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ANALYZING THE EFFECT OF ECONOMIC AND DEMOGRAPHIC FACTORS ON DIGITAL DIVIDE: THE CASE OF TRANSITION ECONOMIES

Abstract. *With the widespread use of information communication technologies, many people and countries with a lack of technology are growing. The term digital divide is a multifaceted phenomenon. It means the gap between people and countries with access to digital technologies and those with very limited or no access at all.*

The main purpose of this study is to investigate the factors affecting digital divide in selected transition countries. In the empirical analysis, The Panel Quantile Regression proposed by Machado and Silva (2019) has been applied. Using panel data for 20 countries for the period 1998 – 2014, the findings of this study revealed that economic and socio-demographic factors are the main predictors of the digital divide.

Keywords*: Digital divide, Panel quantile regression, ICT, Transition economies.*

JEL Classification: C31, C33, O33

1. Introduction

The digital revolution has had a significant impact on how businesses operate, how initiatives are funded, and even how creative-cultural items are produced (Baber and Fanea-Ivanovici, 2021). Nowadays the world has been taken by storm by digital technologies (Dzhalladova et al., 2019). The rapid growth and proliferation of digital technologies have brought a lot of benefits to society. While most societies in advanced economies can reap the benefits of these precious resources, members of less developed societies cannot make full use of the information resources. In other words, the digital divide exists between and within countries (Norris, 2001; Dewan, et al., 2005). The term digital divide can be described as the unseen boundary between those who can afford information

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technology and those who cannot afford it (Marcelle, 2004). The disparity in the rate of ICT adoption between advanced and emerging economies is another definition used to refer to the digital divide (Bagchi, 2005).

International Telecommunication Union (ITU) estimates have revealed that in 2019, only half of the population worldwide has access to the Internet. While in 1995, only 0.04 % of the population had access. Despite the increasing trend of Internet connections, the gap between internet users and non-users remains big. In high-income countries approximately 89% of households are connected to the internet. While in low-income countries this figure floats around 10% (The Inclusive Internet Index, 2020).

Even though the disparity between those individuals who have access to and those who have not is diminishing compared to the 1990s, it continues to be a serious concern for those who are behind in technology access. Since estimations have revealed that in the nearest future almost all workplaces will require any kind of technology competencies. Also, it has been determined that acquiring digital skills lead to higher earnings from 3% to 10% (Office for National Statistics). This highlights that this issue must be addressed comprehensively. Many researchers investigated the factors that widen the digital divide as well as those that can provide the means to bridge it. Understanding fundamental issues related to technological inequalities is vital to be able to determine the appropriate policies that would help in shrinking the divide. Although a lot of studies have been devoted to addressing the issue of digital inequalities, there's still no clear understanding of which factors are more vital than others. Empirical analysis has determined economic and socio-demographic factors among others as the driving forces of digital divides.

Different kinds of international organizations rank countries according to their digitalization level. These organizations develop various indexes to reflect digital divide issues in that or another country. A well-known, the Inclusive Internet Index ranks countries by taking into account the following dimensions; the Internet's availability, affordability, relevance, and readiness.

The low position of transition countries in this rating in 2020 (Uzbekistan ranks 69th, Kazakhstan 49th, Latvia 48th) indicates that the digital divide exists in these economies. Another rating index highlighted that Ukraine, Uzbekistan, and Kyrgyzstan were at the bottom of the regional rankings (ICT Development Index, 2017). Since these countries are lagging in ICT use and proliferation, the issue of the digital divide should be addressed at a regional level. Moreover, these countries share the same history of development. For about 70 years they were part of the Soviet Union. And their demographic, social and economic development exhibited a similar pattern.

This study aims at examining the main drivers of the digital divide. For this purpose, the annual data of 20 selected transition countries for the period 1998-2014 have been employed panel quantile regression model to acquire a more comprehensive understanding of the interactions underlying digital inequalities and their predictors.

