

Diffusion of Information Communication Technology across Indian States and its Determinants: An Empirical Analysis

1. Introduction and Background

Information and Communication Technology¹ (ICT), as a source of disseminating information, plays an important role in economic development as well as has reformed the world economy, not only as a sector but indirectly also by increasing the productivity and reducing transaction costs. Being a general-purpose of technology² (Helpman, 1998), it has been diffused rapidly in all sectors of the economy and segments of the society. In addition to that, it has led to considerable changes in the living and working conditions of an increasing part of the population. However, not all groups of the economy participate similarly in the diffusion process. Sometimes, it takes considerable long period of time to be adopted by those who seem most likely to benefit from their use. The word diffusion is interpreted in two senses, the level of diffusion – the standard attained a stock concept and the speed of diffusion is a flow concept, reflecting the time required between two levels of diffusion (Nabseth & Ray, 1974). The basic premise of studying the technology diffusion relies on the fact that if a technology is superior, then why it is not taken up immediately by all the potential users. During the last one and half decade, among the developing countries, India has done a remarkable improvement in ICT sector³ and its contribution in different sector illustrates its significance. Though there is

¹ ICT is the combination of both information and communication technologies. It is worth noting here that the difference between these two have always been a contentious issue. Communication, which is one of the important facets of human life, may be broadly divided into two categories: one way communication and two way communication. One way communication includes the broadcasting media like radio and television while two way communications comprises faxes, telephones, mobiles, pagers and voice over internet protocol. However, there is no clear outline between information technology and communication technology. For example, mobile phones are generally considered as the communication technology but in the new economy with the advent of wireless applications, data and information can also be accessed through mobile phones. Similarly, the Internet is mainly considered as the indicator of information technology. But many users communicate with other users via voice over internet protocol from their personal computers. In this case it switched to communication technology.

² General purpose technologies are technologies which have the potential to drastically alter the societies through their impact on pre existing economic and social structures. The key characteristics are: pervasiveness, technological dynamism and; innovation complementarities with other forms of advancement.

³ Total ICT spending in India in the year 2001, was 16,844.4 millions of dollars which increased to 93,926.8 millions of dollars in 2009. For more details see, Digital Planet, 2006

remarkable performance in production and export of IT software and services, the diffusion of ICT in India remains at very low levels in comparison to developed nations. It is well known that the economy of a country is not affected by new technology until the use of that technology is pervasive and in addition to that, these technologies are likely to be adopted and used by different sectors and segments of the economy, with their diverse preferences and abilities. Given the major driver of economic growth, these technologies are pre supposed to diffuse properly.

With this background, this paper is an attempt to examine the extent of ICT diffusion and interstate differences across selected Indian States by analyzing the availability of state wise ICT infrastructure and ICT adoption indicators. Subsequently to look at the different factors responsible for its diffusion. More specifically, the paper tries to find out ICT development across Indian States and to explore the nature and direction of the interstate digital divide by relating ICT diffusion with various socio economic indicators within the context of the major states of India.

The remainder of the paper is organized as follows. The first deals with the some theoretical as well as empirical literature. With the help of these literatures, we have tried to frame our empirical work. Attention then turns to the data set and the methodology, which are discussed in third and fourth sections respectively. In addition, the methodology section also includes the empirical model of ICT diffusion. The subsequent section presents the overview of diffusion of different ICT indicators in major states, followed by the construction of ICT diffusion index in section six. It highlights the key observations on the distribution of ICT infrastructure and adoption across different states and discusses the magnitude of interstate divide. Following to that, section seven presents the determinants or factors responsible for the variation in ICT diffusion. The final section concludes with a brief discussion of the results and concluding comments.

2. Analytical Framework:

The endeavor of this section is to provide a short description of the role of ICT in growth and development followed by a brief theoretical literature relates to innovation diffusion processes. In addition to that some empirical literatures relate to determinants of ICT diffusion. The research focusing on the earlier studies guides us in our selection of independent variables.

2.1: Role of ICTs in economic growth and development

Over the last few decades, significant efforts have been devoted to the understanding of the contribution of ICTs on economic growth in both developed as well as under developed countries. The status of ICT adoption of an economy reflects the potential ability of that economy to exploit the economic opportunities afforded by these new technologies (ADB, 2002). However, the contribution of ICT to the economy of a country can be viewed in two basic ways: first, as a producer or supplier of ICT goods and services, it can contribute in output, employment and export earnings, and second, as a user of ICT goods and services, it can improve the productivity and competitiveness of key sectors (Wong, 1998a, Kraemer and Dedrick, 2001). There is a substantial literature on the contribution of ICT to economic growth for both developed as well as underdeveloped countries. Studies based on cross country analysis pointed out that there are considerable returns in terms of productivity and growth from the investments in information technology (Pohojola, 2001; Kraemer and Dedrick, 2001). Wong (2001), in his empirical study on the growth of ICT production and rapid diffusion of ICT in Singapore, found that the country is not only benefited from ICT production, that is, in terms of exporting ICT goods and services to the rest of the world, but also from use of ICT to improve the productivity and competitiveness of key sectors of the economy. Despite its wide dissemination in all the sectors and its contribution to economic growth and labour productivity in both rich and poor countries, the access to communication and information services exhibit major inequalities among and within countries (World Bank, 2006). This uneven distribution of ICTs is recognized as digital divide⁴. In each country there are people who have access to modern communication technology while others are not enabling to make use of telephone connections, the internet and other ICT features. It also can manifest itself in different demographic characteristics of the population such as age, gender, income and race, or different locations (ITU, 2009).

⁴ OECD (2001) defined the term digital divide as the gap between individuals, households, business and geographic areas at different socio- economic levels with regard both to their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities. The digital divide reflects various differences among and within countries. ITU (2009) defined the imbalances in access to physical infrastructure, such as computers and Internet or even conventional communication infrastructure, such as fixed telephone lines.

Coming to Indian context, India is also known in world market for its success in ICT production and export of IT software and services (Joseph & Harilal, 2001; Singh, 2003). The study on technological competence of Indian ICT sector shows that the Indian ICT sector is technologically vibrant and there is upward mobility of ICT firms in terms of their technological competence (Joseph & Abraham, 2005). However, with a compound annual growth rate of above 25% over the previous five years, the Indian IT-ITES industry has shown a remarkable growth both in exports of IT software and services as well as surge in the domestic market (NASSCOM, 2007). Since, there is a substantial literature regarding the contribution of ICT (more specifically IT) sector and IT enabled services to economic growth, the study on diffusion of ICT is comparatively very less. In spite of this it is also well known fact that the process of ICT diffusion in India, as one of the important issues for economic development, is not straightforward. Being the major driver of economic growth of the country, these technologies need to be diffused in all sectors and segments of the society. Identifying the factors which hinder these technologies' diffusion across the different sectors and segments of the economy will be the first step in helping to access and use those technologies productively.

2.2: Theoretical Background

Following to Schumpeterian view; technological change⁵ is a process of three phases, invention, innovation and diffusion⁶. Diffusion is the process by which an innovation or ideas is communicated through certain channels over time among the members of social system (Rogers, 1972). The issue of technology diffusion has been put forward both in demand as well as supply perceptions. The logic behind the demand approach is that technology diffusion is guided by the demand from the potential users while the supply side provides the availability of technology for its diffusion. However, to get the complete picture of diffusion, it is important to understand the process by which diffusion occurs and different models explaining the technology diffusion. Though the literature which tries to explain why this happens is enormous and various theories

⁵ Technological change is defined as the advance of technology, such advance often taking the form of new methods of producing existing products, new designs which enable the production of products with important new characteristics, and new techniques of organization, marketing and management (Mansfield, 1969).

