

Bridging the Digital Divide in India: Barriers to ICT Adoption and Usage

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ICT Potential

- ICT has radically improved **connectivity** & pervaded into several aspects of modern human life (**GPT**).
- Telecommunications services foster **economic growth, welfare** & play vital role in **reducing poverty** (*Hardy, 1980; Norton, 1992; Dutta, 2001; Röller & Waverman, 2001; Waverman, et al., 2005; Vu, 2005; Sridhar & Sridhar, 2006; Abraham, 2007; Jensen, 2007; UNCTAD, 2008; Kathuria et.al., 2009*)
- Tool for the **delivery of developmental services** specially in the **underserved areas** (Foster &Heeks, 2013; Srivastava & Shainesh, 2015; Leong, Pan, Sue, &Cui, 2016)
- “Similarly, industrialization or technological progress or social modernization can substantially contribute to **expanding human freedom**, but freedom depends on other influences as well.” (*Sen A.,1999, Development as Freedom, Pg 3*)

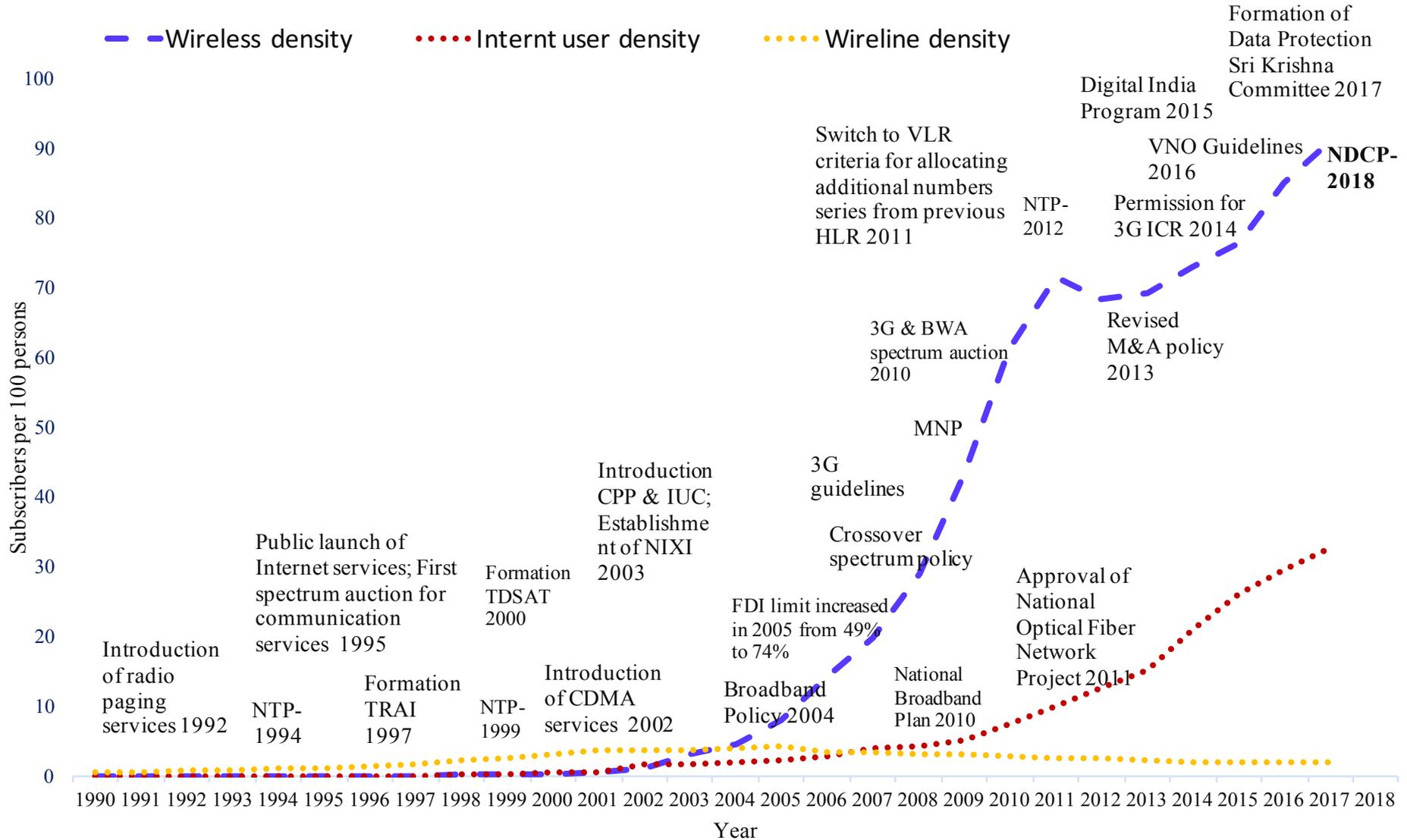
Utility

- Communications
- Knowledge/Information sharing: search, maps, news
- Educational use, online learning
- Finance
- E-commerce
- E-government services : taxes, licenses
- Civic engagement , e-democracy
- Social participation: e-mail, networking
- Access to online job listings, applications
- Online transactions Health information
- Entertainment
- New business models- ride hailing, convenience applications

