CCA) was used. This analysis was carried out to test whether there is a difference between the indicators related to digitisation on the one hand, and income inequalities on the other. Basically, this method provides a simultaneous analysis of the set of dependent variables and the set of independent variables. In general, it determines whether two sets of variables are independent of each other in a linear sense. This is done by finding a composite for the multiple dependent variables and a composite for the multiple independent variables. These composites are correlated simultaneously to obtain a canonical function. This process continues until all the correlations between the two sets are included. In effect, this analysis allows for the evaluation of the strength of the overall relationships between the linear composites (canonical variates; a pair of canonical variates is called a canonical root), for the independent and dependent variables, as well as the relative contribution of each variable to the canonical functions (relationships) that are extracted (Hair et al., 2014, p. 17). The relative contribution of each variable can be evaluated by the canonical loadings and cross loadings which reflect the variance that the observed variable shares with the canonical variate and can be interpreted like a factor loading in assessing the relative contribution of each variable to each canonical function. The larger the coefficient, the more important it is to derive the canonical variate (Dattalo, 2014,

p. 12). An illustration of the canonical correlation analysis is presented in Figure 6. The objective is to find a linear combination (projection) of sets X and Y, or the rotated canonical space, by maximising the linear correlation between the two sets of new canonical variables U and V.

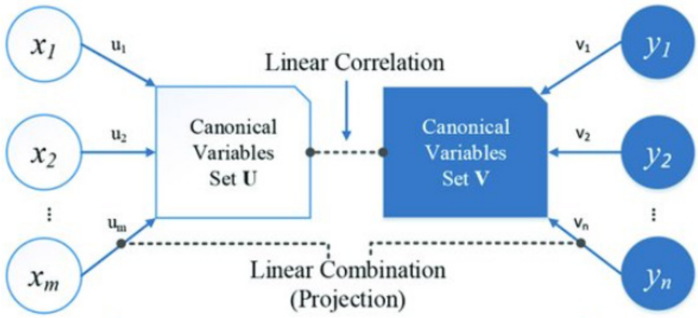

Figure 6. Schematic illustration of canonical correlation analysis

Source: own elaboration, based on (Fan et al., 2018).

The new feature space is constructed by canonical variables set U and V, which correspond to original (X and Y variables – in our case inequality and digitalisation indicators). Formally CCA can be formulated as follows:

$$\arg\max_{U\in Rp,\, V\in Rq} = \frac{U^T X^T YV}{\sqrt{\left(U^T X^T XU(V^T Y^T YV)\right)}} \quad (1)$$

where X is a $n \times p$ matrix that represents n samples in p-dimensional space; Y is a $n \times q$ matrix that represents n samples in q-dimensional space; X and Y are two sets of paired variables that correspond to *n* samples.

In order to investigate the potential interdependence of digitalisation and income inequalities in CEE countries, CCA was performed and tested in hierarchal form for the standardised sets of inequality and digitalisation indicators discussed in the previous section. The basic statistics of the variables used in CCA are presented in Table 1.

As already mentioned, the purpose of CCA is to determine the number of canonical variables (dimensions) that are significant in explaining the association between the set of variables related to the digitalisation and the measures related to the levels of income inequality in CEE countries. Table 2 shows the values of the canonical correlations, as well as the values of the Wilks' Lambda tests, which allows the verification of the significance of the assumed relation. The results obtained indicate that the canonical correlation is statistically different from zero for the combined canonical correlation functions (the p-value of Wilks' Lambda test

Table 1. Data used in CCA

Variables	(1) N	(2) mean	(3) sd	(4) min	(5) max
Gini coefficient	231	0.460	0.0499	0.370	0.569
Top 10% to bottom 50%	231	8.953	2.408	5.394	15.91
Top 10% share	231	0.348	0.0415	0.265	0.450
Top 1% share	231	0.116	0.0261	0.0689	0.192
Internet users	231	54.93	24.03	3.614	90.23
Fixed broadband subscriptions	220	17.13	10.51	0.0119	35.91
Mobile broadband subscriptions	141	64.60	42.63	1.895	197.4
International Internet bandwidth	135	91 168	114 647	5 084	729 708

Source: own elaboration.

for the first dimension is < 0.001), thus these results indicate that the sets of variables related to digitalisation and inequality as a group are significantly related to each other and there is a strong correlation between them. More specifically, in the case of the first pair of canonical variates (functions 1 to 4 root 1), a maximum canonical correlation of 0.7917 was extracted; this value indicates the possibility of a strong relation between the studied phenomena. Based on the residual variance, the other variates were tested in step-down order. The second, third, and fourth canonical variates had canonical correlations of 0.5701, 0.2825 and 0.1114, respectively. All but the last pairs of canonical covariates were statistically significant.

