Social development and ICT adoption. Developing world perspective.

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Abstract

The process of ttechnology diffusion is complex, and one should bear in mind that multiple both qualitative and quantitative elements may be claimed as its essential determinants. Insofar, voluminous theoretical and empirical literature has been issued where attempts of identification of the latter has been made. However, we still lack adequate explanations for cross-country differences in new technology adoption; while the demonstrated evidence is scattered and to a great extend it lacks robustness. Many claim that the speed of ICT diffusion is heavily predetermined of country`s economic achievements; while – in this perspective, high-income economies should faster adopt and use new technologies if compared to economically backward countries.

This paper is designed to provide empirical evidence on the relationship between the process of ICT diffusion and social development across selected low-income and lower-middle-income countries during the period of 2000 and 2014. It main target it so identify whether in low-income and lower-middle-income economies, ICT development and social development (social empowerment) are correlated.

It combines five logically structured sections. Section 1 is the introduction, while Section 2 discusses literature review regarding ICT diffusion determinants. Next, Section 3 briefly presents data used in the research and explains methodological framework. Finally Section 4 demonstrates results of empirical analysis, and Section 5 concludes.

Keywords: social development, empowerment, new technologies, ICT, developing countries
JEL codes: O33, O50, O1

1. Introduction

The process of ttechnology diffusion is complex, and one should bear in mind that multiple both qualitative and quantitative elements may be claimed as its essential determinants. Insofar, voluminous theoretical and empirical literature has been issued where attempts of identification of the latter has been made. However, we still lack adequate explanations for cross-country differences in new technology adoption; while the demonstrated evidence is scattered and to a great extend it lacks robustness. Many claim that the speed of ICT diffusion is heavily predetermined of country`s economic achievements; while – in this perspective, high-income economies should faster adopt and use new technologies if compared to economically backward countries. On the other hand, many researchers argue, that ICT diffuse rapidly across countries regardless level of economic development level; but – at the same time, it would be right to suppose that the process of adoption and implementation of new technologies is determined by socially-related factors.

This paper provides empirical evidence on the relationship between the process of ICT diffusion and social development across selected low-income and lower-middle-income countries during the period of 2000 and 2014. It main target it so identify whether in low-income and lower-middle-income economies, ICT development and social development (social empowerment) are correlated. Bearing in mind the latter, we assume the socially progressing societies create solid background for entering sustainable economic growth and development pattern, which – to a great extend – is accompanied by rapid spread of new technologies. In this line, we treat selected social dimensions are determinants of ICT adoption. Importantly to note that such approach yields drawing careful conclusions, are analyzed elements are obviously not directly interrelated and preconditioned. Additionally, a casual relationship between social and technological factors is heavily preconditioned by legal and cultural environment, and these two shall be borne in mind and drawing conclusions and formulating recommendations.

2. Contextual background and literature review on ICT determinants in developing world.

The process of ICT deployment is preconditioned by multiple social, cultural, economic, institutional and political factors. Insofar, the empirical evidence intending to provide clear answer to the question what determines rapid spread of new technologies, does not provide clear explanations. Importantly to note, that still the empirical works regarding the latter, in a great majority, concentrate exclusively on developed economies.

The seminal contribution on this field was made by Comin and Hobijn (2004), who demonstrated the long-term analysis of technology adoption determinants across countries between years 1788 and 2001. By using panel regression, they ICT diffusion is determined by human capita, government type, openness to international trade, and the degree of adoption of predecessor technologies (Comin and Hobijn 2004). Similar claims have been raised by Comin and Hobijn (2006) in a study for a sample of 19 different technologies across 21 countries over the period 1870–1998. Norris (2000), in his study covering 179 countries, relying on multivariate regression, proofed the Internet penetration rates are neither by literacy rate, level of education nor democratization positively influenced. Instead he found that Internet diffusion was strongly attributed to GDP per capita and R&D expenditures. Caselli and Coleman (2001) used random and fixed-effects regressions for a study covering 89 countries between 1970 and 1990, and they claimed real per capita income, investment per workers, trade openness, the share of the agriculture and manufacturing sectors in an economy, the quality of human capital and property rights effectively foster the use of Internet

