DIGITAL DIVIDE GAP CONVERGENCE ACROSS EUROPEAN UNION: THE ROLE OF URBANISATION

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Abstract: *The paper analyses the convergence of households connectivity to Internet across European Union countries according to the degree of urbanisation and predicts future evolutions based on possibile scenarios. In order to estimate the process of convergence, five families of models were used to approximate the values of standard deviation of households' connection rate to Internet. Among them the linear model seems to describe the process more accurately.*

***Key words**: digital divide, households, convergence, forecasting.*
***JEL Classification**: C13, C53, D10.*

1. Introduction

In the vision of OECD (2001), the term of digital divide refers to the "gap between individuals, households, business and geographic areas regarding their use of the Internet and opportunities to access information and communication technologies (ICT)".

The ICT have a great potential to foster economic growth, human development and improve the life quality of people. Moreover, they are related to the achievement of Millenium Development Goals and building the Information Society (OECD, 2005; World Summit, 2003 and 2005).

The Europe 2020 strategy aiming to a smart, sustainable and inclusive growth for the European Economy includes the Digital Agenda for Europe, together with other six strategy flagships (European Commission, 2010a). It highlights the central role that the use of ICT must play in the strategical growth targets (European Commission, 2010b).

Considering the importance of the digital development to the EU, digital inequalities or assymetries must be identified and corrected in order to achieve the objective of the Europe 2020 strategy.

Several authors have focused on understanding and measuring digital divide across European countries, taking into consideration the focus of the European Commission on a homogenous digital development among of its members. The present paper intends to highlight the convergence process of digital divide in the EU and to forecast probable evolutions in the future.

The percentage of households connected to the Internet is used in the literature to measure the digital development/divide among other metrics (Cuervo and Menéndez, 2006; Chinn and Fairlie, 2007; Vicente and López, 2010; Brandtzaeg et al., 2011;Cruz-Jesus et al., 2012; Várallyai et al.,2015).

The aim of the paper is to highlight the convergence process of households' connectivity to Internet in the European Union countries and to estimate its evolution until 2035.

The paper is organised as follows: after the introduction the study methodology and data are exposed, the third section describes the main findings and the last section is dedicated to conclusions.

2. Methodology and data

In order to analyse the convergence of household connectivity rates to Internet in the European Union countries, the standard deviation of this variable is used:

$$STDEV = \sqrt{\frac{(x-\bar{x})}{n-1}} \quad (1)$$

where n denotes the number of observations, x is the variable (percentage of households connected to Internet), $\bar{x}$ the mean value of x.

The data source is Eurostat, meaning data series from tables: isoc_bde_15b_h and isoc_ci_in_h for 2005-2017, respectively: percentage of household with Internet access in 27 European countries. Croatia was excluded due to lack of data. The Eurostat system makes difference between households living in high densely populated area (at least 500 inhabitants/km2), intermediate urbanised area (between 100-499 inhabitants/km2) and sparsely populated area (at least 100 inhabitants/km2).

In order to forecast the evolution of the convergence of households' connectivity to Internet, the following mathematical functions will be used:

Linear: $y = a + b \cdot t$ (2)

Polinomial: $\frac{1}{y} = a + b \cdot t$ (3)

Power: $y = a \cdot t^b$ (4)

Exponential: $y = a \cdot b^t$ (5)

Logarithmic: $y = a + b \cdot \ln t$ (6)

where: y is the standard deviation of internet connectivity rate, t is the time, a is the intercept and b is a coefficient.

