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

June 2020

INDIAN COUNCIL FOR RESEARCH ON INTERNATIONAL ECONOMIC RELATIONS

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Table of Contents

List of Figures

List of Tables

Acknowledgement

ICRIER is much thankful to the Ministry of Electronics and Information Technology (MeitY) for providing support for this research. We are also thankful to Ms Srishti Sinha, who was an intern with ICRIER during this project for providing her inputs.

Summary

The Information and Communications Technology (ICT) revolution has radically improved connectivity across the globe and pervaded into most aspects of modern human life. The benefits of ICT can only be appropriated by those with access to the technology and capabilities to use the same. India's ICT adoption has been rapid since the year 2000, but with sizable disparities across the country. This study surveys the correlates of ICT adoption and its use capabilities in India. It has been observed that income, education and household demographics are strong determinants of household ICT adoption, while education, age and gender are strong classifiers for variations in individual's ICT use capabilities. The findings will be useful for having informed discussions on taking strategic decisions to bridge India's digital divide.

Keywords: *ICT; computers; Internet; India*

Subject classification codes: *L96; O33*

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

1. Introduction

This section reviews the necessity to bridge India's digital divide and discusses various initiatives undertaken by the Government of India (GoI) to leverage Information and Communications Technology (ICT) to bridge the development service gap.

1.1 Background

The ICT revolution has radically improved connectivity across the globe, and has pervaded into several aspects of modern human life. ICT networks and services have become the basic infrastructure resource for businesses to improve competitiveness and productivity of organisations and are considered a general purpose technology (Jovanovic and Rousseau, 2005; Liao, Wang, Li, and Weyman-Jones 2016). We can now communicate, access information, transact, shop, voice opinion, avail consumer and government services with the click of a button. ICT has emerged as the cutting edge tool for the delivery of developmental services such as healthcare, financial services, e-commerce, education specially in the underserved remote areas (Foster and Heeks, 2013; Srivastava and Shainesh, 2015; Leong, Pan, Sue, and Cui, 2016). The United Nations (2015, 2016) also recognises ICT as an enabler to achieve the Millennium Development Goals and the Sustainable Development Goals.

Scholarly evidence confirms that ICT facilitates poverty reduction, and promotes economic growth and welfare (Hardy, 1980; Norton, 1992; Röller and Waverman, 2001; Jensen, 2007). Prior research explains that ICT positively impacts the growth of developing economies more as compared to that of the developed economies (Waverman, Meschi, and Fuss, 2005; Qiang, Rossotto and Kimura, 2009).

Among the ICTs, the Internet, combining features of both hardware and software builds a network of networks, is the most powerful and is regarded as a 'liberation technology'; redefining the delivery of various services such as education, healthcare and financial services (Naughton, 1999; Diamond, 2010; Dutton, 2013). A ten per cent rise in broadband penetration leads to 1.21 per cent improvement in per capita GDP of the developed countries and 1.38 per cent improvement in per capita GDP of developing countries (Qiang et al., 2009). In case of emerging India, it is observed that a ten per cent rise in the telecommunications investment improves the state per capita GDP by over 3 per cent; while a ten per cent increase in the Internet subscriptions augments India's state per capita GDP 3.2 per cent (ICRIER, 2018). If India is to realise its vision of US$5 trillion economy ICT adoption and its usage will be vital.

Due to the proactive policy measures taken by the GoI to promote competition in the digital communications sector since the late 1990s, India's ICT adoption has witnessed an exponential uptake (Figure 1.1). India now accounts for the second largest pool of wireless communications subscribers and Internet users, worldwide. However, there are significant differences in India's ICT adoption and its usage. The urban tele-density (approx. 160 per cent) is nearly three times of the rural tele-density (approx. 59 per cent), while about 70 per cent of India's population

resides in the rural sector (Census, 2011; TRAI 2020). About 88 per cent of the population uses Internet in urban India, while usage in rural areas is only about 22 per cent (TRAI, 2019a). Across various states the adoption of ICTs also reflects disparities. On one end of the spectrum there are states like Delhi, Himachal Pradesh, Kerala and Punjab with tele-density at 280.11 per cent, 148.29 per cent, 126.48 per cent and 128.09 per cent respectively and on the other end of the spectrum the telecom circles lagging in ICT adoption, pulling down the national tele-density are Bihar, Uttar Pradesh, Assam and Madhya Pradesh with tele-density at 53.07 per cent, 67.17 per cent, 68.57 per cent and 67.10 per cent respectively (see Figure 1.2). With the adoption of digital communications saturating in advanced states, service providers and the policy makers should now focus on the underserved areas, to drive the next wave of growth of digital communications and bridge the digital divide in the country.

It may be highlighted that scholarly research indicates that socio-economic disparities, associated with digital differences, could further magnify/intensify if the existing digital divide is not bridged (Avgerou and Madon, 2005; Wei, Teo, Chan, and Tan, 2011). Progressively, as more services become available online, there could be equity repercussions if certain sections of the population are not included digitally. Furthermore, communications services exhibit positive network externality, the utility of digital services grows as more users subscribe to the service, as it increases the potential number of communications patterns (Hope, Kochar, Noll, and Srinivasan, 2013).[1] The significance of the ICT services augments with time as more people connect through it, since the value of economic activity rises with more numbers of economic agents (consumers and producers) connecting and collaborating via the service, thus enhancing efficiency, opportunities and knowledge sharing. Also as the subscriber numbers in a particular geography escalates, the cost of providing services to a specific user condenses due to the economies of scale. Given ICTs potential to improve economic growth and development, policy makers are concerned about reducing (ideally eliminating) the inequalities in ICT adoption and its usage, so as to leverage the technology as a tool of realising social and economic convergence.

1.2 Initiative by the Indian Government

The Indian Government is determined to bridge the gap between the ICT haves and the have not's, and visions using the pioneering technology for the empowerment of its citizens. With the aim to transform India into a connected knowledge economy, the GoI launched two massive programmes concentrated around ICT in mid-2015: (i) the INR 980 billion 'Smart Cities Mission' to develop 100 smart cities using ICT and best practices in urban planning in June 2015 and (ii) the INR 1,130 billion 'Digital India' programme striving to bridge the rural-urban digital divide, create new jobs, and help businesses with ICT usage in July 2015 (PIB, 2014; Ministry of Urban Development, 2015). The three main objectives of the Digital India programme which were to be achieved by the year 2019 are as follows: (i) develop a secure and stable digital infrastructure, (ii) provide government services digitally and (iii) achieve universal digital literacy. The programme aims to provide broadband connectivity to all *gram*

panchayats, promote e-governance and deliver services like education, financial and healthcare electronically.

Selected programmes undertaken by the government to deliver citizen services digitally (education, health, finance, land records, justice, e-governance, etc.) include: National e-Governance Plan (NeGP), National Mission in Education, National Mission for Delivery of Justice and Legal Reforms, m-*Kisan*, Social Endeavour for Health and Telemedicine (SEHAT) and National Agriculture Market (e-NAM).

The NeGP was launched in May 2006, with an aim to provide government services to citizens in their locality through common service centres (CSCs), to enhance efficiency, transparency and reliability of services at an affordable cost (MeitY, 2018). The e-governance plan covers 31 mission projects including domains such as agriculture, land records, health, education, passport, law and order, municipalities, commercial taxes, income tax, public distribution system, postal services and basic banking services.