network. Kiiski and Pohjola (2002) provide empirical for OECD and non-OECD countries over the period 1995–2000. They used Gompertz model, and found that neither the level of competition in the telecommunication market nor investments in education and mean years of schooling are statistically insignificant and may not be claimed as important factors determining growing usage of Internet. However, just opposite finding are argued by Hargittai (1999), in her study for 18 OECD countries (1995–1998). Baliamoune-Lutz (2003), examining developing countries, reported that Internet and mobile cellular penetration rates are determined growing by per capita incomes and government trade policies. But also in the same study she found that economic freedom and level of education were statistically insignificant with this respect. Dasgupta et al. (2005), in the analysis encompassing 44 economies over the period 1990–1997, claims that increasing rates of Internet usage are fostered by growing per capita income, degree of urbanization, level of education and quality of institutions. While, Crenshaw and Robinson (2006), in their exclusive study for 80 developing countries over the period 1995–2000, report that changes in Internet penetration rates are effectively driven by urbanization which enhances the emergence of network effects.
The study of Chinn and Fairlie (2010) examining ICTs' drivers across 161 countries between 1999 and 2001, demonstrated that illiteracy rate, mean years of schooling, degree of urbanization, telecommunication market regulations and electricity consumption are positively correlated with ICT penetration rates. In works of Kaur and Tao (eds.) (2014) and Lechman (2015), for a study covering low-income and lower-middle-income economies over the period 2000-2012, it is claimed that ICT diffusion is predominantly determined by type of telecommunication market, urbanization and population density; while factors like per capita income, prices of telecommunication services, or level of education do not seem to play an important role in fostering ICT spread across developing countries.
More evidence regarding ICT (mobile cellular telephony, mobile broadband, wireless network and Internet penetration) diffusion's determinants may be found in, e.g., studies by Islam and Meade (1997), Liikanen et al. (2004), Rouvinen (2006), Garbacz and Thomson (2007), Michalakelis et al. (2008), Singh (2008), Jakopin and Klein (2011), Yates et al. (2011), Gupta and Jain (2012), Lee et al. (2011) and Liu et al. (2012).

3. Data and methodological settings.

3.1. Data.

In our research, the empirical sample covers selected developing countries, which according to World Bank Country Classification in 2015, have been labeled as low-income economies and lower-middle-income economies meaning that their annual gross national income per capita is less than 1 045 $ (current US $)[1] and ranges between 1 046 and 4 125 $ (current US $). By definition the group of low-income economies covers 31 countries, and group of lower-middle-income counties – 51 countries; however due to limited data time series availability, our empirical evidence is restricted to 57 countries for which statistical data has been acquired. All data regarding social and economic development indicators has been exclusively extracted from World Development Indicators database 2015, while statistics on ICT penetration has been derived from World Telecommunication/ICT Indicators database 2015 and World Development Indicators 2015. The standard period of analysis is set for years 2000-2014, which allows for developing balanced panel data set. To demonstrate countries` changes in access to and use of information and communication technologies, we use two ICT indicators – Mobile Cellular Subscriptions per 100 inhabitants ($MCS_{i,y}$ – hereafter), and

[1] estimates provided by the use of World Bank Atlas method

Internet penetration rate demonstrating share of total population having access to Internet connection (IU – hereafter). To approximate the level of social development across countries in scope, we have selected 6 indicators: annual population growth rate ($Pop_{i,y}$), total enrolment in secondary education ($Enroll_{i,y}$), urban population ($Urban_{i,y}$), female labor force participation for ages 15-24 ($FlpFem_{i,y}$), adolescent fertility rate ($TFert_{i,y}$) and under-5 mortality rate ($Mort_{i,y}$).

3.2.Methodology.

Our methodological framework combines descriptive statistics; nonparametric techniques including density curves and nonparametric regressions (Kernel-weighted local polynomial smoothing); and – panel regression models.

By definition, the density curves are plotted by adopting non-parametric estimation of the probability density function defined as:

$$f(x) = \frac{d}{dx}F(x), \tag{1}$$

where *F(x)* stands for the continuous distribution of random variable *X*. Kernel density estimator are very useful as they allowed relaxing the restrictive assumptions on the shape of function that *f(x)* should potentially hold (Lechman 2015). The density curves generated by the kernel density estimator are continuous and demonstrate the "empirical' distribution of selected for analysis variables. To estimate the density function of $f(x)$ a discrete derivative is applied, hence the kernel estimator takes a functional form as:

$$f`(x) = \frac{1}{nh}\sum_{i=1}^{n} k\left(\frac{X_i - x}{h}\right), \tag{2}$$

where *k(u)* is a kernel function, and by definition the Eq.(2) satisfies the following:

$$\int_{-\infty}^{\infty} k(u)du = 1. \tag{3}$$

By using nonparametric regressions, we make no assumptions on the form of analytic equation explaining the relationship between response and a vector of explanatory variables. A bundle of methods allowing for nonparametric estimates have been made by, for instance, Nadaraya (1964) and Watson (1964), Cleveland (1979), just to cite few.

If we consider a set of data $(1, \ldots . z)$ to be plotted, if they are defined as $[(x_1, y_1), \ldots (x_z y_z)]$, and we assume that relationship between these data may de describes by the model as:

$$y_i = m(x_i) + \sigma(x_i)\epsilon_i, \tag{4}$$

where mean $m(\cdot)$ variance function $\sigma^2(\cdot)$ are unknown, and the error ϵ_i is symmetric with $E(\epsilon_i) = 0$ and $Var(\epsilon_i) = 1$. Henceforth, under such conditions we estimate the model defines as:

$$m(x_0) = E\left[{}^{Y}/_{X} = x_0\right], \tag{5}$$

while the functional form of $m(\cdot)$is not specified.