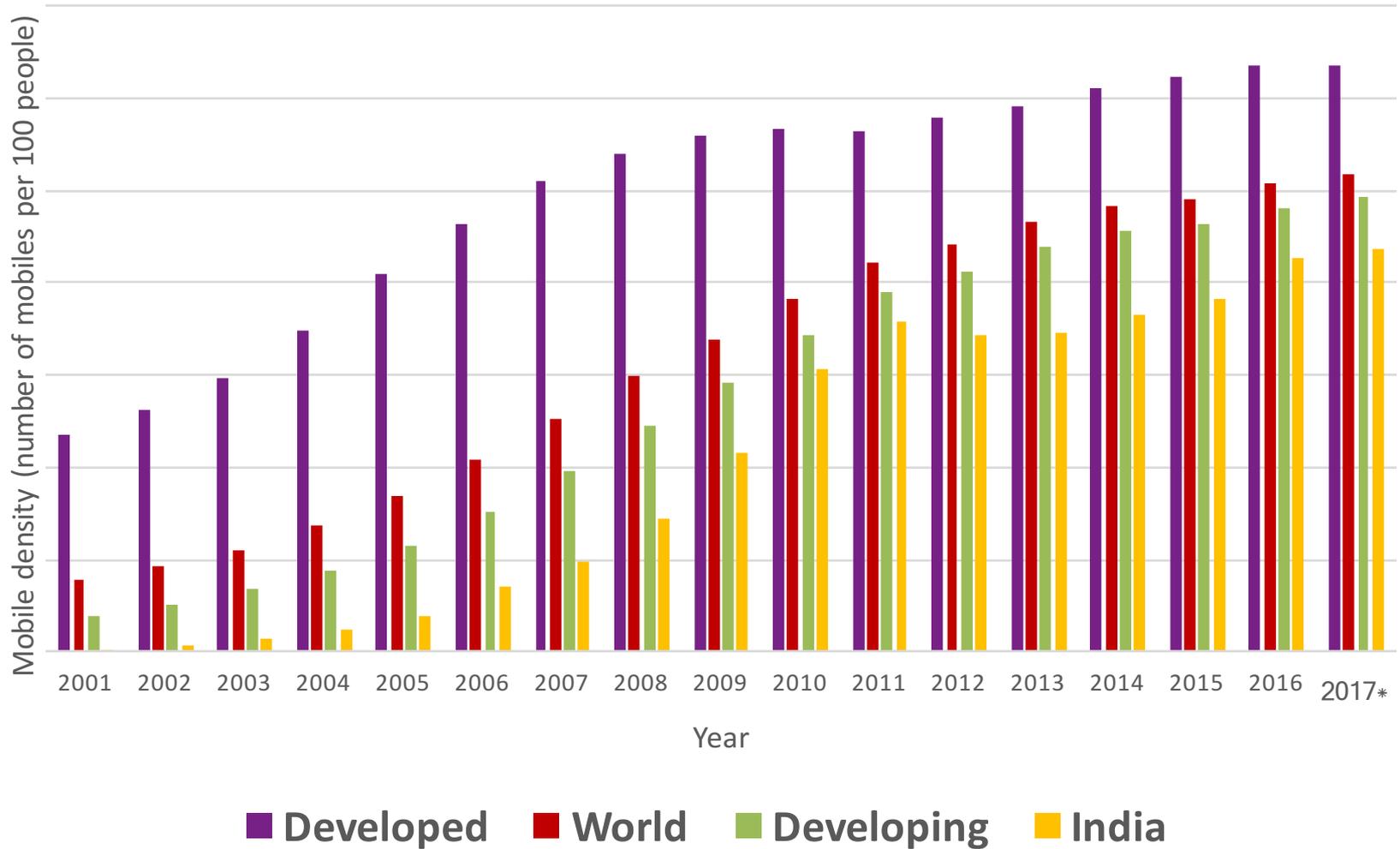
Government Intervention

- National e-Governance Plan (2006)
- National Education Mission (2009)
- National Knowledge Network (2010),
- National Mission for Delivery of Justice & Legal Reform (2011)
- Digital India programme (2015)
- Land record computerization , railway booking through e-platform
- Establishment National Innovation Council (2010) State Innovation Councils
- National Optical Fibre Network (2011)
- m-kisan(2013)
- Agriculture-e-NAM(2016)
- SEHAT (2015)
- BHIM (2016)
- UMANG (2017)