To ensure that future generations have the required digital competencies, the GoI has undertaken various initiatives to integrate ICT in education, since the year 2004. The *ICT in Schools* initiative envisaged to provide opportunities to secondary school students to build their ICT use capabilities and facilitate learning through the cutting edge technology. Through the *Rashtriya Madhyamik Shiksha Abhiyan*, the GoI re-enforced the promotion of ICT in school education. In the year 2009, the government launched the National Mission in Education through ICT to make available knowledge resources to every learner easily accessible to enhance the gross enrolment ratio (MHRD, n.d.). In the year 2010, the government initiated the INR 59.90-billion National Knowledge Network project, to connect all knowledge and research institutions in the country digitally to facilitate knowledge and information sharing, research development and innovation and enabling advanced distance education (MeitY, 2018a). The GoI has also undertaken focused initiatives to improve digital literacy in India; these include the National Digital Literacy Mission or *Digital Saksharta Abhiyan* (DISHA) and *Pradhan Mantri Gramin Digital Saksharta Abhiyan* (PIB, 2015b; 2017b; MeitY, n.d.). These programmes aim to make at least one person in every Indian family digitally literate; that is, the person must have basic word processing skills, be able to search for information from the Internet and use email.

In the year 2011, the GoI launched the National Mission for Delivery of Justice and Legal Reforms, leveraging ICT to provide easy and fair access to justice by reducing delays in the legal system and making the system more accountable through structural changes by setting performance standards and bettering capacities (PIB, 2012).

In July 2013, the government launched m-*Kisan* initiative to inform farmers about better agricultural practices. Under this initiative, farmers are provided information and advisories through SMSs in their preferred language according to their desired agricultural practices and location (PIB, 2015a). In April 2016, the government launched an electronic portal called e-NAM to help farmers gain a better view of prices across different markets, learn about advanced crop production techniques, government schemes and weather-related updates (PIB,

2016). The project envisages to create a unified national market for agricultural produce and remove the information asymmetry between buyers and sellers.

In August 2015, the GoI also launched a pan-India health initiative called SEHAT in collaboration with Apollo hospitals to connect 60,000 CSCs across the country and provide healthcare services to citizens irrespective of their geographical location (PIB, 2015).

Additionally, after demonetization of about 85 per cent of Indian currency in November 2016, the government is encouraging the use of plastic money, online banking and digital applications for financial transactions. The National Payment Corporation of India launched the Bharat Interface for Money (BHIM) application on December 30, 2016 to facilitate easy and quick financial transactions (PIB, 2017). To enable online financial transactions, it is necessary that individuals or households have access to the required ICT device(s), network facility and capabilities to use the same.

To realise India's 2024-25 vision of US$1 trillion digital economy, it is crucial to bridge the digital divide in India. For better policy decisions to bridge India's digital divide it is imperative to understand the factors associated with the differences in ICT adoption and its use capabilities.

This study specifically aims to survey the correlates of digital disparities in India using the recent national representative household sample survey. The findings will be useful in assisting better informed discussions to take strategic decisions for bridging India's digital divide. The paper is organized as follows: Section 2 reviews the literature. Section 3 describes the data and methodology. Section 4 presents the findings and section 5 gives the policy recommendations.

2. Literature Review

2.1 Defining the Digital Divide

Van Dijk (1999) emphasises on four types of impediments to digital inclusion: lack of - 'material access', 'mental or educational access', 'skill access', and 'usage access'. The OECD (2001) describes the differences in chances of access to ICTs and the Internet use for a variety of activities among individuals, households, businesses, and geographic regions at diverse socio-economic levels as the 'digital divide'. Norris (2001) terms digital divide as a multidimensional phenomenon, and differentiates between the global digital divide (access to Internet), the social divide (information gap among nations) and the democratic divide (engagement in public life through digital resource).[2]

Studies have also used composite indices to capture the diverse aspects of digital divide. These indices give weight to supply and demand side variables like electrification of the region, infrastructure availability, the capacity of the people to use technology, tariff rates, etc. Some

[2] The World Information Society report (WIS, 2007) observes that digital inequalities exist at multiple levels: among nations, between different regions of a country, within organizations, between men and women, among the elderly and the young, among various religions, etc.

of the indices are: the UNDP's *Technology Achievement Index*; ITU's *Digital Access Index*; World Economic Forum's *Network Readiness Index*; and ORBICOM's *Monitoring the Digital Divide* (UNDP, 2001; ITU, 2003; World Economic Forum, 2002 and ORBICOM, 2004). To study the preparedness of the government departments in India to use ICT, an e-readiness index was also proposed (GoI and NCAER, 2003).

The documentation of basic ICT adoption differences and variations in its use capabilities for developing economies like India, with a 1.36 billion multicultural population are limited. Selected studies have surveyed the basic ICT adoption differences for India (Thomas and Parayil, 2008; Narayana, 2011; Gupta and Jain, 2015). These studies however survey the variations in ICT adoption only for selected Indian states; a recent study by Agrawal and Asrani (2018) surveys the correlates of digital device adoption and emphasise the importance of education and income in explaining the variations in ICT device(s) access across India, the study uses the data set capturing information on ICT adoption collected during the year 2011-2012. With the introduction of data services in India in the year 2010, coupled with the proactive regulatory measures, fierce competition has been induced in India's communications sector, that advanced the uptake of ICT considerably (Figure 1.1). This study aims to survey the correlates of ICT adoption and its use capabilities in India, to check if the findings of previous studies on India's ICT adoption still hold true and recognise the correlates of ICT use capabilities.

This study surveys the digital divide both in terms of ICT adoption (household's access to Internet enabled device(s) and Internet facility), and basic ICT use capabilities such as-individual's ability to do word processing, search information from the Internet and use email. Given the limitations of ICT data for India, the study takes a binary view to investigate digital inequalities, concerning adoption of ICT device(s) and network at the household level, and surveys the differences in basic ICT use capabilities at the individual level. Though the dichotomous definition is a simplistic way to classify the population as being digitally included or not, but at a national level it does help in preliminary understanding of India's digital divide. Also without the adoption to digital device, network and know-how of basic ICT skills, it is bizarre to think that one could participate in the digital society. Possessing an ICT device, having network access and knowing how to use the technology are necessary pre-requisites to participate in the information economy. Gunkel (2003) has reasoned that though reductive, the binary classification is worthwhile for describing the limits of technological inequalities.

Further, Kalba (2008) suggests that it is vital to understand and address the ICT access disparities (ICT device and network) at the household level in developing countries of Africa and India, as digital device(s) remain household belongings rather than goods of individual possession. Since the digital device(s) are shared among the household members, it is vital to assess the ICT adoption disparities in ownership of these device(s) and network at the household level.

2.2 Determinants of ICT Adoption and its use capabilities

Prior research on digital disparities emphasise the importance of macroeconomic (income per capita, foreign direct investment, size of services sector), demographic, infrastructural (telephone density, electricity consumption), institutional (government effectiveness, regulation), and human capital (illiteracy, years of schooling) variables in describing the cross country variations in ICT adoption (Chinn and Fairlie, 2007; Billon, Marco and Lera-Lopez, 2009; Cruz Jesus, Oliveira and Bacao, 2012; Pick and Nishida, 2015). Scholarship has also assessed ICT variations at household and individual levels and underlined the significance of socio-economic and demographic factors (Hoffman and Novak, 1998; NTIA, 1995, 1999; Venkatesh and Brown, 2001; Wareham, Levy and Shi, 2004; Korupp and Szydlik, 2005; Demoussis and Giannakopoulos, 2006; Cruz-Jesus et al., 2012; Nishida, Pick and Sarkar, 2014; Pick et al., 2015; Nishijimaa, Marislei and Sarti, 2017). These studies have mostly used discrete choice models to study the correlates of digital divide and have suggested that mere deployment of ICT networks may not bridge the digital gap (for instance Mariscal, 2005).