Next, relying on the fixed effects regression, which allows for heterogeneity across countries, we estimate the empirical models defined as in Eq. (6), allowing identifying the strength and direction of the relationships between selected ICT and social indicators. The Eq.(6) follows:

$$ICT_{i,y} = \alpha + \beta\,(x^{`}_{i,y}) + u_{i,y}\ , \qquad (6)$$

where $\boldsymbol{\alpha}$ is the scalar, $\boldsymbol{ICT_{i,y}}$ denotes alternatively $MCS_{i,\ y}$ or $IU_{i,\ y}$; $\boldsymbol{\beta}$ is the $\boldsymbol{L \times 1}$ and $\boldsymbol{x^{`}_{i,y}}$ stands for the $\boldsymbol{iy}$th observation on $\boldsymbol{L}$ explanatory variables (Baltagi 2008; Wooldridge 2005). The subscripts $\boldsymbol{i = \{1, \ldots \ldots N\}}$ stand for country and $\boldsymbol{y = \{1, \ldots \ldots T\}}$ for the time period. In Eq.(6), the $\boldsymbol{u_{i,y} = \mu_i + \nu_{i,y}}$, while the $\boldsymbol{\mu_i}$ depicts the unobservable and time-invariant country-specific effect, which is not captured in the model, and $\boldsymbol{\nu_{i,y}}$ is the remainder disturbance (the observation-specific errors) (Greene 2003; Baltagi 2008).

4. Empirical evidence.

This section comprehensively demonstrates and discusses empirical results regarding identification of the relationships between ICTs deployment and social development across 57 selected developing countries between the years 2000 and 2014. The results of the analysis are summarized in Table 1 presenting descriptive statistics and consecutively in Tables 2-3 showing panel regression results; while the additional graphical evidence is provided in Figs. 1 and 2.

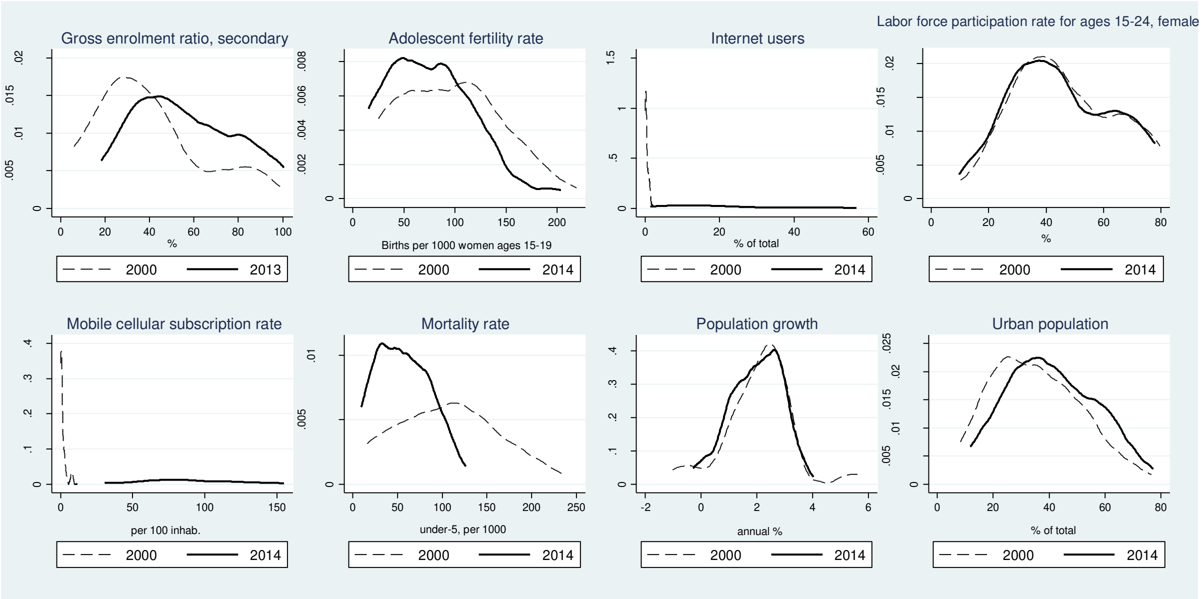
Results provided in Table 1 and Fig.1, show disruptive and dynamic changes, which are easily observed across countries in scope, regarding both in ICT access to and use of, as well as social progress made during the period of 2000-2014. In 2000, in a great majority of countries, the ICT penetration rates were negligible, and countries differed significantly with this respect. However, between years 2000-2014 remarkable increases regarding access to Internet ($IU_{i,y}$) and access to mobile cellular telephony ($MCS_{i,y}$) were observed. The mean MCS penetration in 2000 was at only 1,6 per 100 inhab., while in 2014 it grew at 88 per 100 inhab. (sic!). At a time, we observe significant falls in cross-country inequalities with access to mobile cellular telephony. In 2000, the absolute Gini was at about 0,7, while in 2014 it dropped till 0,2 (authors` estimates), which shows that cross-country differences regarding usage of this form of communication are significantly decreasing (also see density plot in Fig.1). Similar in direction, but slightly weaker increases are observed in terms of Internet penetration rates – to compare see Table 1 and Fig.1.