The contribution of this study to the existing literature is twofold. First, it explores factors that are widening the divide and those factors that contribute to narrowing the divide in the context of transition countries. To the best of our knowledge, researches elaborating on this issue in the case of transition countries have not yet been undertaken. In other words, the study extends the literature by providing evidence from transition countries. The case of transition countries can be important in two ways. On the one hand, it allows researchers to compare one geographic area with another one, for example with Sub-Saharan Africa or MENA regions. On the other hand, addressing this issue thoroughly in countries under consideration, allow policymakers to elaborate appropriate measures contributing to the reduction of the digital divide. Second, to gain an in-depth understanding of the drivers of the digital divide, the novel approach developed by Machado and Silva (2019) is employed in the empirical analysis. Literature reviews have revealed that the above-mentioned approach has not yet been applied in studies investigating digital inequalities. The reason for implementing MM-QR approach is that unlike other methods which are based on the assumption that fixed effects to be location shifters, it allows the individual effects to influence the whole distribution of a dependent variable, in our case digital divide.

The remainder of the current study is organized as follows. In section 2 have been reviewed literature related to the digital divide. Subsequently, the data set and variables are summarized in Section 3. In Section 4 research methodology and obtained findings were discussed. In the final section, the conclusion was presented.

2. Literature

Research on digital inequalities has attracted attention from both scholars and policymakers. Studies addressing the digital divide issue can be grouped as follows: single country and inter country-level studies. In the first case, the focus of the study exploring this issue can be a single country. Quantitative single-country studies are generally based on survey data carried out in a particular country. Second, studies can be devoted to investigating the digital gap between developed and developing countries. In other words, such empirical researches are based on different types of economic, socio-demographic indicators of advanced and emerging nations. These studies deal with the disparities between advanced and emerging economies (Bagchi, 2005). In Table 1 studies devoted to the digital divide in a single country and inter-country level are summarized.

Decision-makers and researchers frequently see a need to address the issue of digital divide at the regional scale. Previous studies investigated the digital divide among the European Union, Asian countries, sub-Saharan African countries, OECD countries, and Latin American countries. As can be seen from past studies digital divide issues within transition countries have not been undertaken by researchers yet. Earlier studies utilized different kind of econometric tools. It can be observed from Table 1 that regression analysis has been used widely. Since OLS regression analysis have some drawbacks, to better reflect the digital divide issue in current study the implementation of panel quintile models is considered appropriate. In addition, literature review revealed that this approach has not been applied yet by scholars (except Dewan et al., 2005).

Table 1. Literature

Single country studies			
Author	**Country**	**Method**	**Result**
Song et al.(2020)	China	Geographically-weighted regression (GWR) model	Urban residential earnings, the total enrolment ratio and rural residential earnings are the key drivers of the spread of ICT.
Mohanty (2020)	India	Probit regressions and reference category methods	ICT innovations and socio-economic factors are main predictors of digital divide.
Gounopoulos et al. (2018)	Greece	Survey data of 2012	Educational, economic and demographic factors are found to be significant in explaining internet use
Badran (2014)	Egypt	Ordered probit model	Such variables as urbanization rate, gender, wealth, and education have also been identified as significant predictors of the digital divide.
Srinuan et al. (2012)	Thailand	Discrete choice model	Prices of telecommunication services and demographic factors are among key drivers of mobile Internet proliferation.
Inter country studies			
Rath (2016)	47 developed and emerging countries 2000-2012	Dynamic panel data models and principal component analysis	Per capita income and the ratio of urban to rural population are key factors that drive the country's digitization divergence
Billon (2009)	Developed and developing countries	Canonical correlation analysis	In developed countries economic, and educational variables are the main predictors of ICT proliferation while in developing countries demographic variables play a key role in ICT proliferation.

Andonova (2006)	1985–2001	Least squares hierarchical regression	Human capital and urbanization rate are main determinants of proliferation of information technology.
Dewan et al. (2005)	40 countries 1985–2001	OLS and quantile regressions	Income is found to be a significant factor determining IT penetration. The effect of demographic and economic variables are differ due to various stages of IT proliferation.
Bagchi (2005)	OECD and ECLAC countries 1995 and 2001	OLS regression	Factors have various and significant influence on the digital divide across economies and over the period.

Researchers have determined government trade policies, political freedom, institutional environment, and credible electronic payments, institutional quality as one of the factors that affect the digital divide. In contrast to earlier ones, Norris (2001) argues that economic factors have outweighed all other factors in explaining cross-national gaps in access to the information society. Similarly, Song et al. (2020) highlighted the important socio-economic issues. Authors concluded that the socio-economic issues, rather than the institutions and innovation dimensions, need to be tackled in order to enhance the use of ICT.