Those on the right side of the digital divide were found to be mostly richer and better educated (NTIA, 1995; NTIA, 1999; Demoussis et al., 2006; Thomas et al., 2008; Narayana, 2011; Nishida et al., 2014; Gupta et al., 2015; Nishijimaa et al., 2017; Agrawal et al., 2018). Population in the disadvantaged social group is less likely to be digitally included (Hoffman et al., 1998; Narayana, 2011), though some such groups (like African Americans) were able to adopt mobile phones faster than the rest (Wareham et al., 2004). Possession of digital device(s) is also influenced by the occupation, with sales professionals and executives more likely to possess a digital device (Rice and Katz, 2003; Wareham et al., 2004; Narayana, 2011). Demographic factors such as age and gender also influences the cohort's chances of ICT adoption and its usage (Schumacher and Martin, 2001; Venkatesh et al., 2001; Korupp et al., 2005; Demoussis et al., 2006; Narayana, 2011; Gupta et al., 2015; Nishijimaa et al., 2017). The general level of modernization (GDP per capita), urbanization and network infrastructure also supports digital inclusion (Goolsbee and Klenow, 2002; Nishida et al., 2014). Figure 2 gives the factors impacting ICT adoption and its use capabilities.

3. Data and Methodology

3.1 Data

To study the correlates of ICT adoption and its use capabilities, national represented household survey conducted by National Sample Survey Organisation (NSSO) of GoI, on social consumption education during January-June, 2014 (71st round) is used. NSSO has been conducting periodical socio-economic surveys since 1950's on varied themes such as-consumption expenditure, health, housing, employment, education, farmer's condition, slums, etc. The 71st survey round contains questions regarding household's computer ownership: whether on the survey day the household owned a computer/laptop/smartphone/tablet/palmtop/desktop. The survey also collects information on access to Internet facility and individual's (above the age of 14 years) know-how of basic ICT skills such as (i) if the individual can do word processing using a digital device (ii) if the

individual is able to search information from the Internet, and (iii) if the individual can email.[3] These basic ICT use capabilities are essential to access and share information and knowledge virtually and participate in the information society. The 71st survey round also contains information on socio-economic and demographic characteristics of households and their members such as age, gender, occupation structure, household relationships, educational background and social group. The respondent is normally the household head. The survey uses a multistage probability sample design, and the first stage units comprise of census villages for the rural sector and urban blocks in the urban sector. The ultimate stage units are households in both the sector (for details see GoI, 2015). The sample in the 71st NSSO round comprises of 36,479 rural and 29,447 urban households, with information on 1,78,331 individuals in rural area and 1,32,496 individuals in urban areas (Table 1).

3.2 Econometric Methodology

To estimate the probability of (i) ICT adoption- that is household's likelihood of ICT access- that is access to an Internet enabled device(s), along with Internet facility, and (ii) chances of individuals (above the age of 14 years) having ICT use capabilities, that is- ability to do word processing, ability to search information from the Internet and ability to email; discrete choice models are used (for details please see appendix).

4. Findings

This section provides descriptive statistics of the national represented household sample data, followed by presentation on the regression results.

4.1 Descriptive statistics

Over 12 per cent of households in India had ICT access that is access to Internet enabled device(s) such as computer/laptop/palmtop/tablet/smartphone and Internet facility during the year 2014. The proportion of households having adopted to ICT device(s) and networks in urban area were about 28.5 per cent and in rural area were about 5.7 per cent (Table 1).

Regarding ICT use capabilities about 14 per cent, 13 per cent, and 12 per cent of citizens of India above the age of 14 years could do word processing, search information from Internet and knew how to email, respectively in the year 2014 (Table 1). The ICT use capability gap in rural and urban sector was substantial at about 20 per cent, with cohorts in urban areas having better ICT use capabilities.

Population with better income has better chances of adopting to ICT. Income (monthly household consumer expenditure) is a measure of capacity to afford ICT device(s) and services, people with better incomes are likely to have ICT access early.[4] Early access to ICTs may lead

[3] Questions as asked regarding ICT access: (i) whether on the day of the survey the households possess a computer? The term 'computer' includes all Internet enabled devices such as desktop, palmtop, tablet, laptop, smartphones or any Internet supporting ICT device and (ii) whether any member of the household has access to use Internet facility?

[4] Given the unavailability of data on income in developing countries like India, often the monthly expenditure is used as a proxy for income. The paper too, uses the monthly household consumer expenditure as a proxy for income.

to better chances of knowing basic digital skills. At lower income levels the gap between rural and urban sector home ICT adoption is about 10 per cent and at highest level of income rural-urban household ICT adoption gap increases to about 50 per cent, with cohorts in urban area more likely to have ICT access. A similar pattern is observed in case of ICT use capabilities, at lower income levels gap between rural and urban sector ICT skill know-how is about 10 per cent and at highest level of income the rural-urban digital literacy gap increases to about 35 per cent, with individuals in urban area more likely to know the basic digital skills. The curve of association between income and basic ICT adoption and its use capabilities has a convex curvature particularly at high income levels in both rural and urban sector, indicating that as income betters the chances of the ICT adoption and its use capabilities rise at an increasing rate (Figure 3).

Education is also positively related to ICT adoption and its use capabilities. The base group of illiterate cohorts had about 3 per cent chance of having home ICT access in the year 2014, whereas cohorts with qualification of graduate or above had about 50 per cent chance of having household ICT access (Table 3.1). In case of know-how of three basic digital skills, individuals with qualification of graduate and above had about 60 per cent chance of knowing how to do word processing and searching information on the Internet while only about 50 per cent of this cohort could email. People with education from secondary until graduation had about 40 per cent chance of knowing how to do word processing and searching information on the Internet while only 30 per cent of this cohort could email (Table 3.2). The education of the individual seems to be a strong deciding factor for ICT adoption and its use capabilities.

The data also indicates variations in ICT adoption and its use capabilities across social and religious groups. Cohorts age group matters in explaining the variations in ICT skills know-how, individuals in the young age group (14 to 29 years) have the best chance of knowing all the three basic digital skill in both the sectors (Figure 4).

Variations are also observed in the chances of ICT adoption and its use capabilities based on cohort's state and sector of residence (Figures 5.1, 5.2, 6.1, 6.2 and 6.3). Household ICT access was highest in states such as Goa, Maharashtra and Kerala and lowest in Bihar and Odisha. Individuals residing in Kerala, Goa and Delhi had the highest chance of knowing basic digital skills followed by states like Maharashtra and Himachal Pradesh. The individuals residing in Assam, Bihar, Madhya Pradesh, Jharkhand, Chhattisgarh and Orissa had less than ten per cent chances of knowing the basic digital skills.

4.2 Regression analysis

The purpose of the empirical analysis is two folds: first, to identify the correlates of household's ICT adoption in India; second to estimate the correlates of individual's (above the age of 14 years) ICT use capabilities in India. To the above aims of surveying the correlates of India's ICT adoption and its use capabilities discrete choice models have been used. To decide between the logit and probit model, Akaike information criterion (AIC) and Schwarz Bayesian information criterion (BIC) criteria is used. Though the results of the two models do not vary perceptible, but the results presented and discussed are of the model with lower AIC and BIC

values, as the models with smaller AIC and BIC value are more parsimonious. The results of the marginal effects of the appropriate discrete choice models are presented and discussed (for details please see appendix).