Table 1. ICT and social indicators – descriptive statistics. Period 2000-2014.

Variable	Obs.	Mean	Std.Dev.	Min	Max	Skewness	Kurtosis
MCS_2000	55	1,6	2,5	0,08	14,5	2,5	9,2
MCS_2014	57	88,0	32,1	30,5	155,1	0,2	2,4
IU_2000	55	0,43	0,45	0,015	1,9	1,3	4,2
IU_2014	57	19,6	14,9	1,4	56,8	0,8	2,5
TFert_2000	57	96,4	48,9	25,2	218,9	0,3	2,3
TFert_2014	57	75,2	42,6	15,3	203,6	0,6	3,1
Mort_2000	57	106,9	56,5	16,3	235,8	0,3	2,3
Mort_2014	57	56,3	30,4	9,5	126,4	0,3	2,2
Pop_2000	57	2,1	1,2	-1,0	5,6	-0,06	4,7
Pop_2014	57	1,9	0,91	-0,3	4,0	-0,3	2,7
Enroll_2000	47	40,2	24,7	6,0	98,8	0,7	2,6
Enroll_2013	34	56,9	23,7	18,3	100,6	0,3	1,9
Urb_2000	57	35,3	15,7	8,2	76,5	0,4	2,5
Urb_2014	57	40,6	15,8	11,7	77,3	0,2	2,6
LfpFem_2000	57	46,9	17,9	10,3	79,7	0,2	2,0
LfpFem_2014	57	45,6	17,9	9,7	77,9	0,2	2,0

Source: Authors` calculations.

Fig.1. ICT and social indicators. Density plots. Period 2000-2014.



Source: Authors` elaboration. Note – Kernel density estimates applied.

Considering social development, we have selected 6 indicators, which may claimed as good proxies of the level of social development regarding progress made in the area of health care (adolescent fertility, under-five mortality, population growth), education (gross secondary enrollment ratio and female labor force participation ages 15-24), infrastructure (urbanization). Assuming that given economy progress in terms of social development, arguably the indicators reflecting adolescent fertility, under-five mortality, population growth and female labor force participation[2] ages 15-24 should be gradually decreasing, while – gross secondary enrollment ratio and urbanization – should be rather increasing. Respective density plots in Fig.1 and summary statistics in Table 1, display changes made regarding each of analyzed social factors. Evidently, most dynamic changes are observed with respect to under-five mortality rates, adolescent fertility and gross secondary enrollment ratio; while indicators explaining changes in urbanization, population growth and female labor force participation ages 15-24 show relative in-time stability if compared to the previous ones. In 2000, the average under-five mortality rate was barely 107 per 1000 births, while in 2014 it fell till 56 per 1000 births, and this constitutes the most significant change of all analyzed indicators. Along with the adolescent fertility rate falling from almost 97 per 1000 women in 2000, to 75 per 1000 women in 2014, and similarly rapid increases in gross secondary enrollment ratio, changes in under-five mortality, reflect essential and positive changes in health care and education systems providing solid foundations for progress in other social and economic spheres of life.

Next, we aim to verify whether changes in social development impact positively growing access to and use of ICT in developing countries over the period 2000-2014. In here, importantly to note, shifts in social wealth do not have a direct impact on the process of deployment and effective usage of new technologies. However, we argue that positive changes on social field constitute an important prerequisite for ICT`s growing propensity to use, and in that context examining these aspects of life yields special interests. One should also bear in mind that Examining the relationships between the process of ICTs diffusion and its social determinants is a challenging task, for one hand because countries in the scope are

[2] We claim that as country develops, women ages 15-24 should rather enter education system and labor market. Hence, this indicator should be rather falling along with growing overall socio-economic development.

heterogeneous, but on the other hand, the analyzed relationships are complex and often difficult to quantify. Econometric modeling is usually applied to verify the nature of the relationships between variables; however, country`s individual characteristics significantly pre-determine investigated relationships, which are poorly captured through econometric models. For this reason, the relationship between the process of ICTs diffusion and its social determinants remains empirically intractable, and one shall consider this fact when drawing conclusions from the analysis presented below.