⁶ The first stage is the invention process, encompassing the generation of new ideas. The second stage is the innovation process with the development of new ideas into marketable products and processes. The third stage is the diffusion stage in which the new products and processes spread across the potential market.

have been developed, here we have tried to give a broad but brief review of different processes to develop the analytical background for this paper. Drawing certain essential facets from this, we have tried to understand the diffusion of ICTs across Indian states and its determinants.

For the purpose of this paper, we have discussed three different perspectives, which basically give details the different processes by which diffusion occurs. Following to Brown (1981), there are four different perspectives for diffusion process: the adoption perspective, the market and infrastructure perspective, the economic history perspective, and finally the development perspective.

Being the traditional and dominant approach to diffusion studies, the adoption perspective, focuses upon the process by which adoption occurs. By emphasizing the demand side of the problem, it assumes all have an equal opportunity to adopt and therefore focuses upon the individual characteristics to explain the differences in actual times of adoption (Roger & Shoemaker, 1971). The adoption of an innovation is basically the outcome of learning and communication process and the factors related to the effective flow of innovation are most significant for the adoption of new technology (Brown, 1981). The conceptualization of adoption process is put forward through five stages⁷: awareness stage, interest stage, evaluation stage, trial stage and adoption stage. Though this conceptualization has been appreciated but it has its own limitation like the fifth stage always talks about the adoption while the rejection may arise and secondly for the critics of adoption process, only two stages are essential and sufficient – awareness and adoption.

In contrast to that, the market and infrastructure calls attention to the supply aspect of diffusion. It takes the stance by which innovations and the conditions for adoption are made available to individuals or households. It conceptualizes diffusion as a process involving three activities (Brown, 1981). The initial activity is the establishment of diffusion agencies through which innovations are propagated. The establishment of diffusion agencies is important in the regard

⁷ When the individual learns of the existence of the new idea but lacks information about it is known as the adoption stage. Developing interest in the innovation and seeking additional information about it is the interest stage. For evaluation stage the individual makes mental application of the new idea to his present and anticipated future situation and decides whether or not to try it. In trial stage, the individual actually applies the new idea on a small scale in order to determine its utility in his own situation and finally in adoption stage, the individual uses the new idea continuously on a full scale (Rogers & Shoemaker, 1971).

that it is these diffusion agencies through which innovation is made available to potential adopters. The establishment of diffusion agencies takes place either through a centralized decision making structure decentralized decision making structure with or without a coordinating propagator. Once the diffusion agency is established, the next stage is to implement new strategy to make it available. Therefore, as a second activity a strategy is developed and implemented by each agency to induce adoption. Though, the strategy includes several activities, four activities are recognized as important for spatial pattern of diffusion: development of infrastructure and organizational capabilities, price structure for the innovation, promotional communications and finally market selection and segmentation. Development of infrastructure permits the diffusion process to be implemented, maintained and expanded. As price charged for innovation is likely to change over time and to vary over the space and time it may influence its spatial variation. The promotional activities provide information across potential adopters about the innovation and finally the market selection and segmentation identifies the clientele for the innovation. However, in market and infrastructure perspective, attention is shifted to the diffusion agencies instead of adopter.

Nevertheless, both of these two perspectives present a static approach to innovation because in both the perspective innovation is essentially same throughout the diffusion process. In contrast to this, the economic historian⁸ talks about the dynamic approach of innovation, by emphasizing both the preconditions of diffusion as well as continual of innovation. Being historical in its focus, the traditional interpretation of economic historians is more concerned with the invention than with the diffusion process. The reinterpretation of economic history takes the view that innovation is continuous and examines various aspects of that continuity. The economic history perspective treats innovation as a continuous process and therefore brings into focus another dimension of supply side. This continuity of innovation affects the temporal and spatial pattern of diffusion in both supply and demand viewpoint. From supply point of view, the time at which a particular innovation is adapted or improved for a given use, market or potential adopters has a direct bearing on where and when the innovation will be available and hence adopted. Second, on the demand side, even if innovation is made available, some potential adopter (individual or

⁸ The view of economic historian is divided into two schools: the traditional interpretation of economic history and reinterpretation of economic history. For more details see Brown, 1981.

firms) will often delay their decision on the basis of expecting further improvements in the innovation. Specifically it can be said that, economic history perspectives examines three complementary perspectives: the economic history perspective, a supply side concern dealing with the preconditions for diffusion; the market and infrastructure perspective, again dealing with supply side by concerning the innovations are made available to potential adopters; and the adoption perspective, a demand side concerning with the adoption perspectives (Brown, 1981). In addition to these three, when the impact of innovation and diffusion is studied, that is considered as the innovation diffusion from development perspectives. It concerns both the ways in which the level of development affects the diffusion process and the outcome and impacts of that process.

To summarize the above discussion, it can be said that none of these perspectives are giving a clear picture of innovation diffusion processes; rather it is giving a partial story of innovation diffusion process. Integration of these three may give a clearer picture. More specifically, the application and usefulness of all these perspectives differ in terms of nature of innovation. The following sub section briefly explains some of the empirical literatures, which talk about the factors responsible for ICT diffusion. Drawing inferences from all the studies, we have tried to use certain adoption as well as infrastructure indicators to discuss state wise ICT diffusion and its determinants.

2.3: Empirical literature on the determinants of ICT diffusion

Since the adoption of new technologies varies across and within the countries, the notion of haves and have nots may depend on the various socio economic indicators. The extent and speed of diffusion of any technology depend on the domestic capacity of absorbing the advanced technologies and this absorption capacity differs both across the countries and within the countries. Though, there is a substantial literature on the possible role of ICT for economic growth and development, while discussing the determinants of ICT diffusion, there are very few studies have been done.

The first empirical study on the determinants of ICT diffusion was by Hargittai (1999) and the differences in the internet connectivity in 18 OECD countries was the spotlight of the study. Her basic conclusion was that other than GDP, it is the competition between telecom service providers which has the significant explanatory power over the internet connectivity across the

countries. In contrast to 18 OECD countries, Norris (2000) investigates the differences in internet penetration in a larger group of 179 countries. She regresses the number of people online with a number of social, economic and political variables. Besides regional dummies, GDP per capita and the share of R & D expenditure in GNP turned out to be statistically significant. But, in both the studies, education did not have any explanatory power. Later, by following the similar approach, Kiski & Pohojola (2002) study the global pattern of internet diffusion and the factors determine technology diffusion across the countries with the help of an explicit model, i.e. Gompertz model of technology diffusion. Besides, OECD countries, they have carried out the estimation for larger sample countries. The basic finding is that GDP per capita and internet access costs explain the best observed growth. In contrast to Hargittai (1999), competition in telecommunications market does not have independent influence in their study. For OECD countries education does not have any significant influence but for larger sample of industrial and developing countries education turns to be significant. Wong, 2002 evaluates the divide in Asian countries based on penetration levels of telephone main lines, PCs and internet use. Analyzing comparisons of the scale of IT adoption relative to national income, he finds that the digital divide in Asia is wide and has potential to become more severe. Balamoune-Lutz (2003), using data from developing countries, examines the diffusion of four ICT indicators and its link with other socio economic indicators. The results show that income and government trade policies influence in ICT diffusion. Among the four indicators, only personal computers and internet hosts seem to have a positive relationship with income. However, ICT diffusion is not associated with education.