Digital Evolution of India-1990-2018

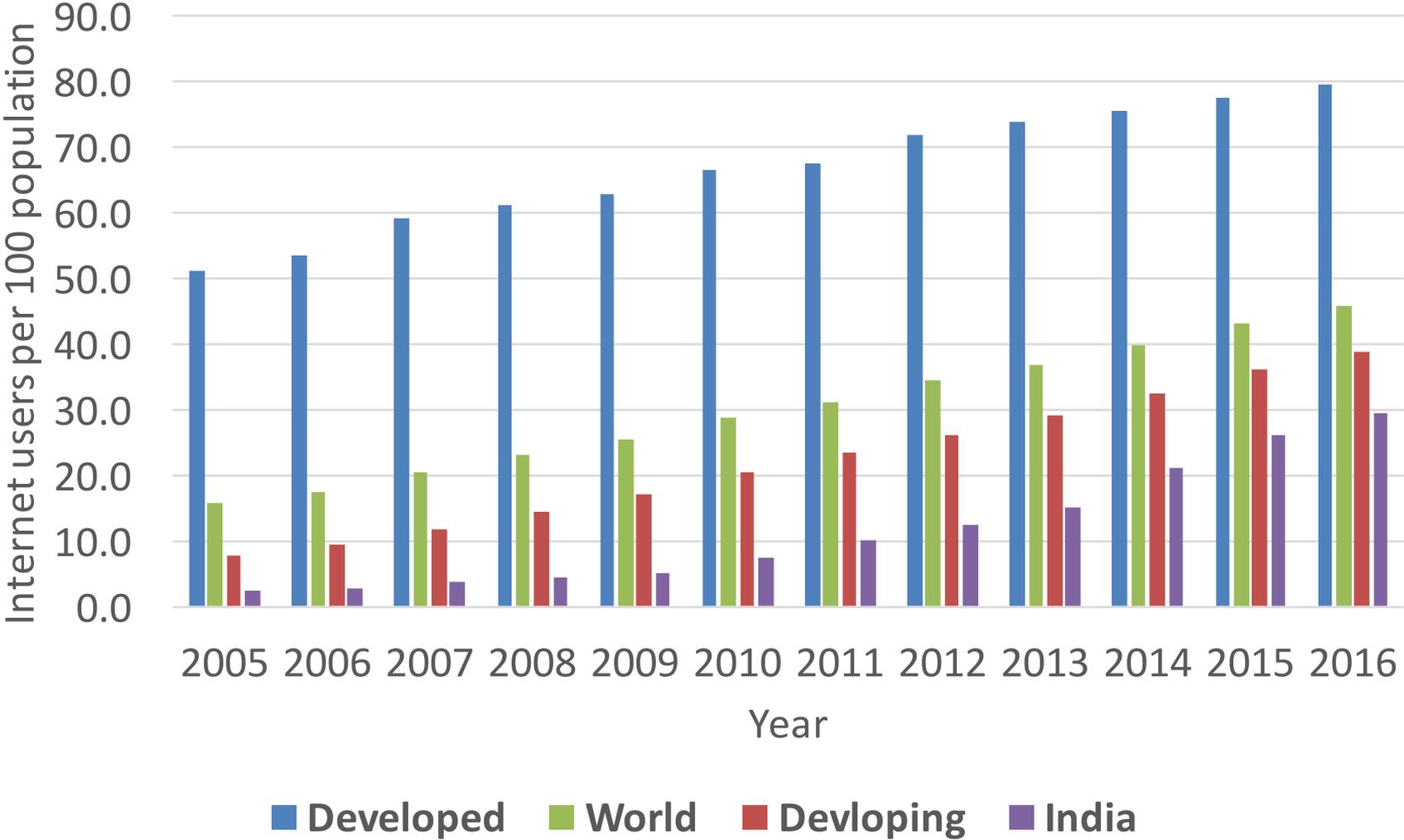


Comparison of India's mobile density with the world



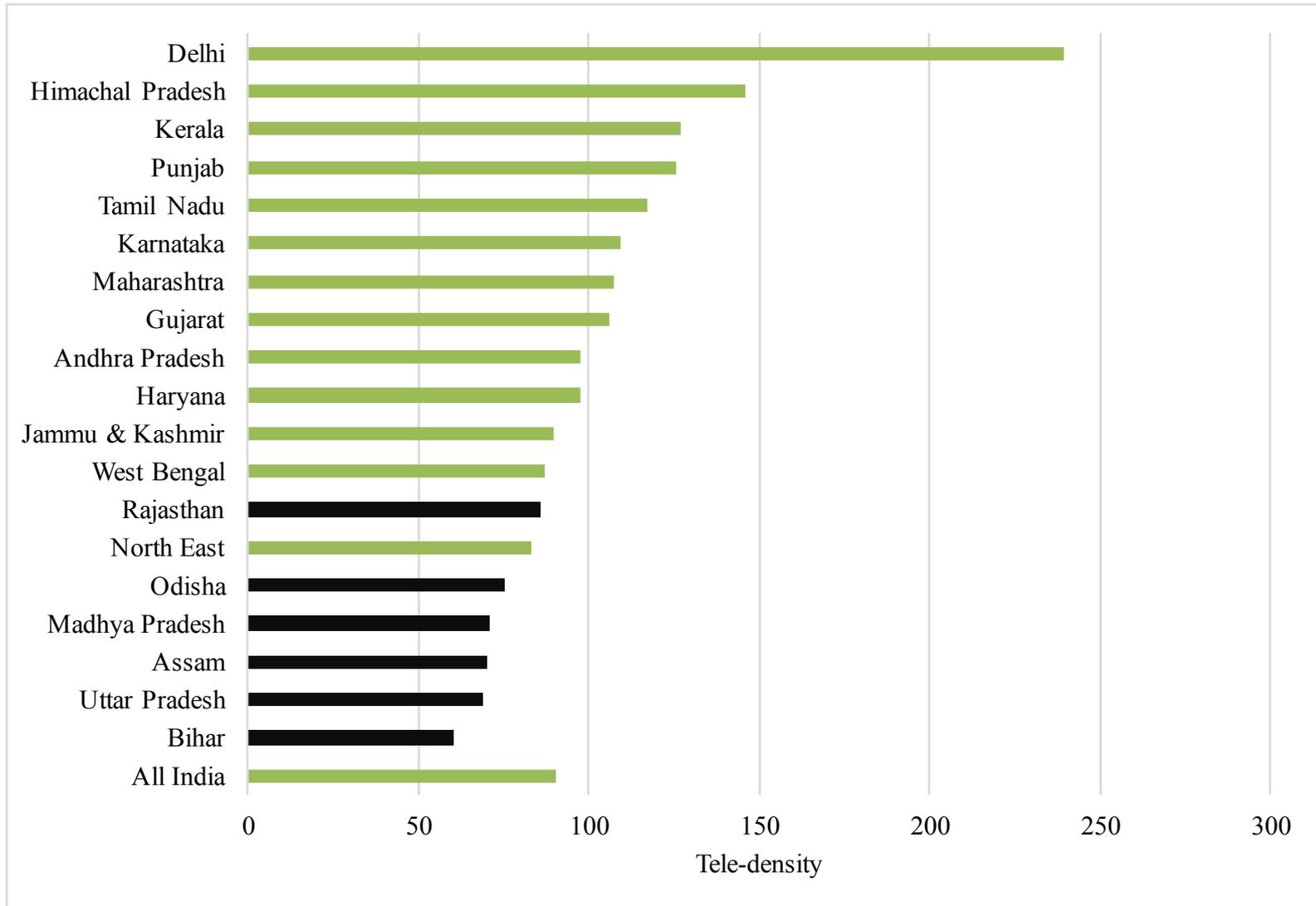
Source: ITU2017

Comparison of India's Internet usage density with the world



Source: ITU2017

Circle/state wise tele-density in India in April 2019



Source: TRAI (2019)

Why is Digital Inclusion Critical? (Adoption)

- Ability to **access, utilize & manage ICT** are prerequisites to **benefit** from the technology & participate in the knowledge-based global economy
- **Marginalized** communities have the **most to gain & most to lose**.
- **Socio-economic disparities** that give rise to digital disparities could further **intensify if the existing digital gap is not bridged** (*Avgerou & Madon 2005; Ching, Basham & Jang 2005; Wei, Teo, Chan, & Tan 2011*)
- **Basic digital skills** are now **crucial** like the basic grammatical & mathematical skills for **employment opportunities, social inclusion & human development**.
 - *Wei et al. (2011)* argue that disparities in access to digital resources may result in a digital capability divide that leads to differences in experienced outcomes.
 - *Malamud & Pop-Eleches (2011)* observe that home computers use use improved cognitive skills of children & adolescent outcomes in Romania
- **Economic Self-Sufficiency** (individual) **Economic Development** (community)

What is digital divide ?