Based on the findings reported in the literature it has been decided to investigate the digital inequalities in transition countries by paying particular attention to economic and socio-demographic factors with the help of the panel quantile regression model.

3. Data and Variables

To determine drivers of digital divide annual data of selected transition countries (Croatia, Czech Republic, Hungary, Kazakhstan, Kyrgyz Republic, Kazakhstan, Moldova, Poland, Romania, Tajikistan, Russian Federation, Slovenia, Uzbekistan, Slovak Republic, Latvia, Lithuania, Estonia, Bulgaria, Bosnia and Herzegovina and Georgia) from 1998 to 2014 are used. The selection of countries has been restricted due to data availability. The variables used are summarized as follows:

Dependent variable. Following (Bagchi, 2005) digital distance is used as the dependent variable. The dependent variable is proxied by the digital distance between the USA and transition countries. In other words, the difference in the value of individuals using the Internet between the USA and other nations. It can measure the magnitude of the digital disparity or the digital divide (DD) between transition countries and the USA.

The first category of independent variables can be defined as economic factors. In order to control the impact of economic factors on digital disparities income and service sector development variables were incorporated into the model.

Per capita income. It is one of the determining variables of digital disparity. Past studies provided evidence of the relationship between these variables. Authors posit that wealthier countries adopt technologies earlier (Dekimpe et al., 2000). It is expected that higher GDP per capita tends to increase the digitization index. Another study has revealed that in the USA three-fifths of households that have yearly earned around 75,000 dollars, can access the internet, while only one-fifth of households earning 35,000 dollars can afford internet connection (National Telecommunications and Information Administration (NTIA), 2002). So, it is expected that an increase in income will narrow the digital divide.

Service sector development indicator. This is one of the determining factors of digital inequalities. It is expected that with the development of the service sector digital inequalities will be reduced.

The second category of variables can be defined as a demographic factor. In this context, three variables are included in the model.

Urbanization rate. The urbanization rate is proxied by the number of people living in cities. Increased access to more sophisticated technologies would have to be obtained by the improved infrastructure of the countries. The digital divide can also be reduced by the level of urbanization because researches have revealed that there are discrepancies in access among different urbanization levels (Katz and Aspden, 1997). The least urbanized countries may lag in technology access. So, it is expected that the urbanization rate will contribute significantly to reducing digital disparities.

Young and working-age population. This variable is included in order to control the impact of the working-age population on digital inequalities. It is expected that the growth of the young and working-age population will shrink the digital divide. As known, the young and working-age population can competently use modern technologies in daily life or at workplaces. Due to this, digital inequalities can be reduced.

Population growth. Population growth affects digital inequalities. It is expected that growth in population will widen inequalities. Rapid fertility has a negative (Malthusian) impact on the digital divide. The Malthusian effect can be seen in forcing people to consume savings which results in depletion of investment rate. On the other hand, a high level of the population reduces income per capita, this declines the possibility of allocating money for the adoption of new technology purposes. It implies that the digital divide will increase in countries with the highest fertility rates.

The definitions of the variables are presented in Table 2. All variables are measured in logarithmic terms. Data are obtained from World Bank databases.

Table 2. Variables and data set

	Variable name	Abbreviations	Units
Dependent Variable	Digital Divide	DDINT	Difference in the value of individuals using the internet (as % of population) between the U.S. and another country.
Economic factors	Per capita gross domestic product	LGDP	Gross domestic product per capita (constant 2010 US dollar)
	Service sector development	Lservice	Services, value added (% of GDP)
Demographic factors	Young and working age population	Lpopyoung	Working age population 15-64 (% of total population)
	Population growth	Lpop	Population, total
	Urbanization rate	Lurban	Population living in cities

To validate empirically the link between the digital divide and the variables stated above panel data of selected 20 transition countries are utilized. As highlighted in past studies economic and socio-demographic factors' contribution to closing the digital divide is tremendous. People's ability to utilize digital technology and accessibility to them will grow with the improvement in the above stated economic and socio-demographic variables. So the present study explores the main drivers of the digital divide by paying close attention to these variables.