In order to estimate the equation (4) we apply ln and we obtain the new equation below:

$\ln y = \ln a + b \ln t$ (7)

In a similar procedure applied to equation (5), the result is as follows:

$\ln y = \ln a + t \ln b$ (8)

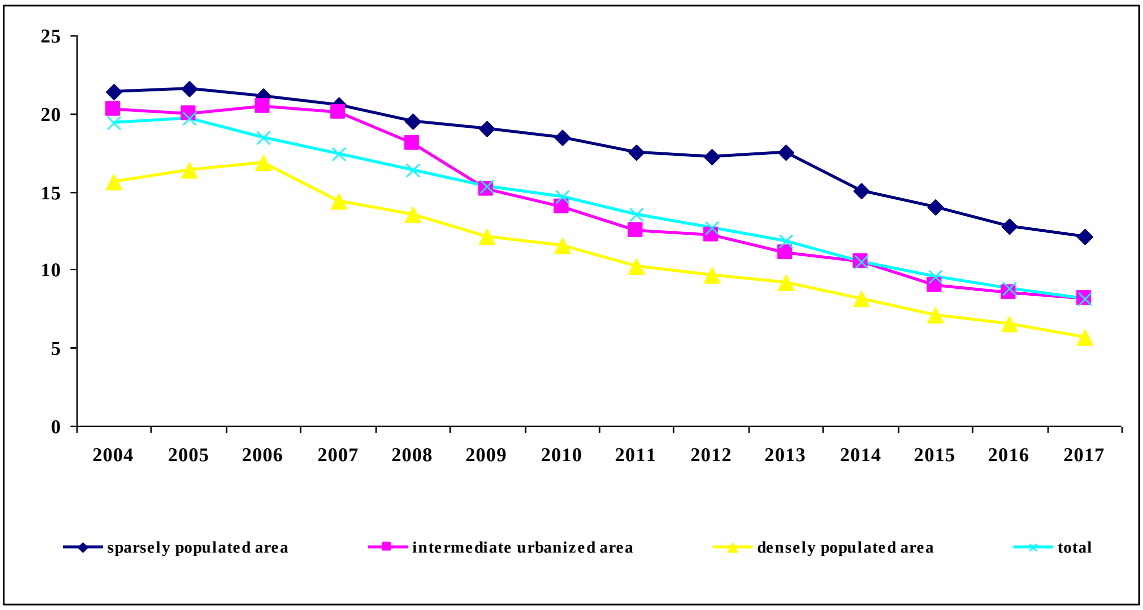
The equations (2), (3), (6), (7) and (8) will be estimated and their statistical accuracy will be checked for a significance of 5%.

3. Main findings

The standard deviation of households connection rate in the European Countries was calculated for the time span of 2004-2017, as total EU, for sparsely, intermediate and high densely areas (Figure no.1). We notice the descending trend in all cases, the convergence process being identified. In the EU densely populated areas, the standard deviation of households Internet access is lower than in other areas and in the EU as total. The digital divide gap in the sparsely populated areas is of 1.3-1.9 times higher than in the densely populated areas, indicating a lagging process of digital technologies penetration.

We notice also, different speeds of convergence in different urbanised areas. We estimate the speed of convergence through estimating the linear models of standard deviation of households' internet connection for total EU, sparsely populated, intermediate urbanized and densely populated areas.

Figure no. 1. Convergence of households' connectivity to Internet in the European Union countries by degree of urbanisation (2004-2017)



Source: author's computation based on Eurostat data

The estimated equations are the following:

total: $STDEV_t = 21{,}08918 - 0{,}93999 \cdot t$

sparsely populated area: $STDEV_s = 23{,}26359 - 0{,}74049 \cdot t$

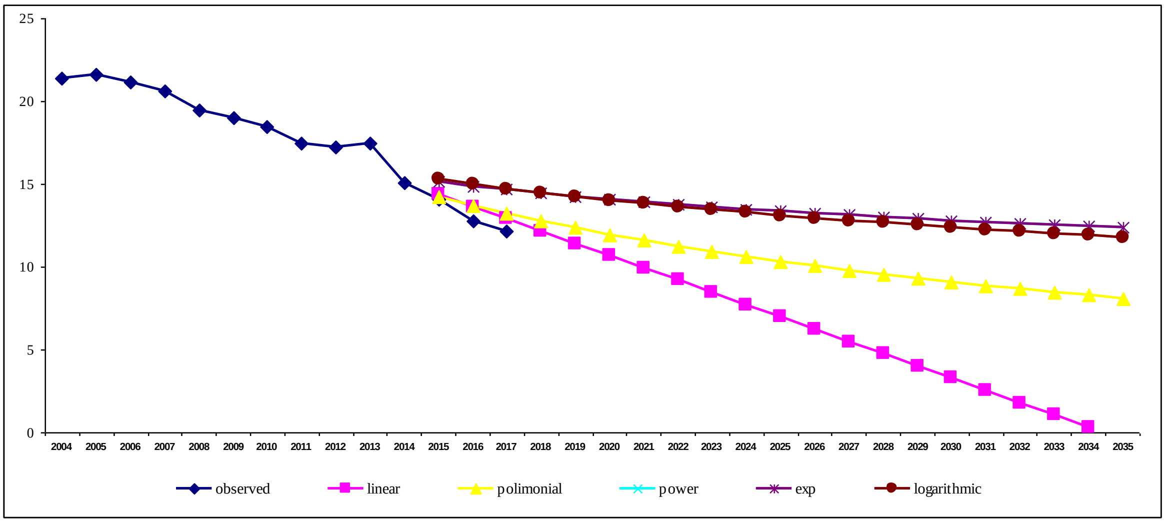
intermediate urbanized area: $STDEV_i = 22{,}50337 - 1{,}09463 \cdot t$

densely populated area: $STDEV_d = 17{,}80346 - 0{,}87758 \cdot t$

All the equations are statistically validated for a significance of 5%, as well as, the intercept and the coefficient of t.

The highest speed of convergence is registered in the intermediate urbanized areas (1.09463 units per year), not in the high densely populated areas, as expected.

Figure no. 2 Digital divide gap in the EU countries observed and forecasted - sparsely populated area

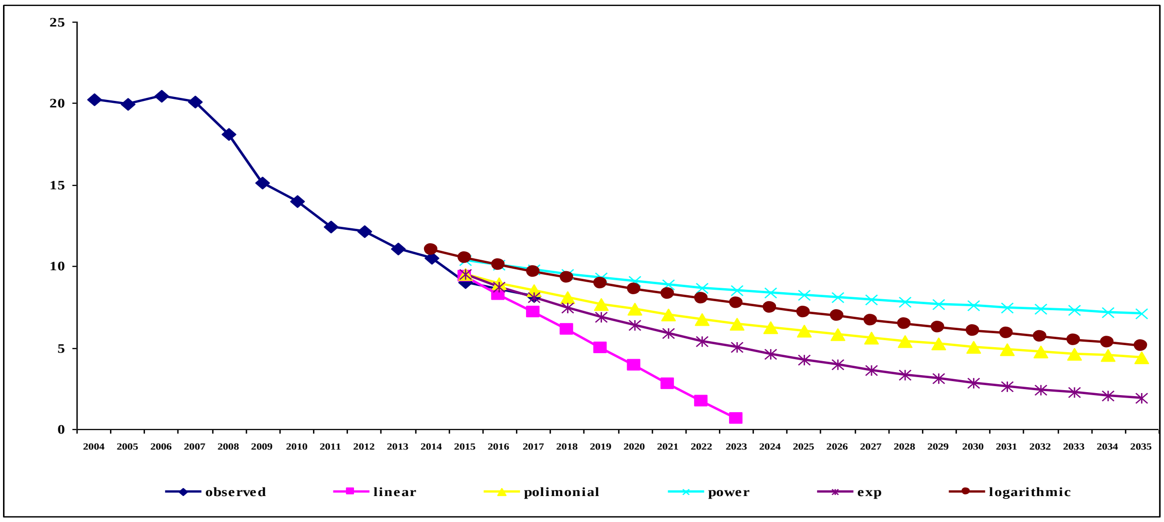


Source: author's computation based on Eurostat data

Figure no. 2, 3 and 4 display the observed dynamics of digital divide gap for 2004-2017 and the forecasted evolution according to the mathematical functions: linear, polinomial, power, exponential and logarithmic. The results of equations estimation are included in the Annex. All estimations are statistically validated for a significance of 5%.