By using a set of independent variables in a cross section of 141 countries in 1998-99, Guillen and Suarez, 2001 study the number of internet hosts and the number of internet users per capita. They consider variables like telecommunications policy and infrastructure as well as predictable policymaking and a democracy index, which are indicative of an environment conducive to entrepreneurship. They find that policy variables have an impact when the entrepreneurship variables are not included, but lose their effect when they are.

Robison and Crenshaw, 2001 examine the level of economic development, political openness, mass education, and the presence of a sizeable tertiary or services sector as drivers of internet diffusion. By a cross sectional analysis of per capita internet penetration for 74 countries over

1995 – 1999, they found that the most significant explanatory variables are development level, political freedom, and education.

Though, several empirical studies have been done to get the determinants of ICT diffusion, most of the studies are confined to internet hosts or internet users and also cross country analysis. Secondly, the issue regarding the diffusion of ICT within the country has not been addressed so far. In this context the present study tries to discuss the diffusion of ICT by considering few indicators.

2.4: Empirical Framework

After reviewing the literature, in this section we have tried to specify the variables in our framework, for both the objectives. We present our framework in figure 1 & 2 and discuss in detail in the following subsections.

Figure 1: Framework for assessing the level of ICT development and interstate divide

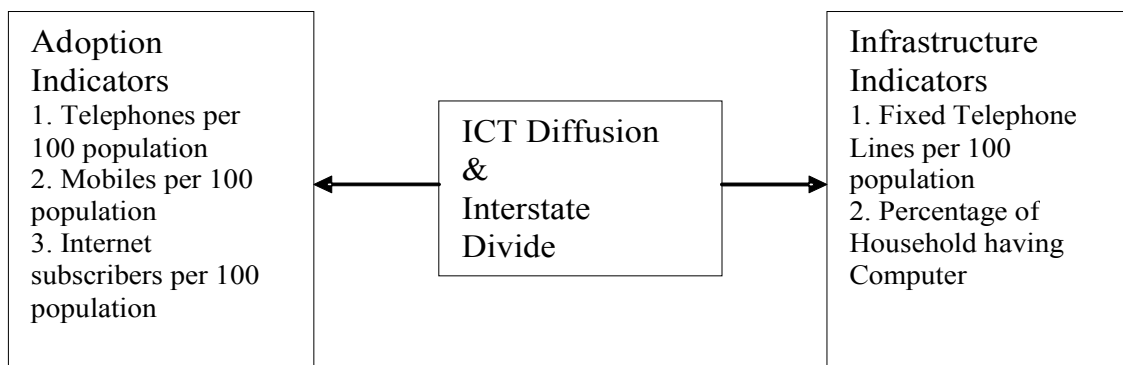
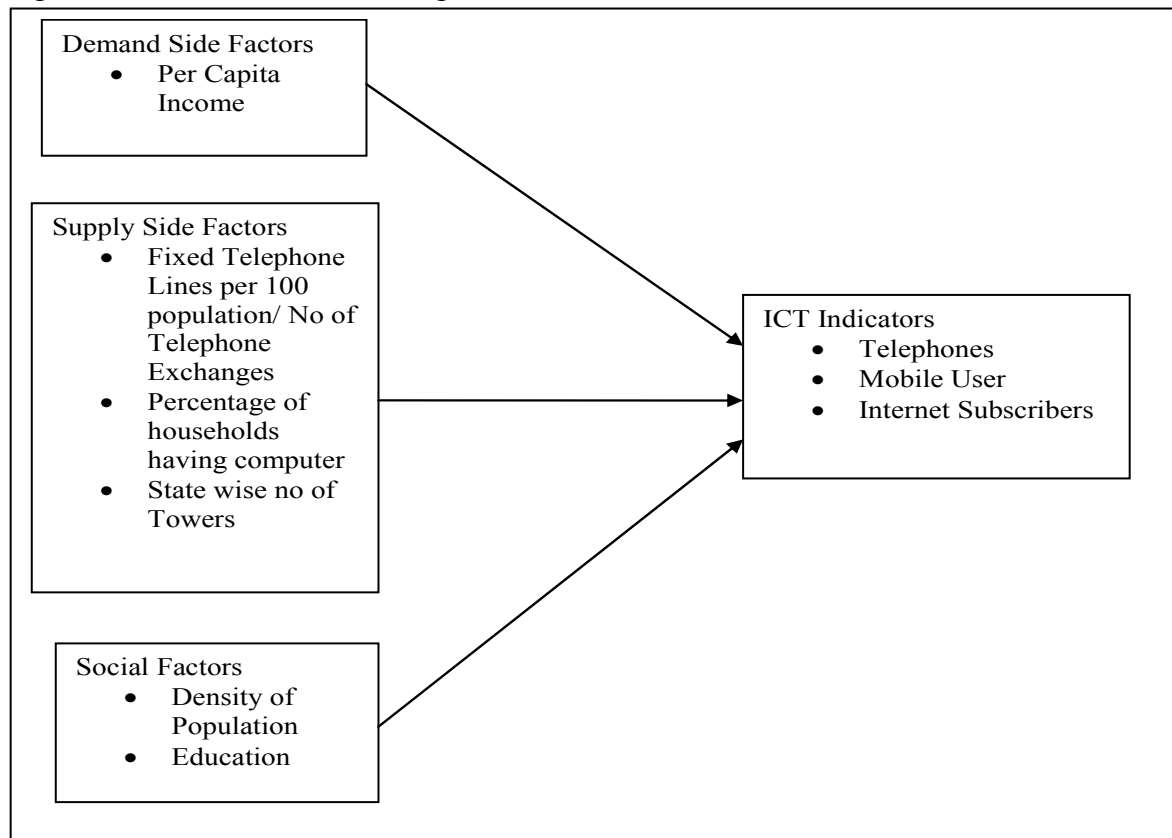


Figure 1 depicts the level of ICT development across the Indian states and interstate divide. We have used both the adoption as well as infrastructure indicators for assessing the level of diffusion and interstate divide over the time. The figure 2 shows the framework for the determinants of ICT diffusion. To look for the determinants we have chosen three ICT indicators: telephone, mobile user and internet subscribers. For each indicator income is considered as the demand side variable while for supply side factors, we have considered three infrastructure variables for respective indicators. The construction of independent variables is explained in the following sub section.

Figure 2: Framework for assessing the determinants of ICT diffusion



2.5: Construction of Variables

Having established a base to evaluate the level of ICT diffusion, in this section we turn to analyzing the factors that impact diffusion of technology. Here we have selected the most likely variables based on the data availability and literature. We have divided the selected variables into three categories. The first is the demand side factors or it can be said as the economic factors. On second category, variables are supply side and third one is some social factors.

Demand Side Variables

Income has been an important factor in the early phases of technology diffusion, when prices of the technologies are higher and only those with higher income can afford those. With that, the assumption that per capita income is a major determinant of ICT diffusion is fairly standard on both theoretical and empirical grounds (Kiski & Pohojola, 2002, Balamoune-Lutz, 2003). In our study, we have considered per capita income (PCI) as one of the explanatory variable for all the three indicators. Average state per capita income over the year 2002 to 2006 has been used in our study. Other than income, technology costs (monthly telephone subscriptions/ costs of a local

call/ monthly internet subscriptions) can be considered as the demand side factors. But as our study is confined to within the country and we are looking for interstate diffusion, technology costs is almost same for all the states.