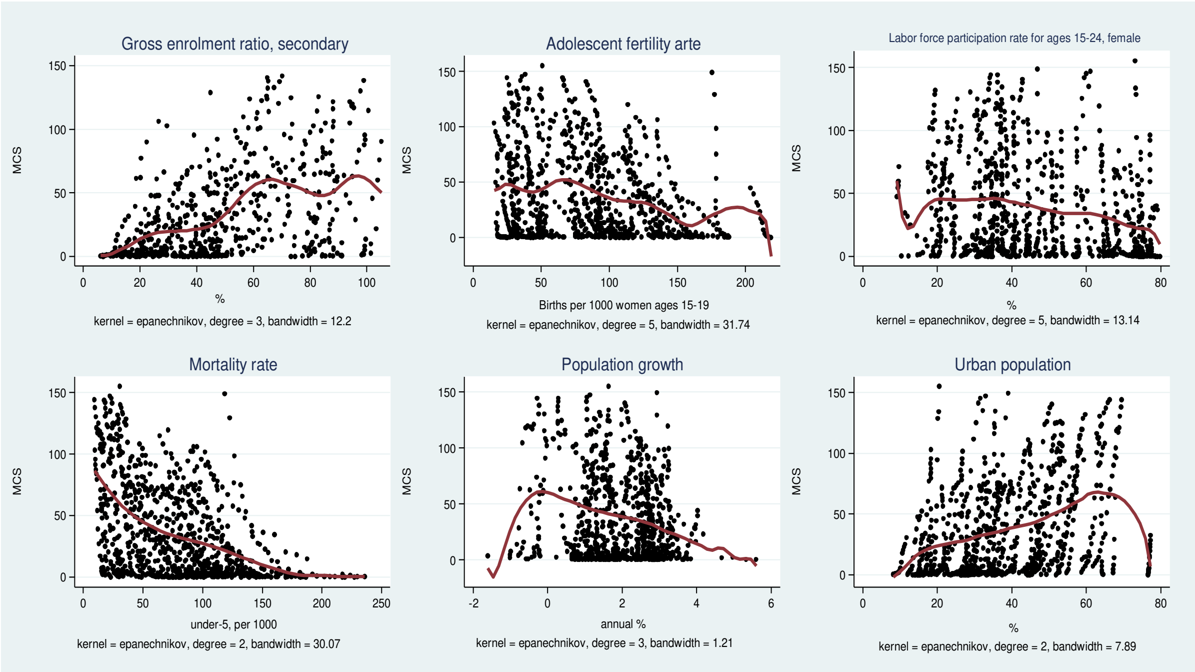
Tables 2 and 3 summarize the results of panel regression estimates; while Figs. 3 and 4 provide additional graphical evidence with this respect. We hypothesize that variables like population growth, female labor force participation ages 15-24, under-five mortality and adolescent fertility should demonstrate negative relationship versus ICT deployment. Put differently, we expect that all listed indicators should demonstrate rather decreasing trends, which would be accompanied by growing level of ICT adoption and use. While, regarding the gross secondary enrollment ratio and urbanization are expected to unveil growing trends, and thus be positively correlated with growing level of ICT adoption and use of.

In here, it should be strongly underlined that we do not claim that all selected social indicators are direct determinants of ICT growing penetration, but rather it aims to unveil whether social and technological sphere of life develop simultaneously in economically backward countries. For this reason, we presume that two selected ICT indicators are depended variables in our panel regression estimates; however one shall borne in mind that no direct causal relationships are claimed in this case.

Figs. 2 and 3 graphically explain the relationship between the level of adoption of mobile cellular telephony ($MCS_{i, y}$) and Internet usage ($IU_{i, y}$) *versus* selected social indicators, across 57 economically backward countries between 2000 and 2014. Preliminary, graphical inspection of the empirical results unveils that, in most of cases – regarding $MCS_{i, y}$ and $IU_{i, y}$, no regular relationships may be easily detected. The only exception is under-fivemortality rate, which demonstrates relatively stable relationship versus mobile cellular telephony adoption rates and Internet penetration (see also correlation matrix in Appendix). Moreover, some regularities might be potentially reported regarding gross school enrollment versus ICT, however – at least visually, these relationships seem to be far less stable if compared to under-five mortality rates. Taking into consideration the remaining social indicators, we may argue that the relationships between consecutive social indicators and ICT are rather dispersed and scattered.