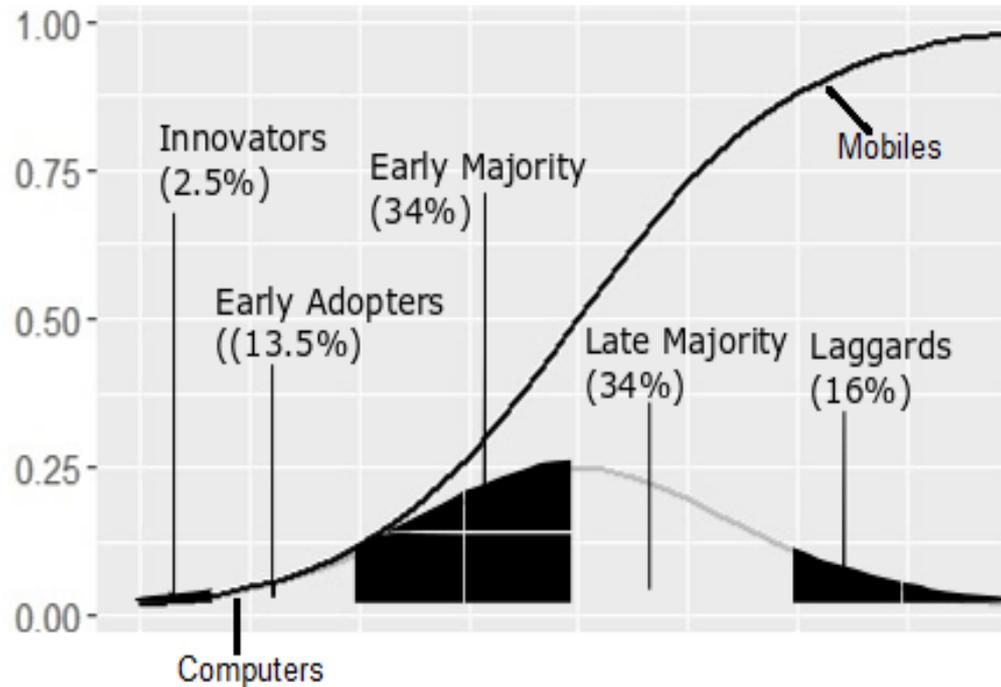
- *Van Dijk (1999)* emphasizes four types of impediments to digital inclusion: **lack of “material access”, “mental or educational access”, “skill access”, & “usage access”**.
- “The term digital divide refers to the gap between individuals, households, businesses & geographic areas at different socio-economic levels with regard both to the opportunities to access ICTs & use of the Internet for a wide variety of activities”. (*OECD, 2001*)
- **Composite indices on digital divide** give weights to **supply & demand side variables** like electrification of region, tower infrastructure, ability of the people to use technology, & tariff rates (*Atkinson et al., 2014; UNDP, 2001; ORBICOM, 2002,2003; WEF, 2002,2003,2004; ITU 2003 Emrouznejad et al., 2010*)
- Digital divide is a **multidimensional** phenomenon of disparities in access to & utilization of ICT (*Wolff et al., 2002; WIS Report, 2007*)
- **Digital divide can simply be understood in a binary way, as a choice between “have” & “have not” access to ICT**

The Approach

- Though, the **binary definition** is reductive it may be **useful** for describing the **limits of technological inequalities** (*Gunkel, 2003*)
- Using the basic **binary** definition of digital divide to document **pan India digital disparities** –Possession of digital devices
- Supports to *Rogers (1983)* theory of **Diffusion of Innovation** theory
- **Household** ICT access (*Kalba, 2008*) and **Individual's** for ICT skills
- Question: What factors are correlated with the digital disparities across India ?
- NSSO, GoI 2014

Understanding the characteristics of technology adopters

Fig.1 The Sigmoid S-shaped curve of diffusion of innovation/technology



Note: The vertical axis indicates the percentage of adopters and the horizontal, time.

Source: Created by the authors based on Rogers (1983: 243).

- Innovation diffusion is defined as the process by which the innovation "is communicated through certain channels over time among the members of a social system" (Rogers, 1983: 5). The key elements in the diffusion process: the innovation itself, Communication channels, time, **the social system**

Why the digital divide?

- Technological utilization depend on
 - Socio-economic factors
 - Government and societal openness
 - Geographic proximity
- Europe: judicial independence and innovation capacity (*Pick et.al. 2015*)
- Asia : FDI, tertiary education, and innovation capacity (*Pick et.al. 2015*)
- Africa & Latin America : press freedom, higher education & FDI (*Pick et.al. 2015*)
- Africa (case of Ghana & South Africa): income, health & education; neoliberal policies of liberalization, deregulation, & privatization of the telecommunication sector have not succeeded in bridging the digital divide (*C. Fuchs, 2008*).
- EU-27: economic asymmetries, the entrance year
- USA : risk of digital exclusion of elderly, women, populations with lower income, education attainment, those with disabilities, those living in rural areas, & ethnic minorities (*Katz and Aspden 1997 ; Bucy 2000 ; Hindman 2000, Mills & Whitacre 2003, Loges & Jung 2001, van Dijk & Hacker 2003*)

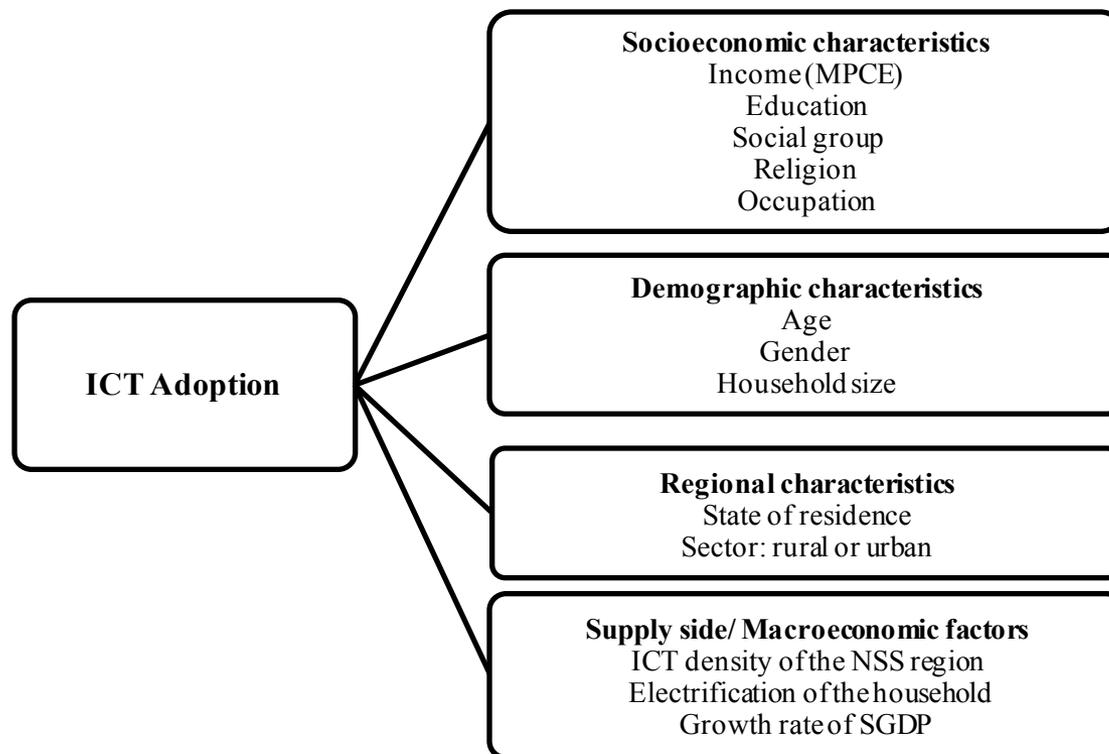
Why the digital divide?