Supply Side Variables

As it has already been discussed in market and infrastructure perspective, development of infrastructure is one of the important strategies and it permits the diffusion process to be implemented, maintained and expanded; here we have tried to consider some infrastructure facilities, which are needed for the development of ICT indicators. Fixed telephone lines or state wise no of telephone exchanges can be considered as one of the important variables for fixed telephones. Similarly, for using internet, computer can be considered as an important infrastructure. We have used percentage of households having computer as the independent variable for internet. In addition to that, state wise number of towers has been considered as the explanatory variable for mobiles.

Social Variables

Our third category of variables is social variables, which includes factors that affect the value of access to technology. Two variables are included in this category. Other than demand and supply side factors, it is also well known that technology adoption is always skill bias and human capital plays a critical role in determining the development of ICT (Lee, 2001). Therefore, education might be an important factor because it provides the skills required for creating, adapting and utilizing such technologies. For example, while we are talking about ICT access, contrast to old ICT like radio or television in which there is no active participation of the user, the Internet, computer, mobile are the interactive technologies and the user needs not only access to that infrastructure but also needs the ability to access the information and use it. For that, education may play an important role in adopting that technology. But, earlier studies give muddled results regarding the importance of education on ICT diffusion. Lee (2001) finds that the level of secondary education is important for the adoption of both main lines and mobile telephone technology. He also comes up with evidence for the strong role of secondary and tertiary education in explaining differences across countries for the internet hosts per capita. In contrast, Hargittai (1999) and Norris (2001) found that education did not have significant influence on ICT diffusion. Kiski & Pohojola (2002), in their study showed that tertiary education had a

positive and statistically significant result on ICT diffusion for large sample of OECD and developing countries. Therefore, as India is a developing nation, the present study assumes education might be an important factor for ICT diffusion. For the present study we have considered adult literacy as the independent variable.

The second social variable is the size of the population. Here we have considered density of population. The reason behind selecting the density of population is that size of population indicates country's characteristics. Other than that we can consider telecommunication policy⁹ as the policy variable but due to data constraint, we can't go for policy variable.

3. Data Sources

The paper is broadly relied on secondary data. Five ICT indicators, such as telephones, mobile user, internet subscribers, fixed telephone lines per 100 populations and proportion of households with a computer are used as the alternative indicators for this analysis. The first three variables may be viewed as indicators for the ICT adoption while rest can be considered as ICT infrastructure. Data are collected from Ministry of Statistics and Programme Implementation (MOSPI)¹⁰, Indian Telecommunication Statistics (2004)¹¹, Lok Sabha Unstarred Question No. 3162¹² and Starred Question No. 469¹³, Rajya Sabha Unstarred Question No 1733¹⁴, Annual

⁹ The telecommunication policy reforms in India take place in three phases. The first reforms in India started in the eighties with the mission better communication. Several private manufacturers of tailor made equipments entered the market. There were private developer for indigenous technologies and the franchisee for STD/ ISD and PCO increased. The VSNL and MTNL were set up under the Government of India, Department of Telecommunication. The second phase came in the early nineties. The New Economic Policy, 1991 was a landmark in the history of telecom sector in India. The manufacturing of equipments pertaining to telecom sector was decentralized and several value added services were introduced into the market. The telecom services were divided into basic telephony, radio paging and cellular mobile. The TRAI was established as an independent regulatory body pertaining to telecom sector. The growth of private sector increased. The third phase of reform in India took place in the period of late nineties. The Government of India introduced the New Telecom Policy, 1999. The TRAI was endowed with more power. The concept of revenue sharing was introduced to replace the fixed license fee. The National Long Distance was introduced with free entrance. The BSNL, a corporate body was reformed, followed by the introduction of the Internet in the Indian market.

¹⁰ Compendium of Selected Indicators of Indian Economy: Special Issue of Time Series Data, Volume 1 is used to get data on the telephones per 100 population.

¹¹ We have used this report for 2001-02 state wise internets per 100 population and fixed telephone lines per 100 population.

¹² <http://164.100.47.132/annexture/lsq14\8\au3162.htm/>. This site is used to get the 2005-06 internet subscribers. Here some states' data, like Jharkhand, Lakshadweep, Goa, Chhattisgarh, Pondicherry, Uttaranchal, Sikkim, are

Report of Telecom Regulatory Authority of India, 2006-07¹⁵ and NSSO 61st¹⁶ round. Data, used in this study, are for the period 2002-06.

4. Methodology

There are two distinct motivations behind this following exercise. One is to recognize status of ICT diffusion across major Indian states, while the other is to identify the determinants of ICTs diffusion. To examine the ICT diffusion and interstate differences, we have carried out two stages of analysis. In the first stage we have constructed ICT diffusion index. In second step, to examine whether the differences is widening or not, we have used Orbicom methodology. Subsequently, Gompertz model of technology diffusion has been used to identify the factors that determine the ICT diffusion across Indian states.

4.1: ICT Diffusion Index

To measure the extent of ICT development and interstate divide, ICT diffusion index has been constructed. The index is calculated in two steps. First, the proportions are normalized by using

included in Bihar, Kerala, Maharashtra, Madhya Pradesh, Tamil Nadu, Utter Pradesh and West Bengal respectively. As the included states and Union Territories have very negligible effect as well as the population share was very less in former period and there is data constraint, we have used this data in our study. Except Jharkhand and Chhattisgarh, we can see that Goa's population is just 1.39 percentage of Maharashtra's population. Likely Sikkim, Lakshadweep, Pondicherry and Uttaranchal have just 0.67, 0.19, 1.57 and 5.11 percentage share of West Bengal, Kerala, Tamil Nadu and Utter Pradesh population.

¹³ <http://164.100.47.132/LssNew/psearch/QResult14.aspx?qref=34604> is used for 2005-06 mobile phone subscribers.

¹⁴ <http://164.100.24.219/annex/200/Au1733.htm> (Annexure-II) is the source for 2001-02 state wise mobile phone users. Like 2005-06 internet subscribers, for 2001-02 mobile phone users, Maharashtra included in the state of Goa. The Union Territories like Lakshadweep, Chandigarh, Pondicherry, are included in Kerala, Punjab, Tamil Nadu and respectively. Here, Sikkim and Andaman Microbar's figure are included in West Bengal and two Union Territories Dadar & Nagar Havelli and Daman & Diu's figures are included in Gujarat. The share of both A & N and Sikkim is only 1.11 percentage of West Bengal's population and even less than one percentage, i.e. 0.75 percentages is both Dadar & Nagar Havelli and Daman & Diu of Gujarat's population. Therefore, in our study we are assuming that there will not be a large change by including these values.

¹⁵ This report has been used for 2005-06 fixed telephone lines.

¹⁶ We have taken state wise proportions of households with a computer from NSSO 61st round (2004-05). As only one round of NSSO is giving the proportions of households with a computer, we have used this one year data to construct the ICT index for both the year.

the formula $\frac{\text{Actual}-\text{Minimum}}{\text{Range}}$. Here ‘Minimum’ is the lower value in the proportion series and range is the difference between maximum and minimum proportion in the series. The purpose of normalizing is that, to convert a range of numeric value without disturbing the distance. After normalizing the proportions, coefficient of variation is used for assigning weight. The weighting considers wide variation in the series. Then the normalized proportions are multiplied with the weights and finally a weighted average is found out corresponding to each state.