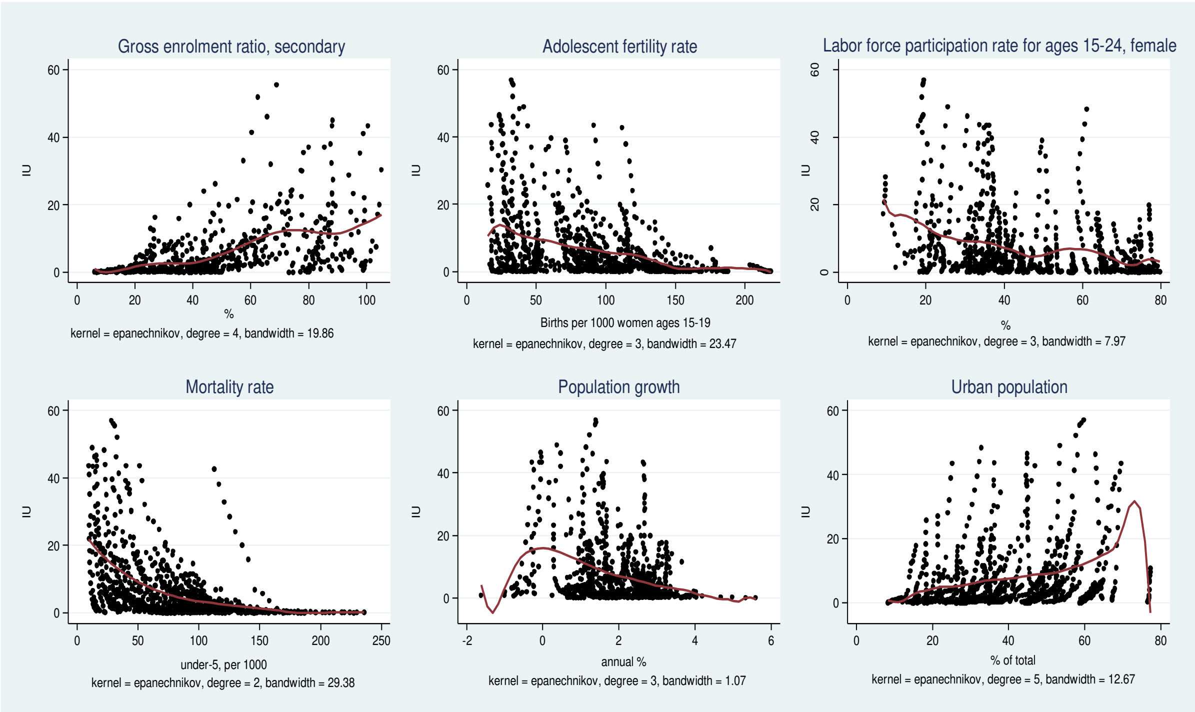
However, importantly to underline, all the evidence that is considered with respect to mobile cellular telephony and Internet penetration rates versus social indicators, demonstrates excepted correlation sign. Meaning that variables like gross secondary school enrollment and urbanization are positively correlated versus ICT; while the remaining indicators are negatively correlatives versus ICT (see results in correlation matrix in Appendix). The latter, at least partially, allows concluding that countries being in scope of our study, significantly progress socially, which is accompanied by rapid shifts in access to and use of ICT.

Fig.2. ICT (Mobile cellular penetration rate) development versus social development. Period 2000-2014.



Source: Authors` elaboration. Note: nonparametric regressions (Kernel-weighted local polynomial smoothing) applied. Kernel=epanechnikov. Polynomials` degrees – adjusted for consecutives models respectively.

Fig.3. ICT (Internet penetration rate) development versus social development. Period 2000-2014.



Source: Authors` elaboration. Note: nonparametric regressions (Kernel-weighted local polynomial smoothing) applied. Kernel=epanechnikov. Polynomials` degrees – adjusted for consecutives models respectively.

Table 2. Mobile Cellular penetration rates and social indicators. Period 2000-2014[3].

Ln_MCS	FE (1)	FE (2)	FE (3)	FE (4)	FE (5)	FE (6)	FE (7)	FE (8)	FE (9)	FE (10)
Ln_Pop	0,52 (0,03)	0,73 (0,00)	-	0,29 (0,01)	0,13 (0,24)	-	-	-	-	-
Ln_Enroll	0,8 (0,00)	-0,11 (0,59)	0,17 (0,35)	-	-	0,41 (0,02)	-	-	-	-
Ln_Urban	2,1 (0,02)	1,5 (0,01)	1,8 (0,00)	-	-	-	2,75 (0,00)	-	-	-
Ln_FlpFem	-0,41 (0,38)	0,45 (0,17)	-	0,76 (0,00)	-	-	-	0,62 (0,01)	-	-
Ln_TFert	-2,02 (0,00)	-1,3 (0,00)	-	-1,3 (0,00)	-	-	-	-	-0,97 (0,00)	-
Ln_Mort	-5,3 (0,00)	-0,76 (0,03)	-0,59 (0,08)	-	-	-	-	-	-	-0,87 (0,00)
r-squared (within)	0,76	0,89	0,88	0,89	0,89	0,88	0,89	0,89	0,89	0,89
Prob>chi2 for Hausman test	0,00	-	-	-	-	-	-	-	-	-
Country-dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-dummies	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
rho	0,96	0,82	0,72	0,82	0,69	0,71	0,76	0,75	0,76	0,64
F test (Prob>F)	28,6 (0,00)	16,6 (0,00)	17,8 (0,00)	27,8 (0,00)	30,5 (0,00)	23,2 (0,00)	24,0 (0,00)	29,9 (0,00)	34,7 (0,00)	25,9 (0,00)
mean VIF (condition number)	1,81 (67,3)	1,81 (67,3)	2,15 (46,8)	1,26 (25,7)	-	-	-	-	-	-
# of countries	57	57	57	57	57	57	57	57	57	57
# of observations	526	526	571	794	794	845	845	845	845	845

Source: Authors` estimations. Note – estimates for conventional standard errors (*p-values* for 5% level of significance – reported below coefficients).

[3] For Gross Enrolment ratio – 2000-2013.

Table 3. Internet penetration rates and social indicators. Period 2000-2014[4].