4. Methodology and Empirical Findings

Before implementing estimation procedures, the normality of the dependent variable must be examined. As can be seen from the Figure 1 dependent variable is not distributed normally. Skewness and kurtosis tests for the digital divide variable indicate that the distribution is non-normal. Skewness and kurtosis tests revealed that the distribution of the digital divide exhibits right skewness and leptokurtic (at the 1 % level of significance) that the dependent variable is positively skewed and leptokurtic (skewness = 1.5643 and kurtosis = 5.1497). A leptokurtic distribution has a higher peak and heavy tails compared to a normal distribution.

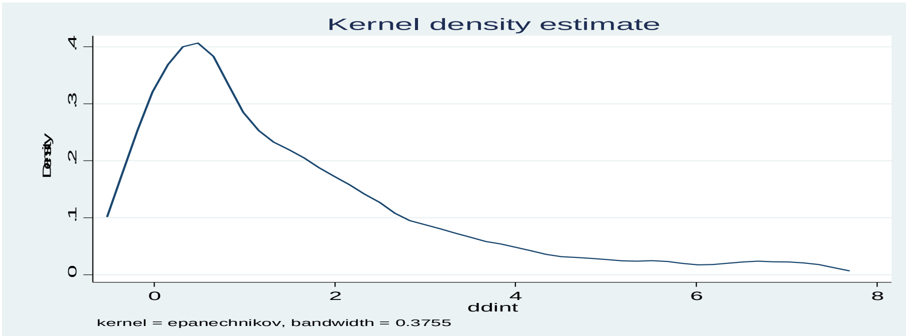

Figure 1. Kernel density

These results indicate that the distribution of the digital distance exhibits nonnormality. In the case of nonnormal distributions, and robustness to outliers applying OLS models can be biased. In other words, these results justify the application of the quantile regression model.

The characteristics of a data set are reported in Table 3. It is evident from Table 3. that data under consideration skewed right and left. The digital divide, population growth, and urbanization rate are positively skewed, while per capita income, young and working-age population and service sector are negatively skewed. Per capita income tends to have thinner tail due to the smallest kurtosis value. All the variables exhibit a leptokurtic distribution (except per capita income). It implies that variables have peak and heavy tails compared to a normal distribution.

Table 3. Descriptive statistics

Vaiables	DDINT	Lgdp	Lservice	Lpop	Lpopyoung	Lurban
Mean	1.5189	8.6345	3.9477	15.7621	4.2098	15.1544
SD	1.6497	1.05184	0.1512	1.1161	0.0544	1.1889
Max	7.3163	10.1437	4.1862	18.8105	4.3068	18.5006
Min	-0.1432	5.9439	3.4002	14.089	3.9659	13.7072
Skewness	1.5643	-0.7681	-1.2560	0.9629	-1.7649	1.1060
Kurtosis	5.1497	2.4896	4.3058	3.5874	7.1448	3.7574

In Table 4 cross-sectional dependence test results are displayed. If cross-sectional dependence is ignored it resulted in unobserved common factors which in turn can decrease panel data efficiency. The cross-section dependence (CD) test, suggested by Pesaran (2004), is one of the widely used tools in the empirical analysis. The results highlight that cross-sectional dependence exists among all the series (except urbanization rate).

Table 4. Cross sectional dependence test

Variables	DDINT	Lgdp	Lservice	Lpop	Lpopyoung	Lurban
Test statistics	53.75	54.30	16.44	3.73	25.98	-0.13
Probability	0.000	0.0000	0.000	0.000	0.000	0.897

Null hypothesis is H_0: $\rho_{ij} = c(u_{it}, u_{jt}) = 0 \; i \neq j$, and indicates that cross-sectional dependence between entity doesn't exist.

In the case of cross-sectional dependence second generation panel unit root tests are recommended in investigating stationarity properties of the variables utilized. First-generation panel unit root tests are considered to be appropriate to use if cross-sectional dependence between variables does not exist. In this study, the second generation panel unit root test proposed by Pesaran (2007) and the first-generation unit root test suggested by Levin-Lin-Chu (2002) is applied. The results are displayed in Table 5.