Symbolically,

$$\text{ICTDI} = \frac{\sum_{i=1}^N w_i NP_i}{\sum_{i=1}^N w_i}$$

Where, ICTDI is the ICT diffusion index, comprising all the five indicators. W_i is the specified weight assigned to each indicators. NP is the normalized proportions.

In addition, we have gone through a further analysis to know whether this divide is widening or shrinking over the time. For this analysis, the paper has followed several methodological steps¹⁷, which is developed by Orbicom (2003) and later it is used by International Telecommunication Union (2009). First, states have been grouped according to their index values by using a certain reference value. In this paper, the overall average index value has been used as the reference value. After splitting the states into various groups, in the next step we have computed the average index values for each group and this value has been used for showing the evolution and magnitude of differences between different groups. In the third step, we have normalized the average values for the year 2001-02, as the absolute index values may not give the real picture of digital divide. For instance, suppose we are considering two states: developed and underdeveloped. The state which is already developed in accessing these technologies may not show much growth in comparison to the states which starts from a very low levels. To avoid this

¹⁷ For more details see Orbicom (2003) Methodology

error, the 2001-02 values have been normalized with 2005-06 values. We have normalized¹⁸ all the three groups' values. Finally, these normalized scores are used to see the magnitude of differences between the groups. The size of the digital divide is computed by subtracting the group's 2001-02 normalized index values from the corresponding 2005-06 values. Changes in the digital divide were computed by subtracting the magnitude of 2005-06 digital divide from the 2002 corresponding value. The sign of the computed values shows the evolution of the differences. A negative value indicates a closing divide between the two groups, while a positive value indicates a widening divide.

4.2: Empirical Model

The diffusion of the ICT is analysed by the aid of a model which is similar to the ones that have been applied in describing the process of natural growth of computer by Chow (1967), cross country diffusion of internet by Kiski and Pohojola (2002) and determinants and effects of ICT diffusion of internet by Balamoune- Lutz (2003). In this paper, the Gompertz model of technology diffusion has been used to study ICT dissemination across Indian states which specify the rate of change in the level of ICT. The determinants of ICTs diffusion is estimated for three ICT indicators, i.e. mobile, telephone and internet.

Let ICT_{ijt} denotes the number of specific ICT (i) of particular state (j) in year t and let ICT_{ij}^* be its post diffusion or equilibrium level. Most of the models of technology adoption assume that over time ICT_{ijt} tends to ICT_{ij}^* along an S-shaped path¹⁹. The Gompertz model of diffusion specifies the rate of change in the ICT adoption as

$$\ln ICT_{ijt} - \ln ICT_{ijt-1} = \alpha_{ij} (\ln ICT_{ij}^* - \ln ICT_{ijt-1}) \dots \dots \dots (1)$$

Here α_{ij} is the speed of adjustment taken to be constant in our analysis. The equilibrium level of ICT adoption will be a function of at least two basic demand side variables, i.e. the level of income and cost of accessing these ICT. As our analysis is confined to within the country, we are not considering the accessing cost because it is almost same in every state. In spite of these

¹⁸ Suppose, we are normalizing the high group values, then the formula is

$$\frac{2002 \text{ Average High group's Value} * 2006 \text{ Overall Average}}{2002 \text{ Overall Average}}$$

¹⁹ For more details see Stoneman (1983), Chapter 5

demand side variables, as the theory implies, it is the interaction of both demand and supply side factors which determine the diffusion. Therefore, in basic model we have considered both demand and supply side variables. Other than this, from earlier studies it is found that there are also some other socio economic variables which affect the ICT adoption. The paper has considered socio economic variable like density of population, education etc will have the explanatory control over the equilibrium or target level of ICT. The equation for the target level of ICT in long term can be expressed as

$$\ln ICT_{ij}^* = \beta_{ij0} + \beta_{ij1} \ln PCI_{it} + \beta_{ij2} \ln X_{ijt} + \beta_{ij3} \ln Z_{ijt} \dots \dots \dots (2)$$

Where, X_{ijt} is the vector of supply side variables for respective ICT indicator. Z_{ijt} is describing the other socio economic factors in state j. The estimable equation is obtained by inserting equation 2 into 1:

$$\begin{aligned} \ln ICT_{ij06} - \ln ICT_{ij02} \\ = \alpha_{ij} \beta_{ij0} + \alpha_{ij} \beta_{ij1} \ln PCI_{it} + \alpha_{ij} \beta_{ij2} \ln X_{ijt} + \alpha_{ij} \beta_{ij3} \ln Z_{ijt} - \alpha_{ij} \ln ICT_{ij02} \\ + \epsilon \dots \dots \dots (3) \end{aligned}$$

Where, $\ln ICT_{ij06}$ represents $\ln ICT_{ijt}$ that is a specific ICT indicator (i) for particular state (j) in the year 2006 and $\ln ICT_{ij02}$ is $\ln ICT_{ijt-1}$, which stands for the year 2002. ϵ symbolizes the error term.

5. ICT Diffusion in Selected Indian States

Table 1 summarizes state wise telephone, mobile user, internet subscribers and fixed telephone lines per hundred populations in two different time periods, in India as a whole and in selected major states in particular. These figures indicate a large variation in both ICT infrastructure and access. In spite of these four indicators, we have also included proportion of households with a computer²⁰ as one of the indicator because having access to a computer at home can be a key enabler for developing ICT skills in particular among children and young people (ITU, 2009). As expected, the diffusion of ICT also varies significantly across the states. We can find that a few states like Maharashtra, Tamil Nadu, Kerala, Karnataka, and Punjab experience substantial improvements in ICT access.