4.2.1 Likelihood of ICT adoption

In case of rural sector the regression models for ICT adoption classified over 90 per cent of the observations correctly, while in case of urban sector the regression models for ICT adoption classified about 80 per cent of the observations is correctly.[5]

A significant positive association between income and the ICT adoption is confirmed. Better income improves the chances of affordability of ICT device(s) and services. Income is a strong correlate of ICT adoption (Table 4.1).

Better education facilitates to operate and use ICT devices with more ease, a positive and statistically significant relation is confirmed with education levels and ICT adoption. The chances of ICT adoption suggestively improve as the education level increases above the secondary level in both the sectors. Demographics also plays a substantial role in household's ICT adoption, more the number of household members in the young age group, better are the chances of household having ICT access (Table 4.1).

Social group and religion also explains variations in ICT adoption, cohort in disadvantageous social group are less likely to be digitally included. Occupation structure also matters; regular salaried cohort is more likely to be on the positive side of the digital divide.

4.2.2 Likelihood of ICT use capabilities

The regression models for ICT use capabilities classified over 90 per cent of the observations correctly in the rural sector, while in case of urban sector the regression models for ICT adoption classified about 80 per cent of the observations correctly.[6]

Demographics play a substantial role in ICT use capabilities after controlling for ICT access. Individuals in young age group of 14 to 29 years have the best chances of knowing all the three basic digital skills, gender gap in know-how of all three digital skills is also strong and significant, with males having better chance of knowing the basic digital skills (Table 4.2).

Better education facilitates to operate and use ICT devices with more ease, a positive and statistically significant relation is confirmed with education levels and ICT use capabilities. The chances of ICT use capabilities suggestively improve as the education level increases above the secondary level in both the sectors. A statistically significant positive association between income and the ICT use capabilities is observed. Better income improves the chances of affordability of ICT device(s) and services, access to ICT positively impacts the know-how

[5] Percentage correctly classified evaluates the predictive accuracy of the discrete choice regression models; it presents that of all the given observation of the dependant variable, the number of times the regression model predicts the observations of the dependant variable correctly. Higher the value of percentage correctly classified better is the model accuracy.

[6] See footnote 7

of basic digital skills. Income is a strong correlate of ICT adoption; but in terms of know-how of basic digital skills, after controlling for ICT access the correlate with income is positive and statistically significant but not of a high magnitude (Table 4.1 and 4.2).

4.2.3 Discussion

This paper studies the correlates of ICT adoption and its use capabilities in India, the empirical evidence in confirmation with the prior literature validates that differences in ICT adoption and its use capabilities in India are correlated with the socio-economic and demographic characteristics of the population. Cohorts on the positive side of the digital divide are richer and better educated, individuals in the young age group of 14-29 years are more likely to adopt to the novel technology, the gender differences in the use capabilities of the technology are also significant. Better income and education allows the cohorts to absorb the losses, if any due to the purchase of new ICT device(s), and education aids them to try new ideas; population in the younger age group is also more open to try new ideas and technologies. The income, education and age composition of the household is a strong classifier in deciding household ICT adoption, while variations in individual's ICT use capabilities are strongly associated with the differences in individual's education, age and gender, after controlling for ICT access.

5. Policy Recommendations

It is observed that ICT adoption is strongly correlated with household's income, better income enhances the affordability of ICT device(s) and services. As the penetration of digital communications in the urban sector of India saturates, the semi-urban and rural areas will be the next geographies driving the growth of ICT uptake, which may be even more price sensitive. The manufactures of ICT devices will have to innovate to ensure quality devices are supplied at best prices. The GoI has undertaken initiatives to back the ICT devices (smartphones) manufacturers through investor-friendly policies, for instance: Phased Manufacturing Programme initiated in April 2017 and the National Policy on Electronics launched the in 2019, for establishing manufacturing hubs to drive indigenous production. Investments in research and development to ensure quality ICT devices at best price are manufactured may prove beneficial for the ICT device manufacturing industry's growth. In order to bridge the digital divide, the government must try to boost the ICT device industry, rather than simply fixating on ICT network and service providers alone (Panda and Asrani, 2018).

ICT networks are critical to promote the adoption of ICT and its usage. Developing infrastructure especially in the underserved areas of India and maintaining service quality may be a challenging task for service provides. The provisioning of communications services is conditioned on the interest of service providers to provision services in the specified geographies, it is essential that government ensures that service providers have a fitting business incentive to provide services in India especially in its underserved regions. Simplifying the regulatory framework and permissions for infrastructure deployment further may accelerate the proliferation of digital communications infrastructure and hence, services. Further, in past few years the behest for spectrum auction has not been very assuring although

much of the spectrum put for sale was sold, the cold market response to spectrum auction may be attributed to the high reserve price of spectrum auction (Jain and Dara, 2017).

For the services providers they will have to strategize and come up with innovative tariff plans and technological solution to cater the price sensitive massive Indian market specially the underserved geographies, to this aim the contemporary virtual network operators and the massive-input-massive-output technologies may assist in bridging the digital divide in India.

It may be highlighted that better education facilitates to operate and use ICT device(s) with more ease, a positive and statistically significant relation is confirmed with education levels and ICT adoption and its use capabilities. To further strengthen the usage of ICT, it may be useful to integrate ICT in India's educational pedagogy. On visiting institutes of higher learning in the National Capital Region, India, it was observed that there is a stark difference in ICT infrastructure in both public and private educational institutes. Differences in ICT access are likely to translate into variations in ICT use capabilities. ICT use capabilities play a vital role in progress of the information society and are essential for social inclusion and human capital development in the digital age. Scholarship explains that variations in digital skills have a considerable influence with the emergence of unequal opportunities and on the risks of exclusion in an information society (Hargittai et al., 2013; Helsper and Eynon, 2013; Livingstone and Helsper, 2010; OECD, 2016; Van Deursen and Van Dijk, 2015; 2015a). For ensuring productive use of ICT services for banking, education, accessing healthcare and e-governance services, and acquiring work-related ICT use capabilities (such as word-processing) integrating ICT in education may be useful.

Further to improve adoption and usage of ICT services among the cohorts in non-favourable demographic profile (older age groups and women) and social groups of digital divide, appropriate interventions by CSC may be promoted. It is crucial that CSC are equipped with the appropriate ICT devices which are connected with the network and have capable resource personnel who can demonstrate the use of ICT to all Indian citizens who do not have the ICT use capabilities. Further, as women population lags in ICT adoption, it may be useful if every CSC can have at least one women resource personnel who can demonstrate the use of ICT as it could be that women are more comfortable interacting with women personnel at the CSCs. Furthermore, to the same aim it may be useful if educational institutes (colleges and high schools) could also support a *mini-CSC.* This study observed that individuals in the age group of 14-29 years have better chances of knowing basic ICT skills. The students at educational institutes can volunteer to teach the population without know-how of basic ICT skills to use the technology, student hours spent at *mini-CSC* may account towards their mandatory social work hours or even National Service Scheme hours. Alternatively, MeitY could issue certificate of recognition to these helpful students who volunteer to bridge India's digital divide. To ensure that the student volunteering program to bridge India's digital divide is successful, MeitY may want to partner with Ministry of Human Resource and Development and aggressively promote the initiative through popular media, social media and other appropriate channels. Team ICRIER will be much pleased to facilitate in designing and promoting the student voluntary program to bridge India's digital divide.