Table 2. Canonical corelation analysis results

Canonical dimensions (roots)	Canonical correlations	Wilks' lambda	*df* 1	*df* 2	*F*	Prob > *F*
Functions 1–4 (root 1)	0.7917	0.228902	16	348.913	13.5276	0.0000*
Functions 2–4 (root 2)	0.5701	0.613422	9	280.03	6.9194	0.0000*
Functions 3–4 (root 3)	0.2825	0.908745	4	232	2.845	0.0250*
Functions 4 (root 4)	0.1114	0.987581	1	117	1.4712	0.2276

Notes: asterisks denote 5% significance level, *p*-value is less than 0.05.

Source: own elaboration.

Table 3 shows the standardised canonical coefficients (weights) which present the relative contribution of each particular indicator to each canonical function. Standardised canonical coefficients are interpreted in a manner analogous to interpreting standardised regression coefficients. Taking into account the relative contribution of each digitalisation measure in CEE countries to each statistically

Table 3. Canonical corelation analysis results

Dimensions	Indicators	Coef.	Std. Err.	t	$P > \|t\|$	(95% Conf. Interval)	
Root 1	gini coefficient	–60.627	14.128	–4.29	0.000*	–88.598	–32.656
	top 10% to bottom 50%	0.238	0.228	1.04	0.299	–0.214	0.690
	top 10% share	73.755	15.269	4.83	0.000*	43.526	103.984
	top 1% share	–69.250	9.404	–7.36	0.000*	–87.867	–50.633
	internet users	0.092	0.010	8.86	0.000*	0.071	0.112
	fixed broadband subscriptions	0.023	0.025	0.93	0.357	–0.026	0.072
	mobile broadband subscriptions	–0.032	0.003	–10.88	0.000*	–0.038	–0.026
	international Internet bandwidth	0.000	0.000	0.52	0.601	0.000	0.000
Root 2	gini coefficient	153.867	26.391	5.83	0.000*	101.620	206.115
	top 10% to bottom 50%	–1.126	0.426	–2.64	0.009*	–1.970	–0.283
	top 10% share	–183.131	28.522	–6.42	0.000*	–239.597	–126.665
	top 1% share	108.833	17.566	6.20	0.000*	74.056	143.609
	internet users	0.064	0.019	3.33	0.001*	0.026	0.103
	fixed broadband subscriptions	–0.128	0.046	–2.75	0.007*	–0.220	–0.036
	mobile broadband subscriptions	0.025	0.006	4.58	0.000*	0.014	0.036
	international Internet bandwidth	0.000	0.000	–2.75	0.007*	0.000	0.000
Root 3	gini coefficient	–26.096	62.170	–0.42	0.675	–149.178	96.986
	top 10% to bottom 50%	2.164	1.004	2.15	0.033*	0.176	4.152
	top 10% share	–81.945	67.190	–1.22	0.225	–214.965	51.074
	top 1% share	–6.969	41.380	–0.17	0.867	–88.892	74.955
	internet users	–0.063	0.046	–1.37	0.172	–0.153	0.028
	fixed broadband subscriptions	0.278	0.109	2.54	0.012*	0.061	0.494
	mobile broadband subscriptions	0.001	0.013	0.10	0.919	–0.025	0.027
	international Internet bandwidth	0.000	0.000	–0.12	0.904	0.000	0.000

Notes: Asterisks denote 5% significance level, p-value is less than 0.05.

Source: own elaboration.

significant canonical function, that is, roots 1, 2 and 3, it can be noticed that the highest values of significant standardised canonical coefficients were observed for income inequality indicators such as the top 10% share, Gini coefficient and top 1% share, whereas in the case of digitalisation measures, the highest values of canonical weights were observed for indicators such as: Internet users and fixed and mobile broadband subscriptions.

The results of the canonical analysis indicate that there is an important relationship between inequalities and digitalisation, specifically in Central and Eastern European (CEE) countries. The analysis highlights the relative contribution of different digitalisation measures to statistically significant canonical functions.