²⁰ This is a core indicator of Partnership on Measuring ICT for Development

Table 1

State wise Different ICT Indicators per 100 Population

ICT Indicators →	Telephone		Mobile		Internet		DEL		% HHS having Computer
	2001-02	2005-06	2001-02	2005-06	2001-02	2005-06	2001-02	2005-06	
States ↓									
Andhra Pradesh	4.93 (0.961)	13.45 (0.883)	0.65 (0.994)	9.15 (0.913)	0.31 (0.997)	0.53 (0.995)	4.14 (0.967)	4.19 (0.975)	0.093 (0.999)
Assam	1.67 (0.994)	5.67 (0.963)	0.11 (1.000)	4.06 (0.964)	0.04 (0.999)	0.11 (0.999)	1.58 (0.993)	1.95 (0.998)	0.004 (0.999)
Bihar	1.08 (1.000)	5.34 (0.966)	0.15 (0.999)	4.34 (0.962)	0.01 (1.000)	0.10 (1.000)	0.91 (1.000)	1.82 (1.000)	0.000 (1.000)
Chhattisgarh	1.25 (0.998)	2.09 (1.000)	-	0.57 (1.000)	0.04 (0.999)	-	1.24 (0.996)	-	0.022 (0.999)
Gujarat	6.37 (0.946)	16.98 (0.847)	0.92 (0.991)	12.05 (0.884)	0.30 (0.997)	0.77 (0.993)	5.60 (0.952)	5.17 (0.965)	0.326 (0.996)
Haryana	5.06 (0.959)	14.47 (0.873)	0.48 (0.996)	9.75 (0.907)	0.06 (0.999)	0.74 (0.993)	4.67 (0.962)	5.31 (0.964)	0.206 (0.997)
Himachal Pradesh	7.48 (0.935)	18.78 (0.829)	0.36 (0.997)	11.21 (0.892)	0.06 (0.999)	0.11 (0.999)	7.17 (0.936)	7.88 (0.938)	0.079 (0.999)
Jharkhand	1.39 (0.996)	2.99 (0.991)	-	1.32 (0.992)	0.04 (0.999)	-	1.38 (0.995)	-	0.025 (0.999)
Karnataka	5.58 (0.954)	17.06 (0.847)	0.76 (0.993)	11.83 (0.886)	0.50 (0.995)	1.02 (0.990)	4.91 (0.959)	5.53 (0.962)	0.069 (0.999)
Kerala	9.51 (0.914)	25.54 (0.760)	1.16 (0.989)	13.50 (0.869)	0.34 (0.996)	1.19 (0.989)	8.45 (0.923)	11.26 (0.903)	0.400 (0.996)
Madhya Pradesh	2.49 (0.985)	7.12 (0.948)	0.35 (0.997)	5.08 (0.954)	0.11 (0.999)	0.36 (0.997)	1.90 (0.990)	3.12 (0.986)	0.073 (0.999)
Maharashtra	25.40 (0.754)	69.83 (0.308)	1.50 (0.986)	14.41 (0.861)	0.80 (0.992)	1.67 (0.984)	6.27 (0.945)	6.66 (0.951)	0.465 (0.995)
Orissa	1.88 (0.991)	7.57 (0.944)	0.13 (0.999)	5.49 (0.950)	0.05 (0.999)	0.16 (0.999)	1.75 (0.991)	2.14 (0.996)	0.049 (0.999)
Punjab	9.15 (0.918)	27.61 (0.739)	1.44 (0.986)	20.73 (0.797)	0.29 (0.997)	1.02 (0.991)	7.92 (0.929)	8.24 (0.934)	0.117 (0.998)
Rajasthan	3.02 (0.980)	9.65 (0.922)	0.21 (0.998)	6.57 (0.939)	0.18 (0.998)	0.48 (0.996)	2.82 (0.981)	3.35 (0.984)	0.092 (0.999)
Tamil Nadu	25.09 (0.757)	75.78 (0.247)	0.89 (0.992)	13.60 (0.868)	0.53 (0.994)	1.23 (0.988)	6.13 (0.947)	6.33 (0.954)	0.071 (0.999)

Uttar Pradesh	1.86 (0.992)	6.87 (0.951)	0.19 (0.999)	5.58 (0.949)	0.06 (0.999)	0.20 (0.998)	1.70 (0.992)	1.98 (0.998)	0.034 (0.999)
West Bengal	13.29 (0.876)	39.23 (0.620)	0.38 (0.997)	7.13 (0.934)	0.16 (0.998)	0.55 (0.995)	2.87 (0.980)	3.28 (0.985)	0.100 (0.999)
All India	4.29	12.74	0.63	9.01	0.32	0.69	3.67	4.04	0.120

Source: Compendium of Selected Indicators of Indian Economy, Lok Sabha Unstarred Starred Question No 469, Rajya Sabha Unstarred Question No 1733, Indian Telecommunication Statistics, 2004, Annual Report of Telecom Regulatory Authority of India, 2006-07, Lok Sabha Unstarred Question No 3162 & NSSO 61st Round

It is evident from Table 1 that the state of Maharashtra is better placed with respect to most of the indicators. The values in parenthesis in Table 1 serves as a position measure for a particular state with respect to an indicator assuming values between 0 and 1 wherein the closer the value to 0, the better is the position of the state as regard universal access of respective indicators. Such a conversion of the raw data helps not only in situating states as regard individual indicators but also helps in making valid comparison temporally as well as across states. For telephone, in 2001-02, the distance between the best state and worst state (i.e. Maharashtra and Bihar) is about 0.24 which in fact widens over time with a gap of 0.75 between the best and worst state of Chhattisgarh and Tamil Nadu during 2005-06. Similar observation can be made for other indicators as well over time and the magnitude of this widening gap is comparable across indicators. Similarly, for internet also there are not many differences across states in 2001-02. In 2005-06, the difference between the best and worse states has been increased due to improvement in top state. What is immediately discernible from the above table is that the urban dominated states like Maharashtra and Tamil Nadu lead in subscribing internet. It is observed that almost all the states (except Gujarat) have bettered their position in 2005-06 in comparison to 2001-02 for fixed telephone line. Unlike to other indicators the distance between best state and world state has not been increased much within the four years. From table 1 it is also easy to discern the condition of state wise proportion of households having computer. For computer also there are not many differences across the states.

By computing the correlation coefficients, we have tried to find out the relationship among different ICTs indicators. The estimated correlation coefficients between the levels of diffusion across four ICT indicators are reported in Table 2 and among the four indicators, fixed telephone lines is the only indicator which depicts the supply side. The estimated values of coefficient for

each indicator are significant. The state where diffusion of mobile is higher in the year 2002 is also high in 2006. In addition to that the coefficients of correlation between mobile phone and internet are strong and highly significant in both the years but have a small decrease in 2006 relative to 2002. It may be because of the extensive increase of mobile users than the internet users. Similarly, the correlation coefficients between direct exchange lines and mobile phones are highly significant and have increased in 2006 relative to 2002. Surprisingly a strong correlation is observed between direct exchange lines and internet subscribers. Further, it also reveals that the result is not only strong and highly significant but also a remarkable improvement in 2006 (0.76) contrast to 2002 (0.57). Here, it can be argued that, the demand for internet among people has been increased since direct exchange lines have been considered as one of the main infrastructure for accessing internet and broadband. The results also show that telephone in 2002 has significant on the diffusion of telephone in 2006 as correlation value is 0.99. Finally, it is worth noting that, there are strong and significant relationships among fixed telephones, mobiles and internet. But for mobile and telephone the coefficients have decreased in 2006 relative to 2002.

Table 2

Correlation among ICT indicators

	Mobile (02)	Mobile (06)	Internet (02)	Internet (06)	DEL (02)	DEL (06)	Telephone (02)	Telephone (06)
Mobile (02)	1.0000							
Mobile (06)	0.9140* (0.0000)	1.0000						
Internet (02)	0.8135* (0.0001)	0.6466* (0.0068)	1.0000					
Internet (06)	0.9129* (0.0000)	0.8067* (0.0002)	0.9124* (0.0000)	1.0000				
DEL (02)	0.8263* (0.0001)	0.9153* (0.0000)	0.5700** (0.0212)	0.7637* (0.0006)	1.0000			
DEL (06)	0.7723* (0.0005)	0.8344* (0.0001)	0.5025** (0.0473)	0.7261* (0.0014)	0.9681* (0.0000)	1.0000		
Telephone	0.6758* (0.0000)	0.5880* (0.0000)	0.8018* (0.0000)	0.8102* (0.0000)	0.5555** (0.0000)	0.4847*** (0.0000)	1.00000	

(02)	(0.0041)	(0.0166)	(0.0002)	(0.0001)	(0.0255)	(0.0571)		
Telephone (06)	0.6487* (0.0066)	0.5700** (0.0212)	0.7862* (0.0003)	0.7900* (0.0003)	0.5190** (0.0394)	0.4464*** (0.0830)	0.9964* (0.0000)	1.0000

Source: Calculated from table 1

Note: P- Values are in parentheses, *indicates significance at 0.01, **indicates significance at 0.05, ***indicates significance at 0.1

Against this background, we now examine the development of ICT across states and interstate differences in a precise manner. In the following section we have discussed the construction of ICT diffusion index by taking all the five indicators (Table 1).