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Appendix

Econometric Methodology

This section explains the discrete choice models used to estimate (i) the probability of ICT adoption- that is household's likelihood of access to Internet enabled device(s), along with Internet facility, and (ii) ICT use capabilities- chances of individuals (above the age of 14 years) knowing the basic digital skills, that is- ability to do word processing, ability to search information from the Internet and ability to email.

Random utility framework is used to model (i) the chances of household's ICT adoption, that is likelihood of possessing an ICT device(s) along with access to Internet facility, and (ii) the probability of individuals knowing the three basic digital skills- ability to do word processing, ability to search information from the Internet and ability to email.

Let $\bar{U}_i$ denote the utility derived by the i^{th} household if it possesses an ICT device(s) and has access to Internet facility and $\tilde{U}_i$, the utility if it does not have access to ICT device and Internet facility (Greene, 2012). The (indirect) utilities may be expressed as follows:

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

where, the vector X_i denotes the characteristics for the i^{th} household and $\bar{\beta}$ *and* $\tilde{\beta}$, are the corresponding parameter vectors, respectively (see Figure 2 and Table 2.1).

The i^{th} household may prefer to own an ICT device(s) and access Internet facility if the associated utility with the possession of ICT device and Internet facility is higher than to do without it, such that, if $\bar{U}_i > \tilde{U}_i$.

The dichotomous dependant variable y_i is expressed such that it takes the value 1 if the i^{th} household possess an ICT device(s) and has access to Internet facility and is 0, otherwise, then

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

If the error term $\varepsilon_i = \bar{\varepsilon}_i - \tilde{\varepsilon}_i$ follows a logistic distribution then G(.) corresponds to the cumulative distribution function of logit model and if error term ε_i follows a normal distribution then G(.) corresponds to probit model.[7]

To interpret the likelihood of household possessing an ICT device(s) and having access to Internet facility based on its socio-economic characteristics marginal effects for independent variables are estimated. The marginal effects provide the slope of probability curve relating to the j^{th} correlate (viz., x_j) and can be mathematically expressed using the below given equation as:

[7] *Note*: Since the dependent variable is dichotomous in nature, it is appropriate to use discrete choice models (logit or probit) to carry out the analysis of correlates.

$$\partial/_{\partial x_j}\,(\Pr[(y_i = 1)/x]) = g(X_i\beta)\beta_j$$

Though the marginal effects of logit and probit model do not vary perceptibly, to decide between the two regression models, penalized likelihood approach is used. AIC and BIC are employed to determine the parsimonious model (Chen and Tsurumi, 2010). The model with better specification is the one with minimum deviance and penalty, where penalty accounts for the number of parameters in the model including the intercept term. Between AIC and BIC, the BIC approach is stricter as it penalises the model harder for greater number of parameters.

AIC is given by:

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

where, k is the number of parameters in the model and $'\,ln\,\mathcal{L}'$ is the maximized log-likelihood. The model with lower AIC is the preferred model.

BIC is defined as:

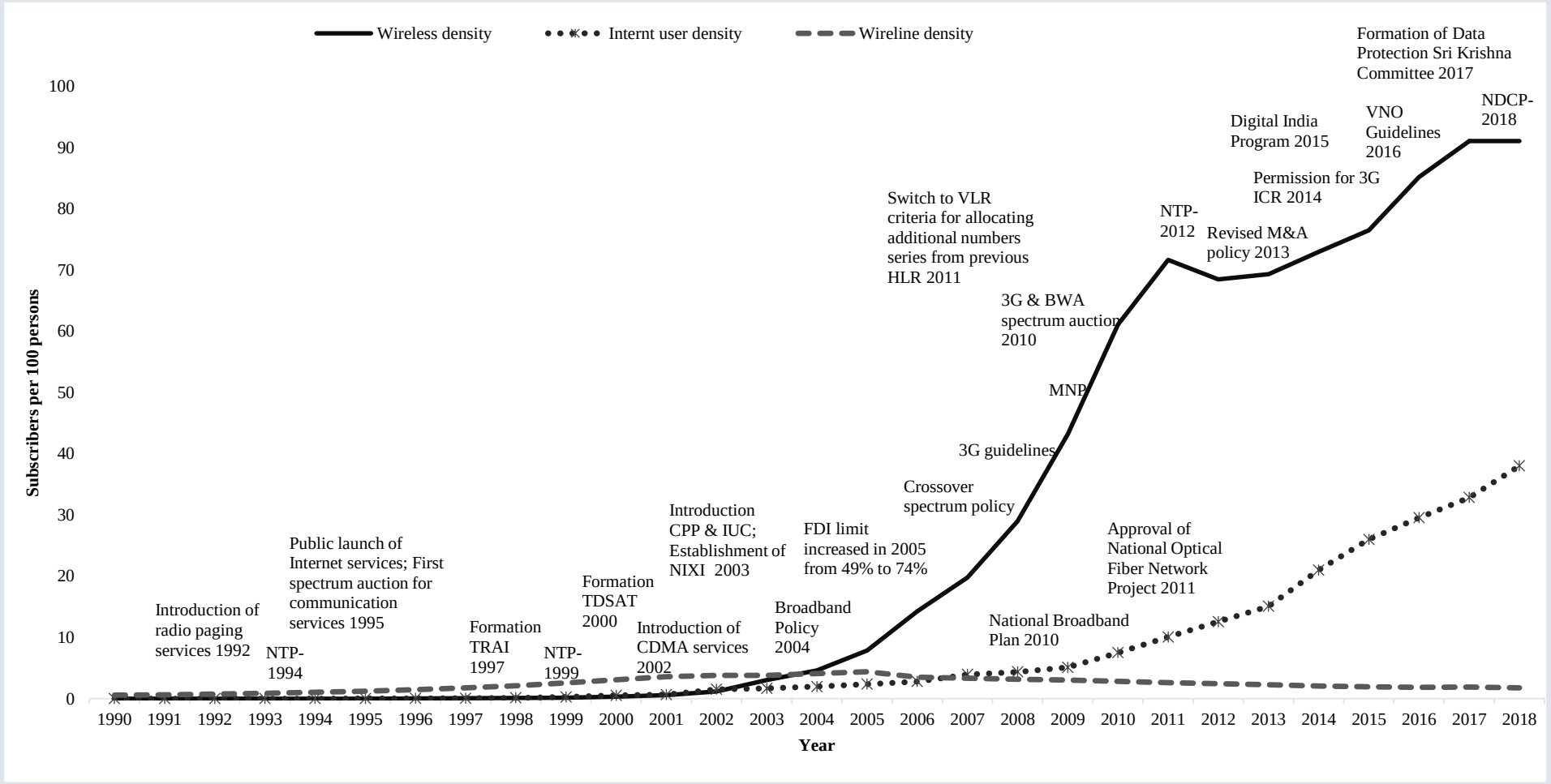
$$BIC = -2\ln\mathcal{L} + klnN$$

where, '*N'* is the sample size, 'k*'* is the number of parameters in the model and $'ln\,\mathcal{L}'$ is the maximized log likelihood of the model. The model with lower AIC and BIC value is regarded as more parsimonious. Independent regression models were run to survey the correlates of ICT adoption in rural and urban sector (Table 4.1)

Next to estimate the probability of individuals knowing three basic digital skills, namely- ability to do word processing, ability to search information from the Internet and ability to email, separate regression models were run for all the three ICT skills, discretely for rural and urban sector (Table 4.2). As the dependent variable in all the six regression models is dichotomous in nature, that is if individual knows the specific ICT skill, or not; again discrete choice models (logit or probit models) discussed above have been used, to predict the likelihood of individual knowing a specific ICT skill. The dependent y_i variable used to study the correlates of each of the three basic ICT skill takes the value 1 if the individual has the know-how of the specific digital skill and is 0 otherwise (see Table 2.2 for variable definition).