In the sparsely populated areas the digital divide gap will be closed in 2034 according to the linear model (Figure no. 2). In the case of logarithmic and power models, the gap is maintained mostly constant until 2035 and the decrease is very slow in the case of polinomial and exponential model.

Figure no. 3. Digital divide gap in the EU countries observed and forecasted - intermediate urbanised area

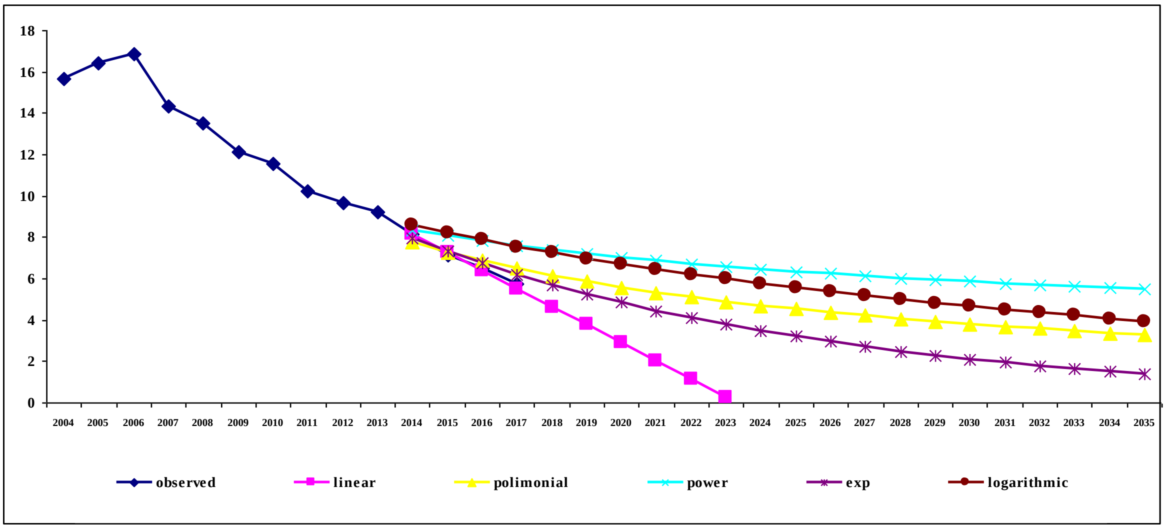


Source: author's computation based on Eurostat data

The gap decreasing is more evident in the case of intermediate urbanised area, for all predictions. A tendency of stagnation is identified in the case of power model starting with 2025.

According to the linear model, the digital divide gap will be closed in 2024 in the intermediate urbanised areas (Figure no. 3) as well as in the high densely populated areas (Figure no. 4).

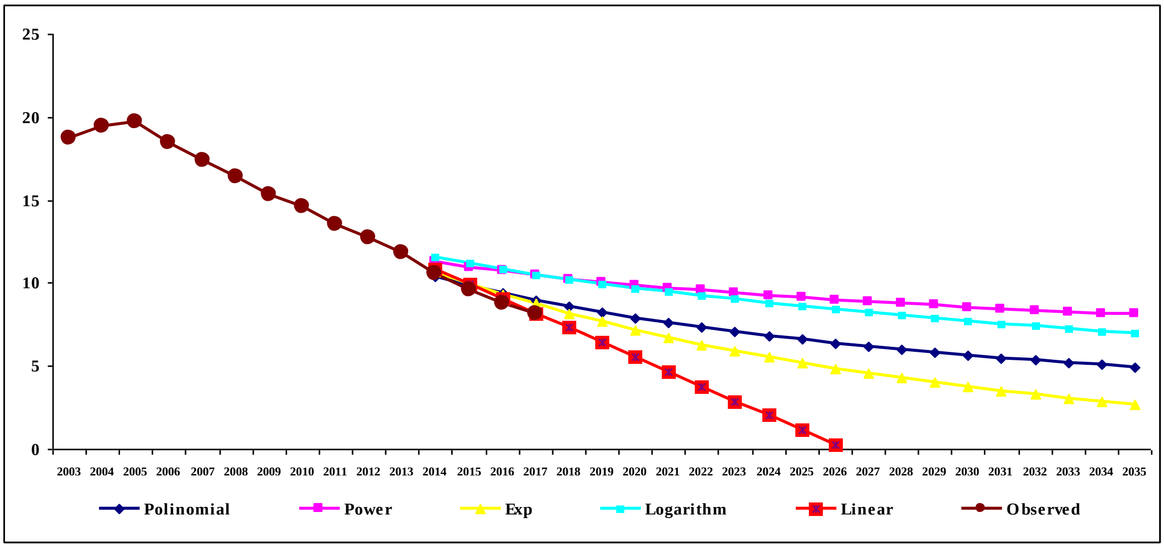
Figure no. 4. Digital divide gap in the EU countries observed and forecasted - high densely populated area