6. ICT Diffusion across Indian States

To identify the state's position in respect to all ICT indicators, we formulated ICT diffusion index. The index measures the development of ICT in different states and the differences among the states with different levels of ICTs. As for most of the indicators, separate data are not available for Chhattisgarh and Jharkhand; we have considered sixteen states in this analysis. The benefit of constructing the composite index is that it captures the magnitude of the differences in the level of ICT development among the states and how it is evolving over time. Considering several indicators or one indicator but independently will not capture the overall dimensions of digital divide. In this sense, by using a single number the composite index can be applied to measure the differences. Here, it is important to note that, we have used 2004-05 data on percentage of households having computer in constructing both the year's index.

Table 3

State's Position in respect to all ICT indicators in the year of 2001-02 and 2005-06

States	Index (2001-02)	Rank	Index (2005-06)	Rank
Andhra Pradesh	0.294	7	0.213	10
Assam	0.026	15	0.007	15
Bihar	0.005	16	0.002	16
Gujarat	0.487	5	0.432	5
Haryana	0.269	9	0.332	6
Himachal Pradesh	0.256	10	0.275	9

Karnataka	0.368	6	0.313	7
Kerala	0.646	2	0.664	2
Madhya Pradesh	0.126	12	0.110	12
Maharashtra	0.962	1	0.857	1
Orissa	0.060	14	0.060	13
Punjab	0.507	4	0.491	4
Rajasthan	0.159	11	0.159	11
Tamil Nadu	0.602	3	0.580	3
Uttar Pradesh	0.061	13	0.053	14
West Bengal	0.279	8	0.285	8
Average Value	0.319		0.302	

Source: Calculated from Table 1

The ICT diffusion index values for two years (2001-02 & 2005-06) are reported in Table 3. The ranks are in descending order that is from best to worst. From the table it appears that Maharashtra tops in the ICTDI 2005-06, unchanged from its position in 2001-02. Similarly, states like Kerala, Tamil Nadu, Punjab, Gujarat, West Bengal, Rajasthan, Madhya Pradesh, Assam and Bihar retain their ranks. Subsequently, with significant improvements in its index score Haryana has gained three places, ranking 6th in 2005-06 contrast to 9th position in 2001-02. Himachal Pradesh and Orissa have also gained one place, to place 9th and 13th respectively in 2005-06. In contrast to these states, states like Andhra Pradesh, Karnataka and Uttar Pradesh have moved down from their places. Andhra Pradesh has moved down three places, to place 10th in 2005-06. Karnataka and Uttar Pradesh have moved down one place between 2001-02 and 2005-06, ranking 7th and 14th in 2005-06.

6.1: Measuring the Magnitude of Interstate Divide

From the above analysis, as expected, it is cleared that the diffusion of ICT is not same for all the states and the differences among the states persist. Though the ICT diffusion index provides an idea about state's position in respect to given ICT indicators, it does not explain the extent and magnitude of divide between states. This section provides a more detailed analysis on this, that is, whether the interstate divide is widening or shrinking. We have used the Orbicom methodology for this exercise. As discussed earlier, to get the exact value of digital divide, the

first step is to form the states into different groups by keeping the reference value. Here we have considered the overall averages for the two year as the reference value. In this paper, we have divided the sixteen states into three groups as high, medium and low (See Table 4). The overall average index value is 0.319 and 0.302 for the year 2001-02 and 2005-06 respectively. The states that score more than 0.319 are deemed as the high group states and remaining are the low group states. Again by estimating the average of low group states, we have found out the medium groups. Same procedure has been followed for 2005-06.

Table 4
Grouping of States

Group	No of States		2001-02		2005-06	
	2001-02	2005-06	Minimum Index Value	Maximum Index Value	Minimum Index Value	Maximum Index Value
High	6	7	0.368	0.962	0.313	0.857
Medium	5	4	0.159	0.294	0.159	0.285
Low	5	5	0.005	0.126	0.002	0.110

Source: Calculated from Table 3

For 2002, six states are coming under the high groups. The minimum index value in high group states is 0.368 and the maximum value is 0.962. Irrespective of these six states, five states are coming under medium and five for low groups. The respective minimum index values for medium and low are 0.159 and 0.005 while the maximum index values are 0.294 and 0.126. Similarly, for 2005-06, by using the overall average index value (0.302), the states are grouped into high, medium and low. In 2005-06, seven states are coming under high groups and 0.313 is the minimum and 0.857 is the maximum index value in this group. However, four and five states belong to medium and low groups.

The average index values for the three groups are presented in table 5. The immediate observation from table 5 is that the index value for all the groups has decreased in 2006 compared to 2002. Second, the difference between the absolute value for all the groups has been decreasing. Third, the percentage change shows that the low groups made more progress and medium groups grew less than the other two.

Table 5
Average Index Value for each Group

Group	IDI Value (2001-02)	IDI Value (2005-06)	Percentage Change
High	0.595	0.524	11.93
Medium	0.252	0.233	7.54
Low	0.056	0.047	16.07
All States	0.319	0.302	5.33

Source: Calculated from Table 3

To find out whether the differences between the states is growing or shrinking, changes in the digital divide over time were computed by subtracting the 2005-06 normalized index values from the 2002 corresponding values (see Table 6). To get the exact figure of digital divide, we have deducted the low groups from the high groups. The second column of table 6 shows the difference between the three groups for respective years. In addition, column 3 provides the final result of changes in digital divide, i.e. the difference between the 2001-02 and 2005-06.

Table 6
Magnitude of Interstate Divide

Difference ²¹	Magnitude of the Differences		Changes in the Digital Divide
	2001-02	2005-06	2002-2006
High – Low	0.511	0.478	0.033
High – Medium	0.325	0.291	0.034
Medium - Low	0.185	0.187	-0.002

Source: Calculated from Table 5

Looking at this table, the main results can be summarized that the magnitude is remaining large between high groups and medium groups than the other two. From all the three groups, the magnitude is less between low and medium. For medium and low groups, the difference in the magnitude of the digital divide is -0.002 which means that the digital divide between those two

²¹ The differences have been calculated first within the year then between the years.

groups is slightly declining. As the changes in digital divide are coming positive between rest two groups, it implies that the digital divide among the groups is widening.

To be able to bridge this interstate difference, it is important to know what factors explain the differences across states in ICT diffusion. Using the Gompertz model of technology diffusion, the following section investigates the factors that explain the diffusion of internet, fixed telephone and mobile phone

7. Empirical Results for Determinants of ICT Diffusion

The results from the model exploring the factors that influence ICT diffusion across 16 major Indian states are reported in table 7 to 9. The following tables present the results of linear least squares estimation of Gompertz equation 3. To get the determinants for each indicator, three equations are estimated. All equations include a constant term and the relevant ICT indicator in 2002 (in log).