Ln_IU	FE (1)	FE (2)	FE (3)	FE (4)	FE (5)	FE (6)	FE (7)	FE (8)	FE (9)	FE (10)
Ln_Pop	0,07 (0,73)	0,15 (0,33)	-	0,00 (0,85)	-0,08 (0,44)	-	-	-	-	-
Ln_Enroll	0,05 (0,82)	-0,67 (0,00)	-0,56 (0,00)	-	-	-0,23 (0,14)	-	-	-	-
Ln_Urban	2,33 (0,00)	1,95 (0,00)	2,2 (0,00)	-	-	-	1,8 (0,00)	-	-	-
Ln_FlpFem	-0,98 (0,00)	-0,39 (0,19)	-	-0,52 (0,04)	-	-	-	-0,45 (0,05)	-	-
Ln_TFert	-1,34 (0,00)	-0,75 (0,03)	-	-0,67 (0,01)	-	-	-	-	-0,61 (0,00)	-
Ln_Mort	-4,43 (0,00)	-0,96 (0,00)	-1,05 (0,00)	-	-	-	-	-	-	-1,4 (0,00)
r-squared (within)	0,75	0,85	0,85	0,85	0,85	0,84	0,86	0,85	0,85	0,86
Prob>chi2 for Hausman test	0,00	-	-	-	-	-	-	-	-	-
Country-dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-dummies	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
rho	,95	0,83	0,83	0,77	0,80	0,84	0,81	0,79	0,79	0,75
F test (Prob>F)	31,04 (0,00)	24,9 (0,00)	27,1 (0,00)	48,8 (0,00)	51,5 (0,00)	29,8 (0,00)	53,5 (0,00)	53,5 (0,00)	58,2 (0,00)	42,4 (0,00)
mean VIF (condition number)	1,81 (67,3)	1,81 (67,3)	2,15 (46,8)	1,26 (25,7)	-	-	-	-	-	-
# of countries	57	57	57	57	57	57	57	57	57	57
# of observations	529	529	574	799	799	574	850	850	850	850

Source: Authors` estimations. Note – estimates for conventional standard errors (*p-values* for 5% level of significance – reported below coefficients).

[4] For Gross Enrollment ratio – 2000-2013.

Next, we intend to report on the relationships between social development and ICT development using panel regression modeling methods. By convention we do so by estimating two distinct panels (with respect to mobile cellular telephony and Internet penetration), which have an empirical form as specified in Eq.6. In each case the ICT variables are treated as response variables, while the social variables – as explanatory ones. Tables 2 and 3 summarize the regression results, regarding mobile cellular subscriptions and Internet penetration rates. In each case, following the results of Hausman test, we used fixed-effects estimator, which allows capturing cross-country variability with respect to analyzed relationships. Moreover, to control for potentially emerging collinearity between explanatory variables, we have calculated with Variance Inflation Factors[5].

Table 2 displays panel regression estimates regarding emerging relationships between mobile cellular telephony subscription rates and social indicators. Estimates model FE(1), is the only specification, in which year-dummies are not included. However following the results of specification tests, we decide to include the year-dummies in each consecutive model – panels from FE(2) to FE(10), which effectively increases regression models` fits. Specification FE(2) presents panel regression results while all six social indicators and year-dummies are included. In this case, the r-square is at about 0,89 demonstrating high goodness of fit of the model. Put differently, basing of this results one might claimed that growths on mobile cellar subscription rates in 89% are subjected to changes in social spheres of life across examined developing countries. Analyzing model FE(2), we see that in case 3 out of 6 social indicators, the estimated coefficients hold the expected sign and the relationship is statistically significant. The latter is valid for urbanization (positive relationship), adolescent fertility and under-five mortality (negative relationship in both cases). Although the relationship between depended variable and population growth is statistically significant, the coefficient holds positive sign, which is rather contradictory to what was expected. Again, in case of school enrollment and female labor force participation, despite the fact that the coefficients are negative, thus as expected, the relationships lack statistical significance. A comprehensive analysis of the results of remanding models allows concluding that irrespectively to the specification, the statistically significant and expected in sigh relationships are reported in case of factors explaining urbanization, adolescent fertility and under-five mortality rates. It may suggest that across analyzed countries the process of urbanization and improving accessibility of health care system are those elements which change relatively fast – compared to other examined factors, and in this context, these positive changes in social and infrastructural sphere of life constitute *drivers* of ICT deployment providing solid background for further economic development. Interestingly, the regression coefficients standing by the female labor force are predominantly positive (see FE(2), FE(4) and FE(8)) (in FE(1) the sign is negative as expected but the relationship is statistically insignificant), which shows that women ages 15-24 still actively participate in labor market instead of entering education system.