Table 5. Panel unit root tests

		t bar statistic	z bar statistic	Probability
Pesaran test	DDINT	-2.735*	-4.407*	0.000
	Lgdp	-2.511*	-3.424*	0.000
	Lservice	-2.409*	-2.978 *	0.001
	Lpop	-2.874*	-2.631*	0.004
	Lpopyoung	-2.818*	-2.381*	0.009
		Statistic		
LLC	Lurban	-4.756*		0.000

Ho: Panels contain unit roots. *significance at the 1% levels

The results highlight that all series exhibit stationarity at levels. It indicates that all series are with the same order of integration, or I(0).

In the study, the Method of Moments Quantile Regression (MM-QR) analysis proposed Machado and Silva (2019) have been implemented. The conditional heterogeneous covariance effects of the factors contributing to the digital divide can be determined using this approach. The authors assert that in this method the whole distribution can be affected by individual effects.

The model can be defined as follows:

$$Q_Y(\tau|X_{it}) = \left(\alpha_i + \delta_i q(\tau)\right) + X'_{it}\beta + Z'_{it}\gamma q(\tau)$$

Where X'_{it} denotes a vector of explanatory variables. In current paper the following variables are incorporated into the model: per capita gross domestic product (Lgdp), service sector development (Lservice), population growth (Lpop), young and working age population (Lpopyoung), and urbanization rate (Lurban).

$Q_Y(\tau|X_{it})$ denotes the quantile distribution of the dependent variable Y_{it}, (the natural logarithm of digital distance) which is conditional on the location of independent variable X_{it}.

$\alpha_i(\tau) = \alpha_i + \delta_i q(\tau)$ denotes denotes a scalar coefficient. It serves as indicative of the quantile-τ fixed effect for entity i. $q(\tau)$ denotes the sample quantile which can be obtained by solving optimization problem described below:

$$min_q \sum_i \sum_t \rho_\tau (R_{it} - (\delta_i + Z'_{it}\gamma)q)$$

Where $\rho_\tau(A) = (\tau - 1)AI\{A \leq 0\} + TAI\{A > 0\}$ indicates check function.

In the empirical analysis, quantiles consisting of three parts were used: the bottom quantiles (10th, 20th, and 30th) imply the nations with low digital disparities (highly digitalized countries), the middle quantile (40th, 50th and 60th) indicates the medium digitalized countires and the top quantiles (70th, 80th, and 90th) indicate countries with the high digital disparities (or low digitalized countries). The MM-QR regression results are summarized in Table 6.

Before interpreting estimated parameters it is useful to address Wald test results. It tests the equality of coefficients across quantiles. Estimation results indicate that the hypothesis of homogeneity is rejected, which imply that the coefficients of explanatory variables are statistically different across quantiles.

Table 6. MM-QR regression results

Variables	Lgdp	Lservice	Lpop	Lpopyoung	Lurban
0.1	-3.4907***	-1.3113	4.4678*	-7.8876**	-8.3491***
	(0.3367)	(1.2238)	(2.3005)	(3.5543)	(1.7093)
0.2	-3.4187***	-1.6989*	4.9126***	-9.0080***	-8.5256***
	(0.2676)	(0.9734)	(1.8274)	(2.8252)	(1.3583)
0.3	-3.3776***	-1.9200**	5.1663***	-9.6473***	-8.6263***
	(0.2346)	(0.8549)	(1.6007)	(2.4795)	(1.1897)
0.4	-3.3183***	-2.2393***	5.5327***	10.5703***	-8.7717***
	(0.2009)	(0.7361)	(1.3682)	(2.1320)	(1.0156)
0.5	-3.2657***	-2.5227***	5.8579***	-11.3894***	-8.9007***
	(0.1909)	(0.7041)	(1.2979)	(2.0369)	(0.9615)
0.6	-3.1953***	-2.9019***	6.2929***	-12.4855***	-9.0733***
	(0.2099)	(0.7713)	(1.4281)	(2.2328)	(1.0591)
0.7	-3.1351***	-3.2261***	6.6650***	-13.4228***	-9.2210***
	(0.2495)	(0.9096)	(1.7020)	(2.6378)	(1.2648)
0.8	-3.0911***	-3.4629***	6.9367***	-14.1073***	-9.3288***
	(0.2873)	(1.0439)	(1.9630)	(3.0306)	(1.4596)
0.9	-3.0213***	-3.8389***	7.3681***	-15.1940***	-9.5000***
	(0.3577)	(1.3020)	(2.4428)	(3.7798)	(1.8146)
F stat.	3.35**	2.50**	2.41**	5.18***	2.26*
	(0.0105)	(0.0423)	(0.0488)	(0.0005)	(0.0623)