Table 7
Diffusion of Internet

Dependent Variable →	$\ln ICT_{i,t06} - \ln ICT_{i,t02}$		
Independent Variable ↓	Model 1	Model 2	Model 3
Speed of Diffusion	.517*** (.068)	.527*** (.066)	.518*** (.00001)
Constant	-.255 (.336)	-.948 (.613)	-.422 (1.237)
Per Capita Income	.00003*** (9.68)	.00003*** (9.37)	.00003*** (.00001)
Percentage of Households having Computer	.147** (.069)	.148** (.067)	.150* (.075)
Density of Population		.118 (.088)	
Adult Literacy			.046 (.333)
R²	0.86	0.88	0.86

<i>Adjusted R²</i>	0.82	0.84	0.81
Number of Observations	15	15	15

Source: Same as in table 1

Note: Standard errors are in parentheses. *significant at 10%, ** at 5% and ***at 1% level

Table 7 displays the determinants of diffusion of internet across Indian states. The first column displays the estimation results for the basic model in which the explanatory variables are per capita income and households having computer. As mentioned earlier, we have not included ICT access costs because our analysis is focused within the country and therefore, the access costs are almost same for all the states. Our post diffusion level is a function of per capita income and vector X and Z (equation-2), where vector X includes the supply side factors and vector Z includes other social indicators. The results show that both explanatory variables are statistically significant and have the expected sign. The second model extends the first model by including in it variables measuring density of population. But the results show that density of population does not have any explanatory power over the internet diffusion. Since, the level of education contributes basic literacy and better educated workers may have a comparative advantage with respect to learning and implementing new technologies, here we have added the adult literacy rate for education and the variable enters in logarithmic form. However, result reveals that adult literacy rate is not a statistically significant predictor of the diffusion of internet. It can be argued that adult literacy rate is not the best measure of educational attainment of these states, but our experiments with other educational variable, such as the tertiary enrolment ratio and educational index (adult literacy rate, secondary enrolment ratio and tertiary enrolment ratio) were not any more successful. Consequently, our conclusion is that education does not seem to have any predictive power in explaining internet diffusion is consistent with the findings of Hargittai (1999), Norris (2001), Kiski & Pohojola (2002) and Lutz (2003). The speed of adjustment $\alpha = 0.517$ suggests that the diffusion of internet will increase from $ICT_{ij} / ICT_{ij}^* = 0.1$ to $ICT_{ij} / ICT_{ij}^* = 0.9$ in about 30 years.

The estimation of using fixed telephone as the ICT indicator is detailed in table 8. It is observed that all the models fails to capture the process of diffusion since the coefficient on the lagged value of this variable is not significant. This may be due to wide substitution of mobile phones for fixed telephone. Therefore, the more appropriate indicator for communication technologies

would be sum of mobile and fixed telephones. Though, the per capita income is coming significant at 5 percent, a negative relation is observed between per capita income and fixed telephone. While the supply side factor, number of telephone exchanges does not have explanatory power over the telephone. Like internet, in model 2, we have extended our model by including density of population. The results show that density of population has the significant influence on diffusion of telephone. To see whether education has significant impact on telephone diffusion, we have added adult literacy rate as an explanatory variable in model 3. Like to internet diffusion, telephone diffusion appears to be not influenced by adult literacy or any other education variables.

Table 8
Diffusion of Telephone

Dependent Variable →	$\ln ICT_{ijt06} - \ln ICT_{ijt02}$		
Independent Variable ↓	Model 1	Model 2	Model 3
Speed of Diffusion	.017 (.057)	.039 (.056)	.047 (.073)
Constant	1.964*** (.467)	1.241** (.570)	3.662*** (1.334)
Per Capita Income	-.00001** (6.37)	-.00001* (6.05)	-.00001** (6.16)
No of Telephone Exchanges	-.063 (-.060)	-0.393 (.056)	-.133 (.077)
Density of Population		.087* (.046)	
Adult Literacy			-.319 (.236)
R²	0.64	0.73	0.69
Adjusted R²	0.55	0.63	0.58
Number of Observations	16	16	16

Source: Same as in table 1

Note: Standard errors are in parentheses. *significant at 10%, ** at 5% and ***at 1% level

Table 9 exhibits the results from estimating the model where ICT is represented by the number of mobile users per 100 people. All three equations have captured the diffusion process as α is highly significant. From model 1, it is observed that other than the number of towers per capita income and constant are coming significant. However, in model 3 of table 1, we have included adult literacy. But similar to our earlier two conclusions, adult literacy or any education indicator does not have influence on mobile diffusion. The speed of adjustment $\alpha = 0.636$ suggests that the diffusion of internet will increase from $ICT_{ij} / ICT_{ij}^* = 0.1$ to $ICT_{ij} / ICT_{ij}^* = 0.9$ in about 39 years.

Table 9
Diffusion of Mobile

Dependent Variable →	$\ln ICT_{tj06} - \ln ICT_{tj02}$		
Independent Variable ↓	Model 1	Model 2	Model 3
Speed of Diffusion	.636*** (.081)	.619*** (.094)	.635*** (.085)
Constant	1.997*** (.442)	2.421** (.952)	2.173* (1.115)
Per Capita Income	.00002* (.000)	.00001 (.000)	.00002* (.00001)
Number of Towers	-.002 (.038)	-.016 (.048)	-.004 (.041)
Density of Population		-.043 (.085)	
Adult Literacy			-.043 (.253)
R^2	0.89	0.90	0.89
Adjusted R^2	0.87	0.86	0.86
Number of Observations	16	16	16

Source: Same as in table 1

Note: Standard errors are in parentheses. *significant at 10%, ** at 5% and *at 1% level**

8. Conclusion:

To sum up, the paper is broadly focused on the ICT diffusion across selected Indian states and interstate differences. In second stage we have tried to find out its determinants. To find out the interstate differences, we have constructed the ICT diffusion index by using data on telephone, internet, mobile and direct exchange lines per hundred population and percentage of households having computer. In addition to that, the paper has also investigated the factors, that determine the diffusion of ICT indicators by using the Gompertz model of technology diffusion with data on telephone, internet and mobile per hundred population.

However, the overall results show that among all the indicators, diffusion of mobile is more in comparison to other indicators. A comparison of ICT diffusion index results for 2002 and 2006 illustrates that, by retaining their position, the top ICT performers are Maharashtra, Kerala, Tamil Nadu, Punjab and Gujarat in both the years. The index also shows that states like Andhra Pradesh, Karnataka and Uttar Pradesh have come down from their positions. In contrast to these states, Haryana and Himachal Pradesh have gained in their positions. Generally speaking, all states have improved in their ICT index scores (except West Bengal and Kerala) during the four-year period but huge differences remain across the states. Further, it is also found that, the interstate divide among the states is widening over the period.

In second stage, the paper has examined the determinants of ICT diffusion. It is observed that per-capita income is the most important factors which determine the diffusion of ICT. Among the three indicators for telephone, though income is coming significant but it enters with negative sign. This may be due to the fact that, telephone is considered as old ICT and it is already replaced by mobile phones. Further, it is observed that density of population has positive impact diffusion of fixed telephone. Though, it is argued that technology is skill bias and education may have the positive impact on ICT diffusion, somewhat unexpectedly education does not have significant impact on ICT diffusion in our analysis.

However, it is a well known fact that there is data constraint on ICT indicators for developing countries as well as within the countries. Since, there are no existing studies regarding the determinants of ICT diffusion in India, our attempt is to give the state wise picture. One avenue

for future research is to study in detail the diffusion all ICT indicators. For instance, in our study, we have not included the diffusion of personal computers, which is one of the important ICT indicators in the economy. Another opportunity is to study more on internet related indicators like determinants and diffusion of internet hosts per hundred inhabitants. In addition to that, as the use of internet is widely spreading among the youth as well as voice over internet protocol is increasing; the separate study can be done for the diffusion of internet and factors affecting the growth of internet.

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