Variable	Literature
Income	<i>Katz and Aspden 1997, 1997; Hoffman and Novak 1998, 1998; NTIA, U.S. Department of Commerce, 1999; Rice and Katz 2003; Wareham, Levy and Shi 2004; Shih and Venkatesh 2004; ; Korupp and Szydlak 2005; Chinn and Fairlie, (2007) ; LaRose; Gregg, ; Straubhaar and Carpenter, 2007; Lopez et.al, 2010; Nishida, Pick and Sarkar 2014;</i> Higher income increases the chance of adoption digital devise.
Electricity	On the supply side, access to infrastructure facilities (such as electricity, availability of telephone network, etc.) also decides if a household would possess a digital device <i>Chinn & Fairlie, 2007; Nishida et.al, 2014).</i>
Macro-factors	<i>Nishida, Pick and Sarkar 2014; Várallyai et.al, 2015</i>
Social Groups	<i>Katz and Aspden 1997 ; Hoffman and Novak 1998; NTIA, U.S. Department of Commerce, 1999 .</i> It is expected that the scheduled tribes and scheduled castes, being the most vulnerable groups in the Indian society, to have lower probability of possessing the digital devices among all the social groups.
Demographics	<i>Ahn, 2001;; Rice and Katz 2003; Korupp and Szydlak 2005; LaRose et.al, 2007; Ching, , Basham., and Jang, 2005; Chinn, and Fairlie, 2007; Billon, Marco and Lera-Lopez 2009; Brandtzæg, Petter Bae; Heim, Jan and Karahasanovic', Amela (2011). ; Nishida, Pick and Sarkar 2014; Gupta et.al, 2015).</i> Elderly and women population are relatively less likely to be digitally included. Higher proportion of members in the age group of 14-29 years and with higher proportion of male members is more likely to possess a digital device. There is a positive relationship between the household size and possession of digital devices by the household Furthermore, women experience more computer related anxiety than do men and generally exhibit lower levels of information technology achievement (<i>Whitley 1997, Cooper 2006</i>). Although the physical access gender gap has diminsed in developed countries (<i>Cooper 2006; Katz & Rice 2002; Zillien & Hargittai 2009</i>)
hhszise	<i>Kalaba (2008)</i>
Education	<i>NTIA, U.S. Department of Commerce, 1999; Ahn, 2001; Korupp et.al, 2005; Chinn et.al, 2007; Nishida, Pick and Sarkar 2014; Kilenthong and Odton 2014;)</i> Education level is linearly positively associated to be with households possess of a digital device.
Occupation	<i>Wareham et.al, 2004; Kilenthong et.al, 2014.</i> Higher the share of services sector more is the adoption of digital devices

Digital disparities in India

- *Thomas & Parayil (2008)* observed digital inequalities in two Indian **states Andhra Pradesh & Kerala** using **Sen's capability approach**, & found that **social structures with illiteracy, landlessness** are related with ICT adoption
- *Narayana (2011)* studies **the socio-economic determinants of demand** for telecom using a survey of **1100 households** in **Karnataka state** & distinguishes the importance of **caste, education level, nature of occupation, age** of household head & **family size**.
- Based on a survey of **578 respondents**, *Gupta & Jain (2015)* observed differences in mobile telephony adoption among rural population on the basis of **gender, age**, technology subscription & region (**UP & Chhattisgarh**).
- *Rao (2005)* reviews the infrastructural bottleneck that includes electricity, IT penetration, tele-density & projects that made an impact in bridging the digital divide in India, viz. passenger reservation system, Akshaya e-centres, Akashganga, Bhoomi

Methodology



Sources: Hodge and Siegel (1968) and Authors

Analysis

The multivariate analysis of various correlates is carried out using **discrete choice models**, where Dependent variables is if the household owns a PC/laptop and possession of mobile.

Methodology

- Random utility framework is used to model the chances of ICT adoption,

$$\bar{U}_i = X_i \bar{\beta} + \bar{\varepsilon}_i$$

$$\tilde{U}_i = X_i \tilde{\beta} + \tilde{\varepsilon}_i$$

where, the vector X_i denotes the characteristics for the i^{th} household and $\bar{\beta}$ and $\tilde{\beta}$, are corresponding parameter vectors, respectively ; If i^{th} household own ICT device then the associated utility with the possession of ICT device, is $\bar{U}_i > \tilde{U}_i$.

- The **dichotomous dependant variable** y_i is expressed such that it takes the value 1 if the i^{th} household possess the ICT device is 0, otherwise, then

$$Prob (y_i = 1) = Prob (\bar{U}_i > \tilde{U}_i) = G(X_i \bar{\beta} - X_i \tilde{\beta}) = G(X_i (\bar{\beta} - \tilde{\beta})) = G(X_i \beta)$$

- Depending on the distribution of error term ($\varepsilon_i = \bar{\varepsilon}_i - \tilde{\varepsilon}_i$) **logit model** (logistic distribution of error term) or **probit model** (normally distributed error term)

- To estimated household's likelihood of ICT adoption based on its socio-economic characteristics **marginal effects** are calculated

Marginal effects provide the slope of probability curve relating to the j^{th} correlate (viz., x_j) are expressed using the following equation as: $\partial / \partial x_j (\Pr[(y_i = 1)/x]) = g(X_i \beta) \beta_j$

- To determine the parsimonious model, Akaike information criterion (**AIC**) & Schwarz Bayesian information criterion (**BIC**) is used (Chen & Tsurumi, 2010).