Similar claims may be raised when analyzing the results of panel regression models summarized in Table 3. In this case, the variable Internet penetration rate is treated as response one, while the six social variables are explanatory variables. Again, only in specification FE(1), year-dummies were not include, reversely to each consecutive model (FE(2)-FE(10)). The results of the model FE(2) report that in case of four variables, namely – urbanization, female labor force participation, adolescent fertility and under-five mortality rates, the estimated regression coefficients hold the expected sign. For urbanization,

[5] The Variation Inflation Factor (VIF) is the reciprocal of the Tolerance $(1 - R_i^2)$, and determine how much of the variance of estimated regression coefficients are being inflated due to emerging collinearity between examined variables. Usually, we should be concerned about the multicollinearity once the VIF exceeds 10 (Mansfield and Helms 1982; O`Brien 2007; Dormann et al. 2013).

adolescent fertility and under-five mortality rates the relationships are statistically significant; while for female labor force participation it is statistically insignificant. However, importantly to observe that when considering specifications FE(1), FE(4) and FE(8), the coefficients are negative and emerge as statistically significant. The variable school enrollment ratio although being statistically significant, it holds the negative sign, which would indicate that growing Internet penetration rate, across analyzed economies, are accompanied by decreasing school enrollment, which – for obvious reasons, may not be claimed valid conclusion[6].

Trying to draw more general conclusions on panel regression estimates, regarding mobile cellular telephony subscriptions and Internet usage, interestingly we may claim that in both cases the results for the same social indicators, like urbanization, adolescent fertility and under-five mortality rates are fully robust. In other words, irrespective to the specification and the depended variable, the estimated regression coefficients are positive and statistically significant for urbanization; and negative and statistically significant for adolescent fertility and under-five mortality rates. These results allow concluding that across examined 57 developing countries over the period 2000-2014, the relationships between changing ICT (approximated by mobile cellular subscription and Internet usage) is stable and statistically significant. The latter shows that all of analyzed countries, during the period 2000-2014 have intensified their urbanization process, but also it demonstrate significant shifts in access to healthcare systems, which is exhibited through essential falls in adolescent fertility and under-five mortality (to compare see also density plots in Fig.1). Arguably, positive changes in terms of urbanization, adolescent fertility and under-five mortality reflect more general development trends across analyzed economies, which in our case may foster not only rapid spread of new technological solutions, but also their effective usage to enhance over socio-economic development contributing to general wealth.

5. Summary.

The major target of this paper was to report on the emerging relationships between social development and the process of ICT diffusion approximated by changes in access to and use of mobile cellular telephony and Internet network. In our study we have concentrated on 57 developing countries, between years 2000 and 2014. The examined relationships have been extensively investigated by the use of descriptive statistics, nonparametric regressions and panel regression applying fixed effect estimator. Regarding observed progress in terms of social development, we have found that most seminal changes are reported for significantly decreasing under-five mortality rates and adolescent fertility rates. Also significant, but less in strength changes are unveiled for growing urban population and gross secondary enrollment. Instead, in terms of population growth and female labor force participation, reported changes are negligible, and do not allow justifying the conclusion that in these two areas examined countries progressed significantly. On the other hand, across all of countries being in scope of our study, we observe pervasive shifts in access to and use of ICT, and these are very promising changes (Wilson 2004, Torero and Von Braun 2006). In our research, we have intended to verify the hypothesis on the relationships between all six social indicators and ICT indicators, arguing that changes in the area of the first may contribute positively to the second. To verify our suppositions we have run panel regression analysis, which was complemented by graphical evidence. The latter means that have presumed that ICT diffusion is – at least partially, determined by changes on social ground. However, as already underlined, we do not claim existence of direct and automatic casual relationships between these two spheres, but

[6] In FE(3) and FE(6) – still the coefficients are negative. In FE(1) the coefficient is positive, but statistically insignificant.

we rather claim that social progress may effectively enhance further changes in ICT deployment and effective usage (Perez and Soete 1988, Mansell 2001, Hanna 2010). Following our panel regression results, we may conclude that in case of mobile cellular telephony model, the relationship between $MCS_{i,y}$ and three social indicators was found as relatively robust. There are: urbanization (positive), under-five mortality and adolescent fertility rates (negative). Interestingly analogous results were reported for the Internet users models.

Unveiling the relationships between ICTs diffusion and its social factors, which hypothetically may determine the later, is complex and challenging task. Not only because the group of countries that was in scope of this research is extremely diversified and heterogeneous, but also because the examined relationships are complex and are influenced by multiple factors, which are often difficult to identify or quantify (Wresch and Fraser 2012). We bear in mind that econometric methods are broadly used to report on the relationships between selected variables. However, to some point, the relationship between the process of ICTs diffusion and its social determinants is empirically intractable, and drawing direct conclusions from in-here presented analyses yield over-simplification.

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Appendix.

ICT and social indicators – correlation matrix. Period 2000-2014.

	IU	MCS	Pop	Enroll	Urban	FlpFem	TFert	Mort
IU	1,0							
MCS	0,72	1,0						
Pop	-0,30	-0,21	1,0					
Enroll	0,50	0,46	-0,67	1,0				
Urban	0,27	0,34	-0,33	0,45	1,0			
FlpFem	-0,28	-0,21	0,28	-0,45	-0,44	1,0		
TFert	-0,36	-0,23	0,61	-0,60	-0,19	0,25	1,0	
Mort	-0,49	-0,49	0,62	-0,78	-0,35	0,29	0,69	1,0

Source: Author`s calculations. Note: results statistically significant at 5%. Joint sample sizes reported below coefficients.