The maximum variance inflation factor (VIF) value in all the eight regression models on ICT adoption and its use capabilities was less than 5. As the VIF values are below 10, multi-collinearity may not be a serious problem (Greene, 2012). To account for possible heteroscedasticity, robust standard errors results are reported.

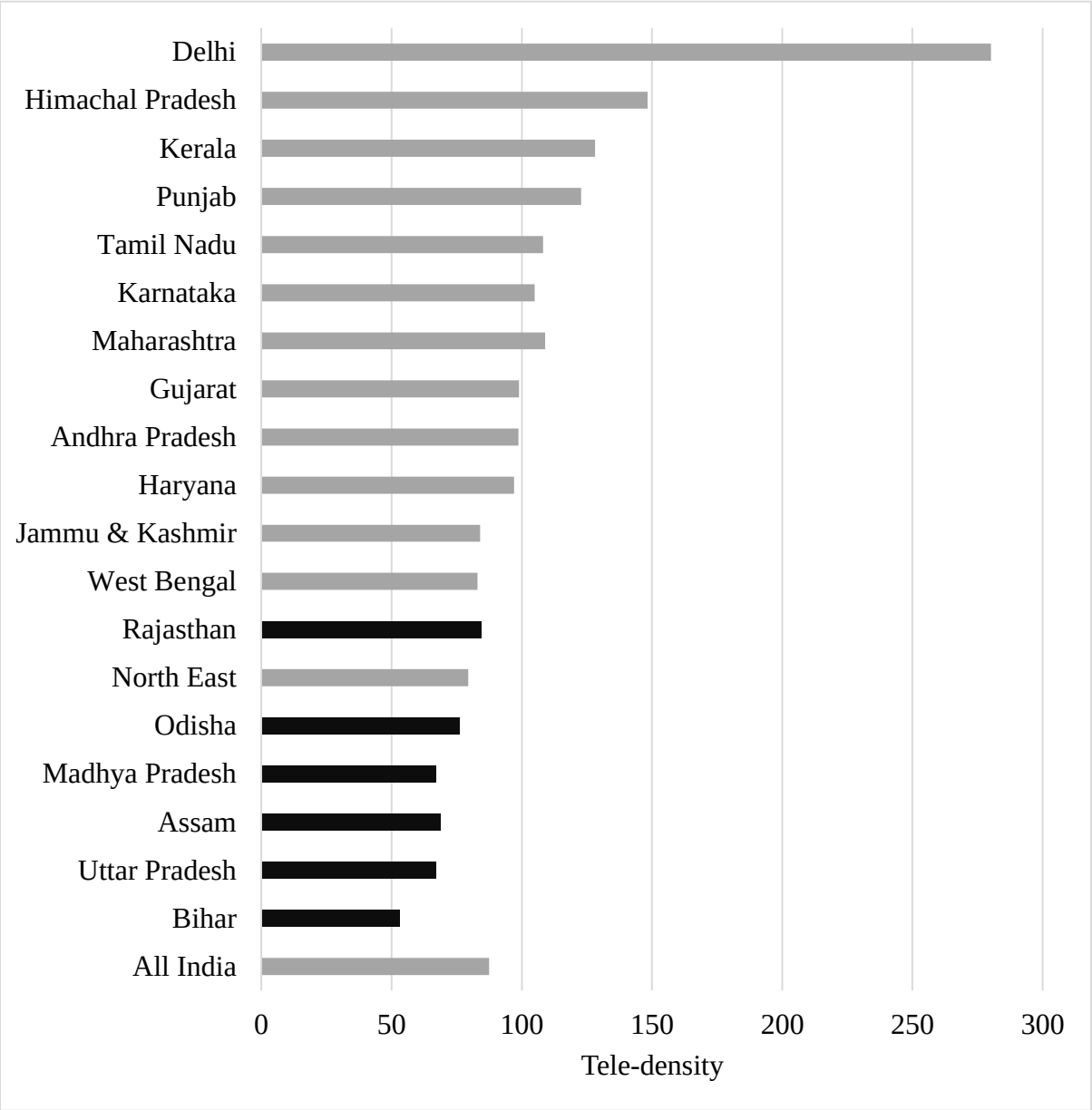
Figure 1.1: Digital Evolution of India-1990-2018



Source: World Development Indicators (2018) and compiled by the author from various TRAI reports

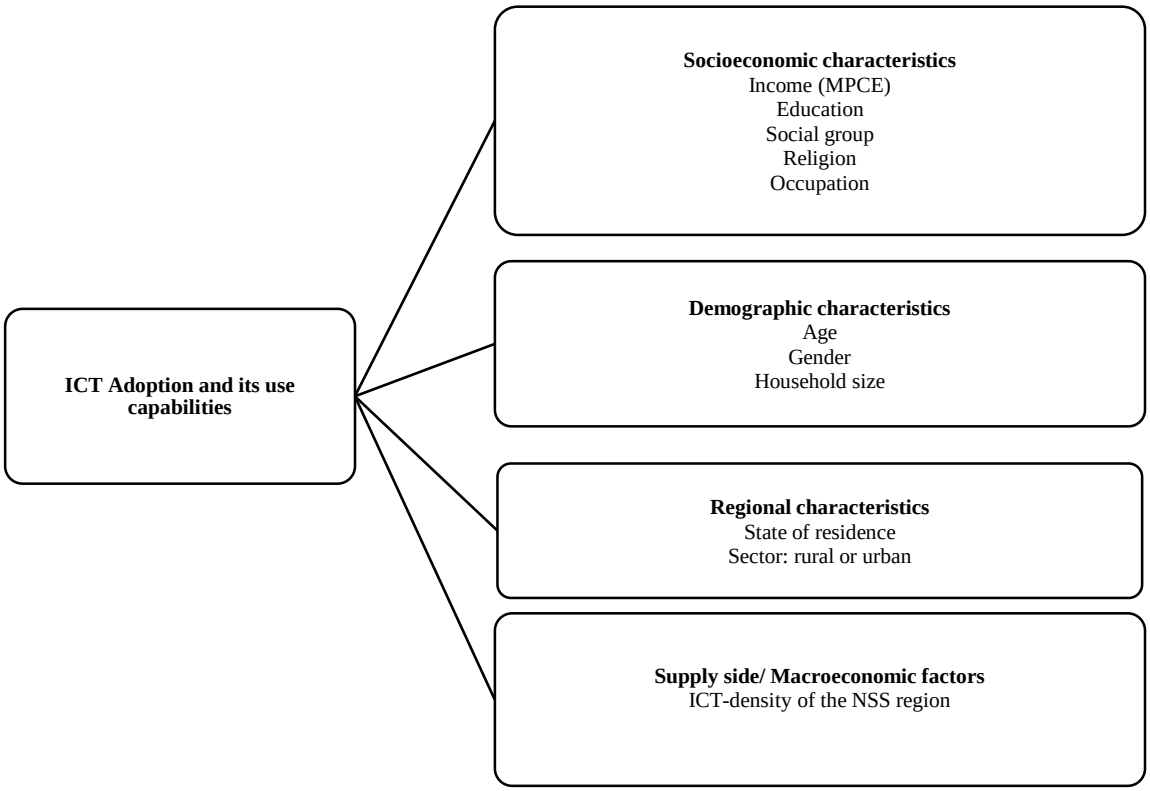
Note: NTP-National Telecom Policy; TRAI-Telecom Regulatory Authority of India; TDSAT- Telecom Disputes Settlement and Appellate Tribunal; CPP-Calling Party Pay; IUC-Interconnection Usage Charge; NIXI- National Internet Exchange of India; CDMA- Code Division Multiple Access; MNP- Mobile Number Portability; BWA- Broadband Wireless Access; HLR- Home Location Register; VLR- Visitor Location Register; ICR- Intra-circle Roaming; VNO- Virtual Network Operators; NDCP-National Digital Communications Policy