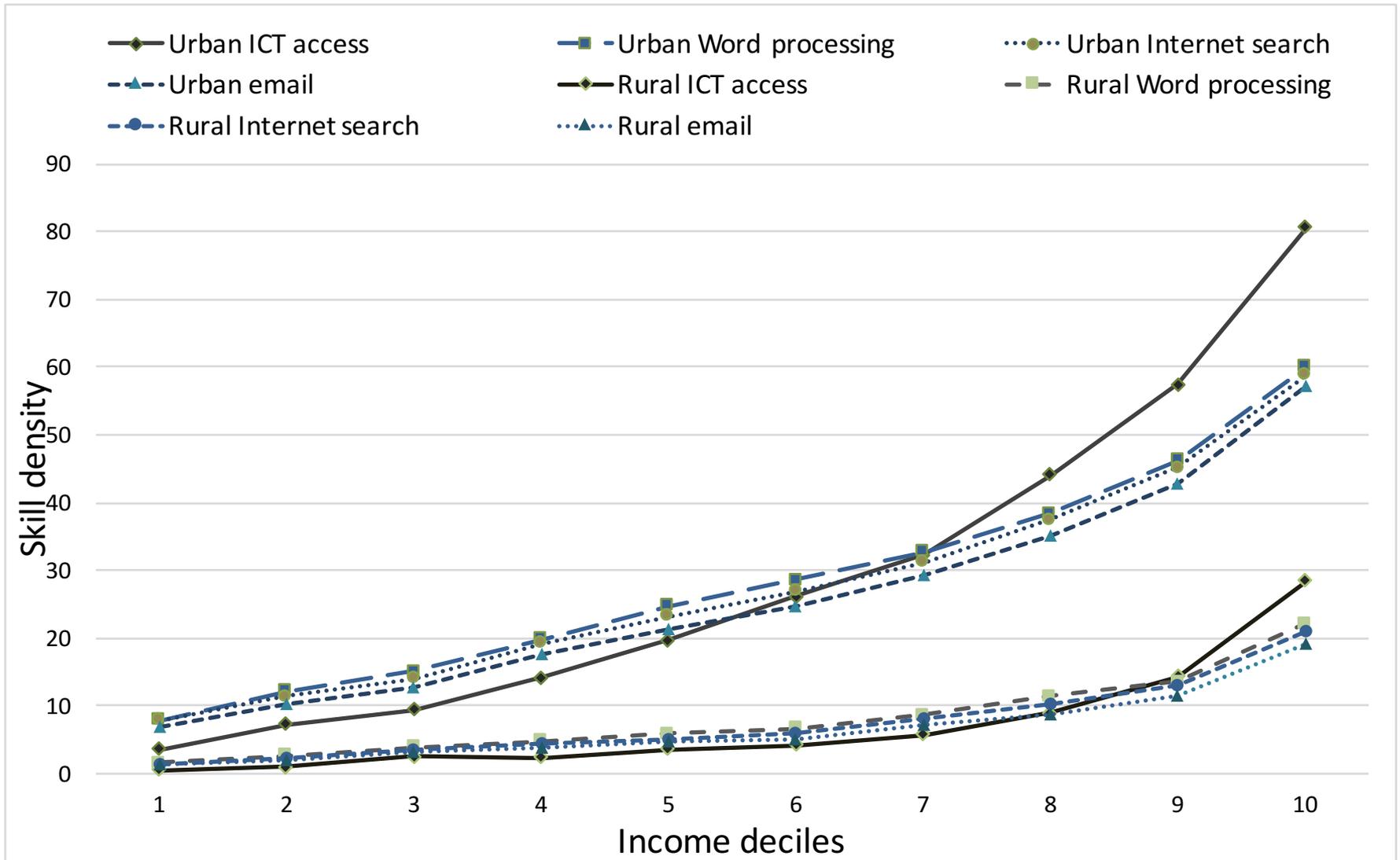
$$AIC = -2 \ln \mathcal{L} + 2k$$

Where, k is the number of parameters in the model & $\ln \mathcal{L}'$ is the maximized log-likelihood.

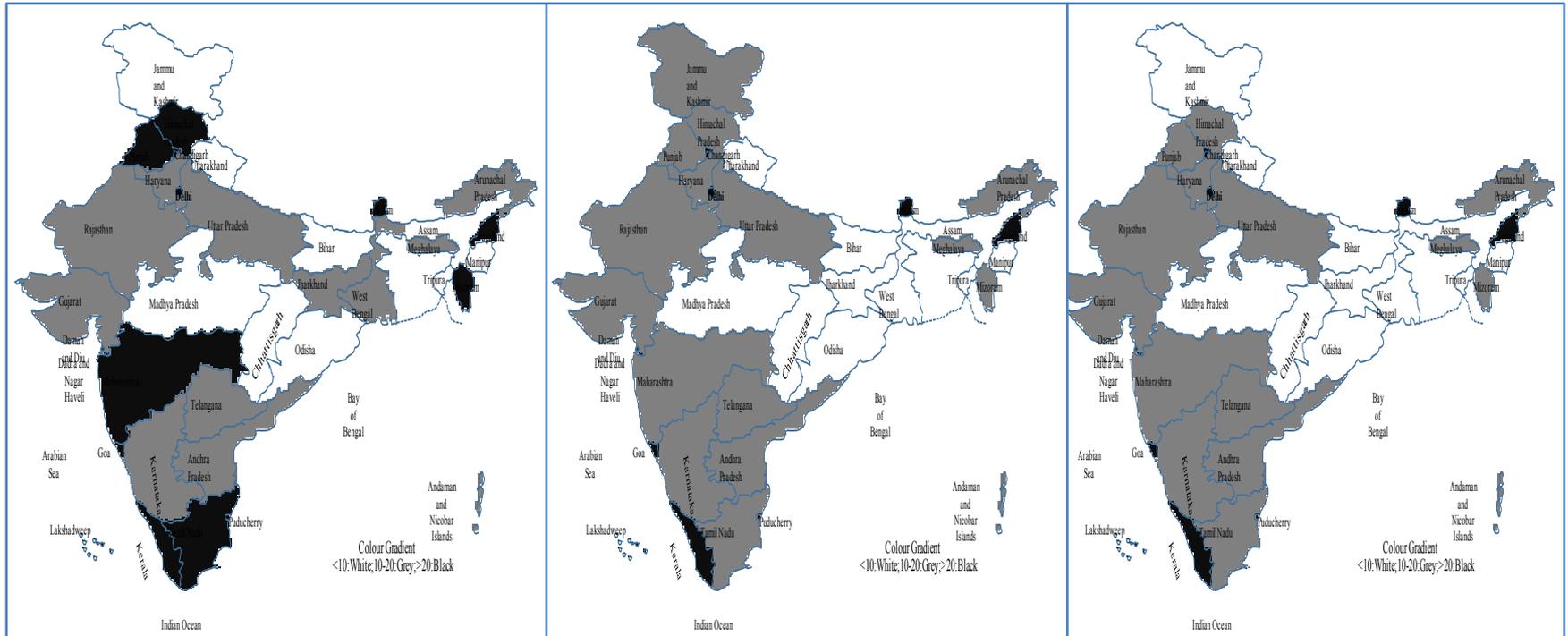
$$BIC = -2 \ln \mathcal{L} + k \ln N$$

where, ' N ' is sample size, ' k ' is number of model parameters & $\ln \mathcal{L}'$ is model maximized log likelihood