Note: Standart errors are given in brackets.
*, ** and *** denotes significance at 10%, 5% and 1% levels, respectively.
The null hypothesis of Wald test is testing coefficient equality across quantiles.
***, **, and *denote 1%, 5%, and 10% significance levels, respectively.
Probability values are shown in brackets.

According to the results obtained the coefficients of all variables under consideration are found to be statistically significant at all quantiles of the distribution (except the service sector is not significant at the 10th quantiles). The signs of the estimated coefficients have the expected signs. As expected per capita income, service sector development, young and working-age population, and urbanization rate affect negatively digital divide at all quantiles. In other words, an increase in the above-mentioned variables will contribute to bridging the digital divide. In contrast to the earlier ones, population growth has a positive impact on the digital divide. It means with the population growth the digital inequalities will be expanded.

Per capita income has the expected negative sign in all quantiles. The estimated coefficients for income per capita change very little across quantiles. The magnitude of the estimated parameters is between -3.4907 and -3.0213, implying that a 1 % rise in income will reduce digital divide between 3.5% and 3.0%. It can be observed that per capita income exhibits diminishing magnitude, which indicates that the digital divide is less influenced by the income at the higher quantiles.

Service sector has the expected negative sign across all quantiles too. It implies that service sector development will contribute to reduce digital divide. Unlike per capita income, the coefficient of service sector increases in magnitude, which indicates that the digital divide is more affected by the service sector at the top quantiles.

Estimation results point to a considerable positive impact of population growth on digital divide. The coefficient of population growth increases in magnitude, which indicates that the digital divide is more affected by the population growth at the upper quantiles. The magnitude of the estimated parameters is between 4.4678 and 7.3681, implying that a 1 % increase in population will widen digital divide between 4.5% and 7.4%.

The young and working-age population has a negative association with digital divide. The estimated coefficients vary across quantiles. The magnitude of the estimated parameters is between -7.8876 and -15.1940, implying that a 1 % increase in the young and working-age population will reduce digital divide between 7.9% and 15.2%. From Table 5 it appears that the coefficient of this variable increases in magnitude, which denotes that the digital divide is more influenced by this type of population at the higher quantiles.

Similarly, the urbanization rate negatively associated with digital divide. The magnitude of the estimated parameters ranges between -8.3491 and -9.5000, indicating that a 1% increase in urbanization rate will reduce digital divide between 8.3% and 9.5%.

According to the results obtained it can be concluded that in transition countries under consideration socio-demographic factors have a greater impact on the digital divide. The coefficients of the socio-demographic variables are much larger compared to the economic variables. Moreover, the impact of explanatory variables on the digital divide is noticeably higher in low digitalized countries (except per capita income)**.**

5. Conclusion

This study aims at exploring contributing factors to the digital divide in selected transition countries. The annual data of 20 transition countries over the period 1998-2014 is implemented panel quantile regression model.

According to the obtained findings, it can be concluded that economic and socio-demographic factors are significant in explaining digital divide in countries under consideration. The impact of the socio-demographic factors is found to be higher compared to the economic factors. Per capita income, service sector development, young and working-age population, and urbanization rate were found to be critical factors contributing to bridging the digital divide. In contrast to the previous variables, population growth was found to be an important factor widening the digital divide. The young and working-age population, the variable with the largest effects in terms of magnitude, can promote the diminishing of the digital divide. The findings highlight that the improvements in economic and socio-demographic factors would help narrow the digital divide.

Overall, this study sheds light on the in-depth understanding of the drivers of digital divide in transition countries. Improving economic and demographic conditions would provide a significant impetus for sustainable digital advancement. In other words, policy-makers of transition countries, while making an effort to bridge the gap should pay close attention to economic and socio-demographic indicators, among others.

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