Figure 1.2: Circle wise tele-density in India as on January 31, 2020



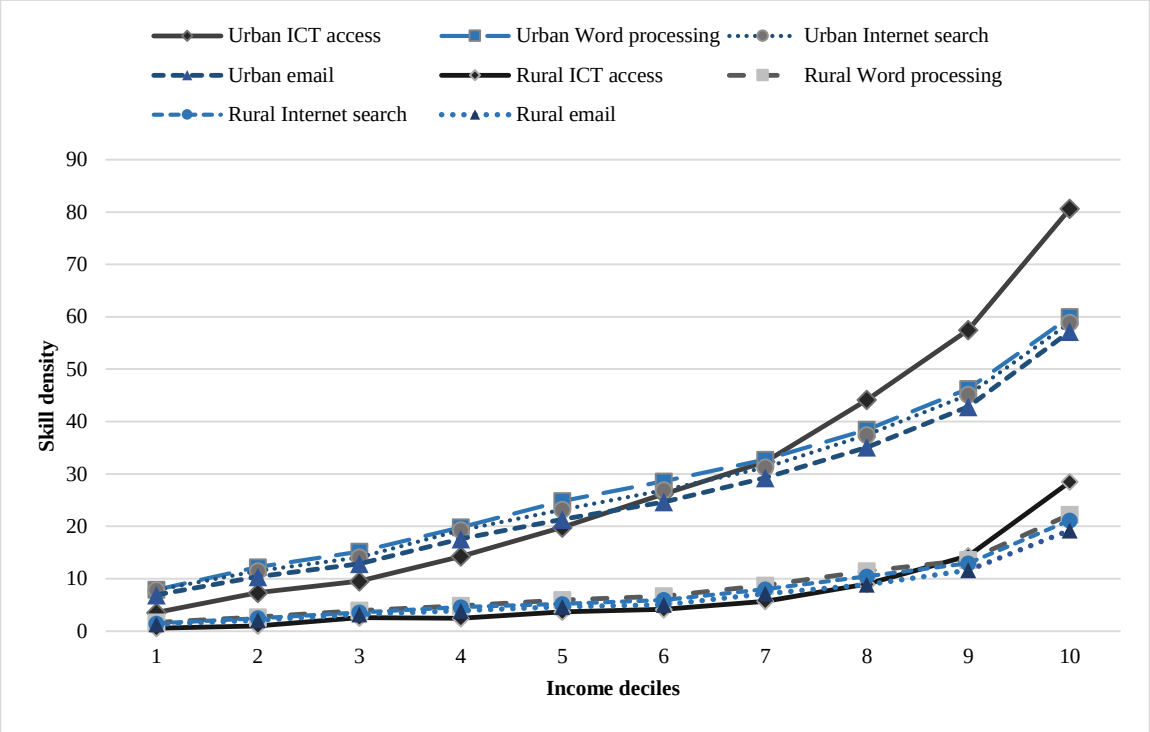
Source: TRAI (2020)

Figure 2: Factors influencing ICT adoption and its use capabilities



Sources: Hodge and Siegel (1968) and Author, see Tables 2.1 and 2.2 for description.

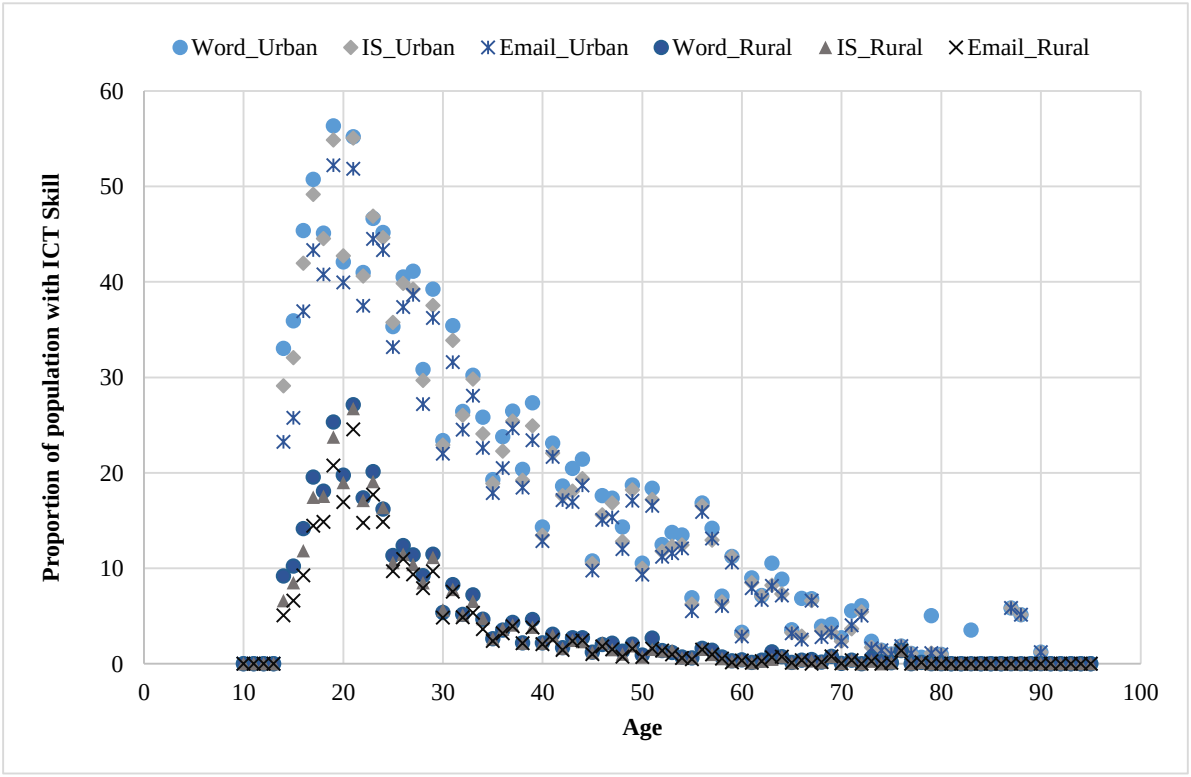
Figure 3: Bivariate plot of ICT adoption and its use capabilities with income



Source: Author's computations based on the NSSO 71st round surveys

Note: Given the unavailability of data on income in developing countries like India, often the monthly expenditure is used as a proxy for income. The figure above uses the monthly household consumer expenditure, which is divided into ten equal decile groups, where the highest decile (10th) represents the richest households