Bivariate plot of ICT adoption & its use capabilities with income



Digital Skill map of Indian states

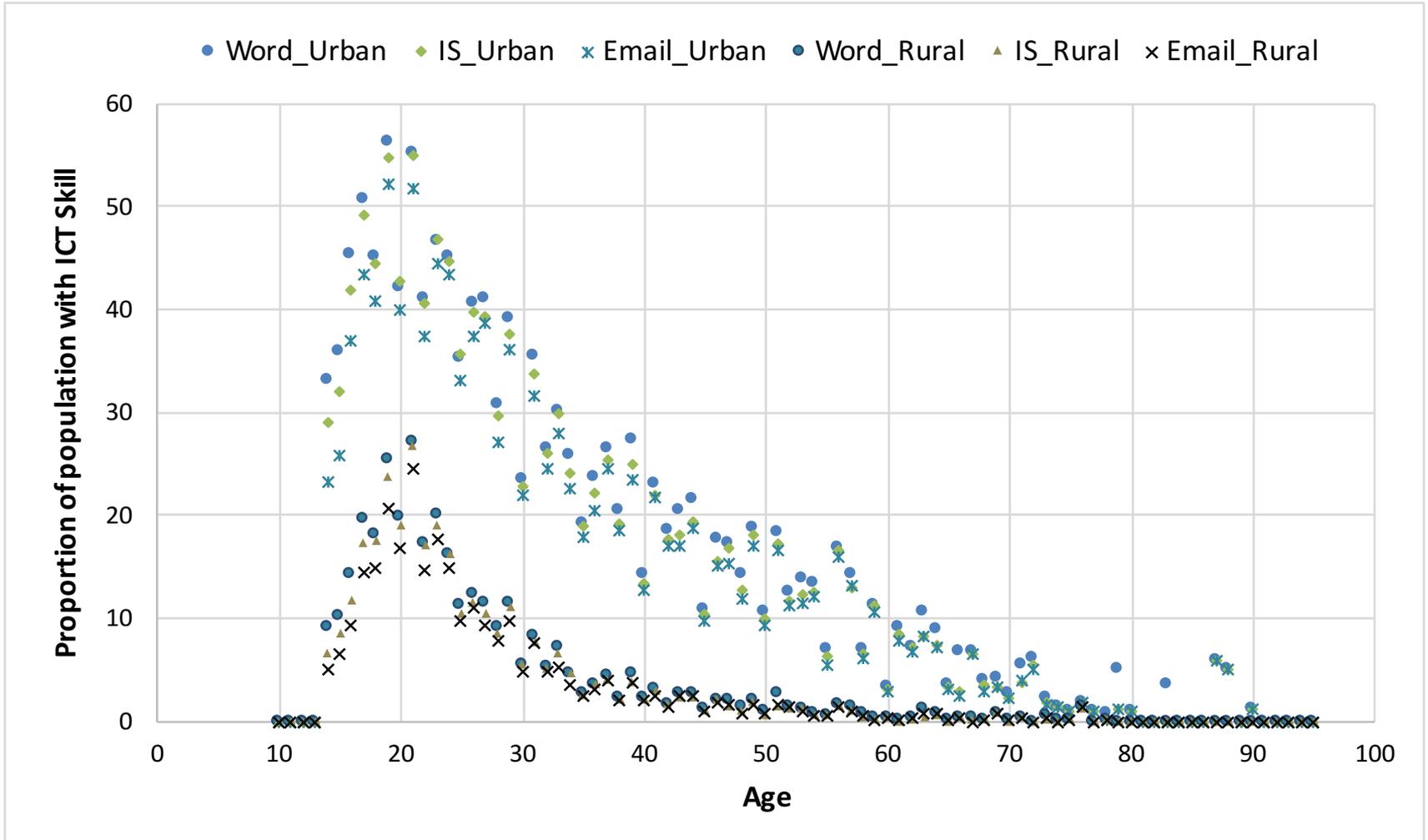


Word use

Internet search

Email

Regional ICT skill density by Age



Share of households having adopted ICT

	ICT Adoption		
	Rural (in %)	Urban (in %)	Total (in %)
Education of household head			
Illiterate	2.2	8.79	3.31
Literate but less than primary	4.19	13.56	6.46
Primary until secondary	6.89	22.26	11.76
Above secondary but less than graduate	12.97	40.19	25.97
Graduate and above	24.91	64.06	51.08
Social group			
Scheduled Tribe	2.78	24.48	5.29
Scheduled Caste	3.49	17.37	6.64
Other Backward Classes	6.12	21.81	10.75
Others	8.65	40.29	21.95
Religion			
Hinduism	5.64	30.11	12.67
Islam	4.9	17.96	9.63
Others	12.64	44.24	23.29