The highest values of significant standardised canonical coefficients were observed for such income inequality indicators as the top 10% share, the Gini coefficient and the top 1% share. This suggests that income distribution plays an important role in shaping the relationship between inequalities and digitalisation in CEE countries. These indicators capture the concentration of income among the top segments of the population, which can have significant implications for social and economic dynamics.

However, the highest values of canonical weights were observed for digitalisation measures such as Internet users, fixed broadband subscriptions and mobile broadband subscriptions. This implies that these indicators of digitalisation have a strong influence on the relationship with inequalities. Internet users and broadband subscriptions represent access to information and communication technologies, which are vital for participation in the digital economy, accessing educational resources and connecting with opportunities.

The combination of high canonical coefficients for income inequality indicators and high canonical weights for digitalisation measures suggests that the level of digitalisation in CEE countries interacts with income inequalities. It implies that the extent of access and use of digital technologies has the potential to either exacerbate or alleviate existing income disparities.

Conclusions

The presented paper aimed to study the theoretical and empirical aspects of the relation between digitalisation and income inequality in CEE countries between the years 2000–2020. In the analysis of the relation between digitalisation and inequality, both qualitative and quantitative methods have been used.

The literature review indicates that the analyses related to the potential negative distributional consequences of technological change have a very long tradition dating back almost to the first independent economic analysis. While there is a broad consensus on the positive impact of digital transformation on productivity and its effect on economic growth, the impact on labour market and its different elements including expected income inequalities and wage polarisation remain a matter of debate. In the majority of conducted analyses, digital transformation is assumed to be an important driver of income inequalities; however, there is no agreement on the main channels and the scale of this relation. From one side, some authors argue that uneven diffusion of new digital technologies across firms matters greatly for both productivity dynamics and income distribution, resulting in the growing wage differences between firms. Another strand of literature assumes that wage differences arise within firms. This approach explains the growing income inequality due to changing occupational tasks or skill requirements as a result of the fact that technology increases demand for specialised skills, thus allowing skilled employees to command higher wages.

The empirical verification of the relationship between digitalisation and income inequality in CEE countries indicates that the studied countries differ significantly in terms of income inequalities and digitalisation trends. The highest level of income inequalities among the studied countries was observed in Bulgaria and Romania, while the least polarised as far as income inequalities are concerned were the Czech Republic and the Slovak Republic. Analysis of the indicators related to the digitalisation indicated a rapid increase of all indicators related to the implementation of new digital technologies in the studied period; however, some important differences can be observed. For example, in 2000 only the Estonian share of Internet users was higher than 20%, whereas in 2020 in most countries the indicator was higher than 80%.

A deeper empirical verification of the potential interdependence of digitalisation and income inequalities in CEE countries based on canonical correlation analysis indicated that the sets of variables related to digitalisation and inequality as a group are significantly related to each other and a strong correlation exists between them. Analysis of the relative contribution of each indicator to each canonical function showed that the highest values of significant standardised canonical coefficients were observed for income inequality indicators such as the top 10% share, the Gini coefficient and the top 1% share, while in digitalisation measures, the highest values of canonical weights were observed for indicators such as Internet users and fixed and mobile broadband subscriptions.

It is important to underline that conducted analysis underscore the intricate interplay between digitalisation and income inequality in CEE countries, shedding light on the multifaceted challenges and opportunities facing the region. It becomes evident that addressing the underlying socio-economic disparities is crucial for harnessing the full potential of digitalisation to foster inclusive growth. Concurrently, investments in enhancing digital infrastructure and promoting digital literacy are imperative steps towards building a more resilient and competitive landscape in the region. By tackling these issues holistically, CEE countries can pave the way for sustainable development and ensure that the benefits of digitalisation are equitably distributed across society.

The authors want to underline that analysing the correlation between various macroeconomic values is important to acknowledge that the presence of a correlation does not necessarily establish a definitive causal relationship, nor does it provide insight into the direction of the correlation being examined. While the results of the analysis may indicate associations between variables, it is crucial to exercise caution in attributing causality or inferring a specific cause-and-effect relationship based solely on the observed correlations. To truly understand the underlying dynamics and causal mechanisms at play, further research and a comprehensive analysis of additional factors are necessary.

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