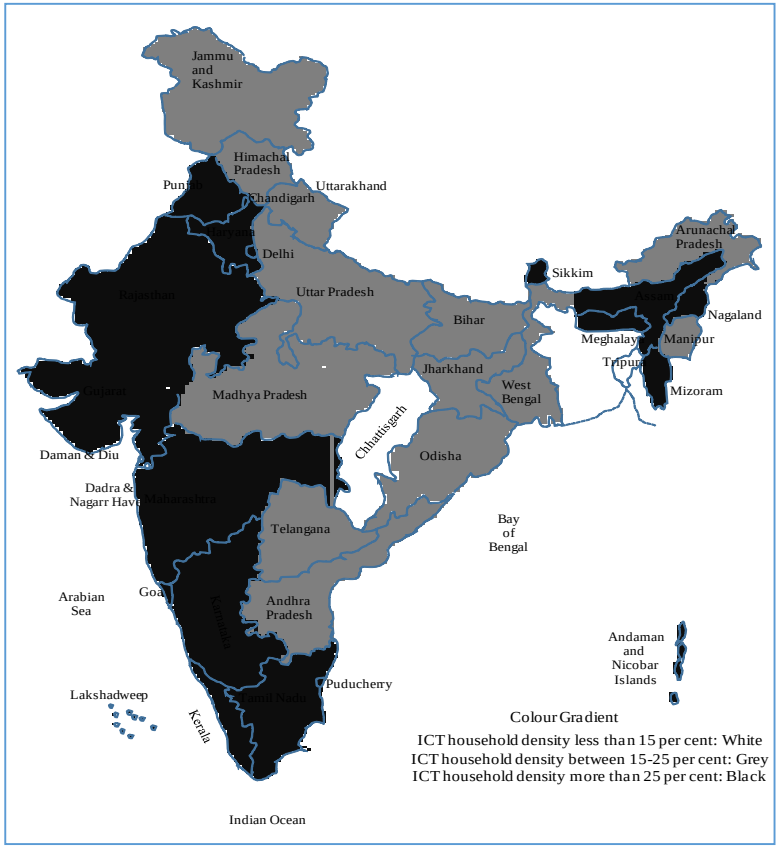
Figure 4: Regional ICT skill density by Age



Source: Author's computations based on the NSSO 71st round surveys

Figure 5.1: State wise household ICT adoption density in the rural sector of India during the year 2014

Figure 5.2: State wise household ICT access density in the urban sector of India during the year 2014



Source: Author's computations using the NSSO 71st round survey.

Figure 6.1: State wise ICT skill density in India during the year 2014-ability to do word processing

Figure 6.2: State wise skill density in India during 2014-ability to search information online

Figure 6.3: State wise digital skill density in India during the year 2014-ability to email

Source: Author's computations using the NSSO 71st round survey.

Tables

Table 1: Characteristics of the NSSO 2014 sample

Characteristics/Sector	Rural	Urban	Total
Number of households	36,479	29,447	65,926
Number of individuals	1,78,331	1,32,496	3,10,827
Percentage of households possessing computer(s)	6.68%	30.33%	13.78%
Percentage of households, where any member of the household has Internet access	17.03%	49.82%	26.87%
Percentage of households with ICT access (households having computer and access to Internet facility)	5.77%	28.49%	12.58%
Individuals above 14 years of age able to do word processing	7.84%	28.10%	14.22%
Individuals above 14 years of age able to do Internet search	7.27%	27.08%	13.51%
Individuals above 14 years of age able to email	6.46%	25.35%	12.41%

Table 2.1: Variable definitions for the regression model surveying correlates of household ICT adoption

List of variables	Definition
Dependent variable	
Access to ICT	=1, if the household possesses an Internet enabled device(s) such as computer/laptop/palmtop/tablet/smartphone and has access to Internet facility; 0, otherwise
Independent variables	
Income	Monthly household consumer expenditure
Education level	Education of the household head divided into following five categories: Illiterate; Literate but less than primary; Primary until secondary; Above secondary but less than graduate; and Graduate and above
Social group	Divided into following four categories: Scheduled Tribe; Scheduled Caste; Other Backward Classes; and Others
Religion	Divided into following three categories: Hinduism; Islam; and Others
Occupation structure	Divided into six categories for the rural sector: self-employed in agriculture, self-employed in non-agriculture , regular wage/salary earning , casual labour in agriculture , casual labour in non-agriculture and others; and four categories for the urban sector: self-employed, regular wage/salary earning, casual labour and others
Gender composition	Share of male members in the household, that is the proportion of male members in the household to the total number of household members
Proportion of adults (14-29 Years)	Share of household members in the age group of 14-29 years
Regional ICT access density	Percentage of households having ICT access in the NSS Region (Household device-density in the NSS region is taken as an alternative variable to account for the ICT infrastructure such as network and telecom towers. Such a variable has also been used in selected studies to account for network or learning effects, which positively impacts ICT adoption (Goolsbee et al., 2002; Demoussis et al., 2006)).

Table 2.2: Variable definitions for the regression model surveying correlates of ICT use capabilities

List of variables	Definition
Dependent variable	
If Individual knows the specific skill (word processing, Internet search and email)	=1, if the individual knows the specified digital skill; 0, otherwise
Independent variables	
If the individual has access to computer device(s)	=1, if has access to computer ; 0 otherwise
If the individual has access to Internet facility	=1, if has access to Internet; 0 otherwise
Education level	Divided into following five categories: Illiterate; Literate but less than primary; Primary until secondary; Above secondary but less than graduate; and Graduate and above
Social group	Divided into following four categories: Scheduled Tribe; Scheduled Caste; Other Backward Classes; and Others
Religion	Divided into following three categories: Hinduism; Islam; and Others
Household Income	Monthly household consumer expenditure
Gender	=1 if male ; 0 if female
Age	Divided into five categories:14-21; 22-29; 30-44; 45-59 and over 60 years of age
Occupation	Divided into six categories for the rural sector: self-employed in agriculture, self-employed in non-agriculture, regular wage/salary earning , casual labour in agriculture , casual labour in non-agriculture and others; and four categories for the urban sector: self-employed, regular wage/salary earning, casual labour and others
Regional digital skill density	Percentage of individuals knowing the specified skill in the NSS Region calculated separately for rural and urban sector (This variable has been used in select studies to account for network or learning effects, which positively impacts ICT adoption (Goolsbee et al., 2002; Demoussis et al., 2006)).

Table 3.1: 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

Table 3.2: Share of individuals (above the age of 14 years) 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

Table 4.1: Correlates of household ICT adoption - households with computer device(s) and Internet access

Model (Marginal effect)	ICT Adoption Probit	
Variable	**Rural**	**Urban**
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 and 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

Notes: The figures reported above are probit model marginal effects, calculated at means for continuous variables. For categorical variables they are calculated at the following values: education level= primary until secondary; social group = others; religion = Hinduism; age group = 14 to 21 years of age; household type rural= self-employed in agriculture; household type urban= self-employed

Table 4.2: Correlates of individual's ICT use capabilities (above the age of 14 years)

Sector	Rural			Urban		
Model	Word Processing Probit	Internet use Logit	Email Probit	Word Processing Probit	Internet use Logit	Email 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%

Notes: The figures reported above are logit/probit model marginal effects, calculated at means for continuous variables. For categorical variables they are calculated at the following values: education level= primary until secondary; social group = others; religion = Hinduism; age group = 14 to 21 years; household type rural= self-employed in agriculture; household type urban= self-employed