Share of individuals having the basic ICT skills

	Word Use (in %)			Internet Search (in %)			Email (in %)		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Education of Individual									
Illiterate	0.01	0.08	0.02	0.03	0.08	0.03	0.03	0.07	0.02
Literate but less than primary	0.17	0.63	0.28	0.27	0.49	0.27	0.22	0.37	0.17
Primary until secondary	5.88	15.56	8.94	8.01	14.41	8.01	6.69	12.29	4.1
Above secondary but less than graduate	35.76	52.66	43.46	41.71	50.88	41.71	38.64	48.19	30.65
Graduate and above	52.56	72.49	65.69	64.3	71.18	64.3	62.23	69.21	48.72
Social group									
Scheduled Tribe	4.63	24.5	7.08	4.02	23.26	6.4	3.62	21.78	5.87
Scheduled Caste	5.88	18.44	8.87	5.42	17.73	8.35	4.72	16.15	7.44
Other Backward Classes	7.85	23.88	12.79	7.29	22.71	12.05	6.53	20.97	10.98
Others	11.14	36.17	22.06	10.46	35.19	21.26	9.3	33.42	19.83
Religion									
Hinduism	7.87	29.85	14.54	7.33	28.76	13.83	6.52	26.95	12.72
Islam	6.12	17.37	10.41	5.57	16.76	9.84	4.83	15.52	8.91
Others	14.19	36.49	21.92	12.55	35.1	20.37	11.47	33.25	19.02
Gender									
Female	5.25	22.48	10.61	4.48	20.73	9.54	3.94	19.3	8.72
Male	10.37	33.41	17.71	9.99	33.06	17.34	8.93	31.07	15.98
Age group									
14 to 21 years of age	18.02	48.81	26.85	16.27	46.68	24.99	13.97	42.12	22.05
22 to 29 years of age	14.39	42.9	23.99	13.8	42.31	23.4	12.65	40.39	21.99
30 to 44 years of age	3.97	23.82	10.34	3.8	22.91	9.92	3.49	21.84	9.37
45 to 59 years of age	1.29	13.87	5.32	1.14	13.03	4.95	1.03	12.32	4.65
Over 60 years of age	0.32	5.83	2.08	0.24	5.26	1.85	0.25	5.04	1.78

Correlates of ICT adoption

Model (Marginal effect)	ICT Adoption	
	Rural	Urban
Variable		
Education level of the household head		
Illiterate	Control group	
Literate but less than primary	0.012***	0.036***
Primary until secondary	0.024***	0.082***
Above secondary but less than graduate	0.065***	0.203***
Graduate & above	0.137***	0.367***
Social Group		
Others	Control group	
Scheduled Tribe	-0.017***	-0.039***
Scheduled Caste	-0.016***	-0.064***
Other Backward Classes	-0.005*	-0.016***
Religion		
Hinduism	Control group	
Islam	-0.013***	-0.030***
Others	-0.002	0.036**
Household income (log)	0.098***	0.299***
Gender composition	0.043***	0.039***
Proportion of adults (14-29 Years)	0.158***	0.342***
Household type		
Self-employed in agriculture (rural)	Control group	
Self-employed in non-agriculture (rural)	0.020***	
Regular wage/salary earning (rural)	0.028***	
Casual labour in agriculture (rural)	-0.025***	
Casual labour in non-agriculture (rural)	-0.033***	
Others (rural)	0.031***	
Self-employed (urban)		Control group
Regular wage/salary earning (urban)		-0.007
Casual labour (urban)		-0.096***
Others (urban)		0.035***
Household ICT density	0.004***	0.006***
N	36,469	29,434
Percentage correctly classified	90.48%	80.03

Correlates of individual's ICT use capabilities

Sector	Rural			Urban		
	Word Processing	Internet use	Email	Word Processing	Internet use	Email
Model	Probit	Logit	Probit	Probit	Logit	Logit
Variable						
Internet access- Yes	0.051***	0.042***	0.038***	0.138***	0.109***	0.087***
Computer access- Yes	0.014***	0.009***	0.007***	0.077***	0.051***	0.041***
Education level of the individual						
Illiterate	Control Group					
Literate but less than primary	0.000**	0.000**	0	0.004***	0.004***	0.003***
Primary until secondary	0.011***	0.010***	0.005***	0.082***	0.057***	0.047***
Above secondary but less than graduate	0.124***	0.082***	0.086***	0.355***	0.290***	0.259***
Graduate and above	0.298***	0.215***	0.223***	0.634***	0.604***	0.562***
Social group						
Others	Control Group					
Scheduled Tribe	0	0	-0.001***	-0.003	-0.007***	-0.008***
Scheduled Caste	-0.003***	-0.002***	-0.002***	-0.025***	-0.017***	-0.015***
Other Backward Classes	-0.002***	-0.001***	-0.001***	-0.014***	-0.010***	-0.009***
Religion						
Hinduism	Control Group					
Islam	-0.003***	-0.001***	-0.001***	-0.018***	-0.010***	-0.008***
Others	0.001	0.001	0	0.002	0.002	0.002
Households income (log)	0.003***	0.002***	0.002***	0.025***	0.017***	0.015***
Gender- male	0.016***	0.013***	0.011***	0.084***	0.068***	0.055***
Age group						
14 to 21 years of age	Control Group					
22 to 29 years of age	-0.104***	-0.061***	-0.054***	-0.279***	-0.257***	-0.208***
30 to 44 years of age	-0.149***	-0.095***	-0.084***	-0.439***	-0.393***	-0.317***
45 to 59 years of age	-0.153***	-0.100***	-0.087***	-0.477***	-0.418***	-0.338***
Over 60 years of age	-0.153***	-0.101***	-0.087***	-0.485***	-0.426***	-0.345***
Household Type						
Self-employed in agriculture (rural)	Control Group					
Self-employed in non-agriculture (rural)	0.002***	0.002***	0.001**			
Regular wage/salary earning (rural)	0.008***	0.005***	0.004***			
Casual labour in agriculture (rural)	-0.001**	-0.002***	-0.001***			
Casual labour in non-agriculture (rural)	-0.003***	-0.002***	-0.002***			
Others	0.007***	0.006***	0.006***			
Self-employed (urban)	Control Group					
Regular wage/salary earning (urban)				0.020***	0.012**	0.010***
Casual labour (urban)				-0.012***	-0.010***	-0.009***
Others (urban)				0.041***	0.026***	0.023***
Skill Density	0.001***	0.001***	0.001***	0.005***	0.003***	0.003***
N	1,29,402	1,29,402	1,29,402	1,01,956	1,01,956	1,01,956
Percentage correctly classified	92.93%	93.61%	93.72%	87.91%	88.65%	88.36%

Policy Recommendations

- ICT adoption is strongly correlated income
- Focus on semi urban & rural geographies
- Boost the ICT device industry– Phased Manufacturing Programme, National Policy on Electronics launched, Making in India
- Service providers have a fitting business incentive to provide services in India especially in its underserved regions- simplifying regulation & ensuring competition in the industry
- Spectrum to be priced to facilitate ICT adoption & not to be looked as a revenue source for the government
- Innovative tariff plans & technological solution- VNO & MIMO
- Better education facilitates to operate & use ICT device(s)
- Integrate ICT in education
- Role of CSC to improve ICT adoption & usage
- Student led initiative- Role of educational institutes and creating *mini-CSC- NSS hour credits- collaboration of MeitY with MHRD*

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Thank you !