Source: author's computation based on Eurostat data

At EU level, in the linear model prediction, the digital divide gap can be closed in 2026.

Figure no. 5. Digital divide gap in the EU countries observed and forecasted - total



Source: author's computation based on Eurostat data

4. Conclusions

The aim of the paper was to analyse the digital divide gap convergence across EU countries on the basis of calculation of the standard deviation of the households' connection rates to Internet and to predict its values until 3035.

The digital gap is different according to the degree of urbanisation and the convergence process is identified in all cases (sparsely, intermediate and high densely populated areas).

As expected, in the EU densely populated areas, the digital divide gap is lower than in other regions, but the speed of convergence is higher in the intermediate urbanised areas.

The digital divide gap in the sparsely populated areas is of 1.3-1.9 times higher than in the densely populated areas, indicating a lagging process of digital technologies penetration.

In order to estimate the process of convergence, five families of models were used to approximate the values of standard deviation of households' connection rate to Internet. Among them the linear model seems to describe the process more accurately.

The digital divide gap can be closed in different time moments in different urbanised areas, in a linear predicted evolution. The degree of urbanisation is driving the speed of gap closure. As expected, the gap will be closed earlier in intermediate and high densely populated areas.

The digital divide is consequence of the social and economic influences: income, culture, urbanisation, education, as well as people's economic and social behaviour or social and individuals values.

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Annex

odel	Total EU	sparsely populated area	intermediate urbanised area	high densely populated area
Linear	$y = 21{,}39331 - 0{,}88307 \cdot t$	$y = 23{,}26359 - 0{,}74049 \cdot t$	$y = 2250337 - 1{,}09463 \cdot t$	$y = 17{,}80346 - 0{,}87758 \cdot t$
Polinomial	$\frac{1}{y} = 0{,}035125 + 0{,}005067 \cdot t$	$\frac{1}{y} = 0{,}03852 + 0{,}002652 \cdot t$	$\frac{1}{y} = 0{,}031756 + 0{,}006127 \cdot t$	$\frac{1}{y} = 0{,}037074 + 0{,}00837 \cdot t$
Power	$y = 25{,}22312 \cdot t^{-0{,}32444}$	$y = 25{,}25131 \cdot t^{-0{,}20611}$	$y = 27{,}303247 \cdot t^{-0{,}388561}$	$y = 21{,}76968 \cdot t^{-0{,}39889}$
Exponential	$y = 23{,}2427 \cdot 0{,}936871^{t}$	$y = 24{,}11564 \cdot 0{,}957107^{t}$	$y = 24{,}65442 \cdot 0{,}923467^{t}$	$y = 1976659 \cdot 0{,}920508^{t}$
Logarithmic	$y = 22{,}73294 - 4{,}5069 \ln t$	$y = 24{,}11564 - 3{,}5599 \ln t$	$y = 24{,}19315 - 5{,}50164 \ln t$	$y = 19{,}10427 - 4{,}3808 \ln t$