

Across Indian States: Diffusion and Determinants of Information and Communication Technologies

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Outline of the Paper

- Introduction
- Analytical Framework
- Data Sources
- Methodology
- ICT diffusion in selected Indian States and construction of ICT Diffusion Index
- Magnitude of Interstate Divide
- Determinants of ICT Diffusion
- Summary and Conclusion

Objective

- To examine the extent of ICT diffusion across the selected states and find out the interstate divide.
- Second, to examine the determinants of ICT diffusion across the states.

Analytical Framework

- Theoretical Background
- Brown (1981)
 - a. Adoption Perspective
 - b. Market and Infrastructure Perspective
 - c. Economic History perspective

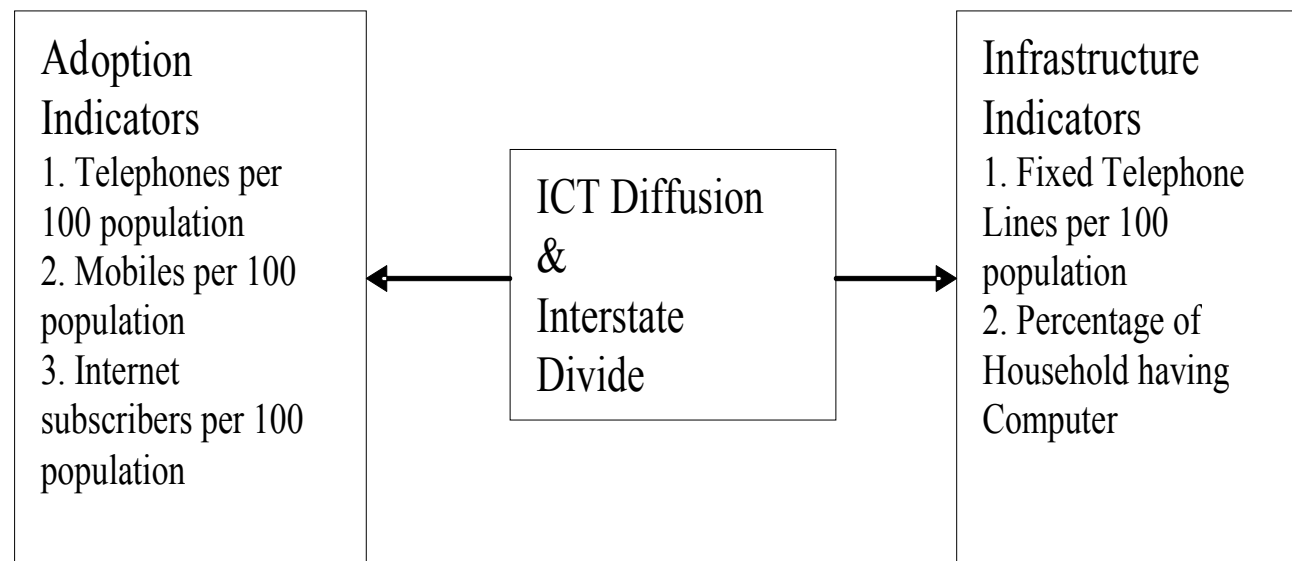
Empirical Literature

- Hargittai (1999) : The difference in 18 OECD countries. Other than the GDP, it is the competition between telecom service providers which has the significant explanatory power.
- Norris (2000): Internet penetration in a larger group of 179 countries. Besides GDP per capita, regional dummies and the share of R & D expenditure in GNP turned out to be statistical significant.
- Kiski & Pohojola (2002): Study the global pattern of internet diffusion and the factors determine technology diffusion across the countries. Besides the OECD countries, they have carried out the estimation for larger sample countries. The basic findings is that GDP per capita and internet access costs explain the best observed growth.
- Balamoune – Lutz (2003):Using data from developing countries, examines the diffusion of four ICT indicators (internet hosts, internet users, personal computers and mobile phones) and its link with other socio economic indicators.

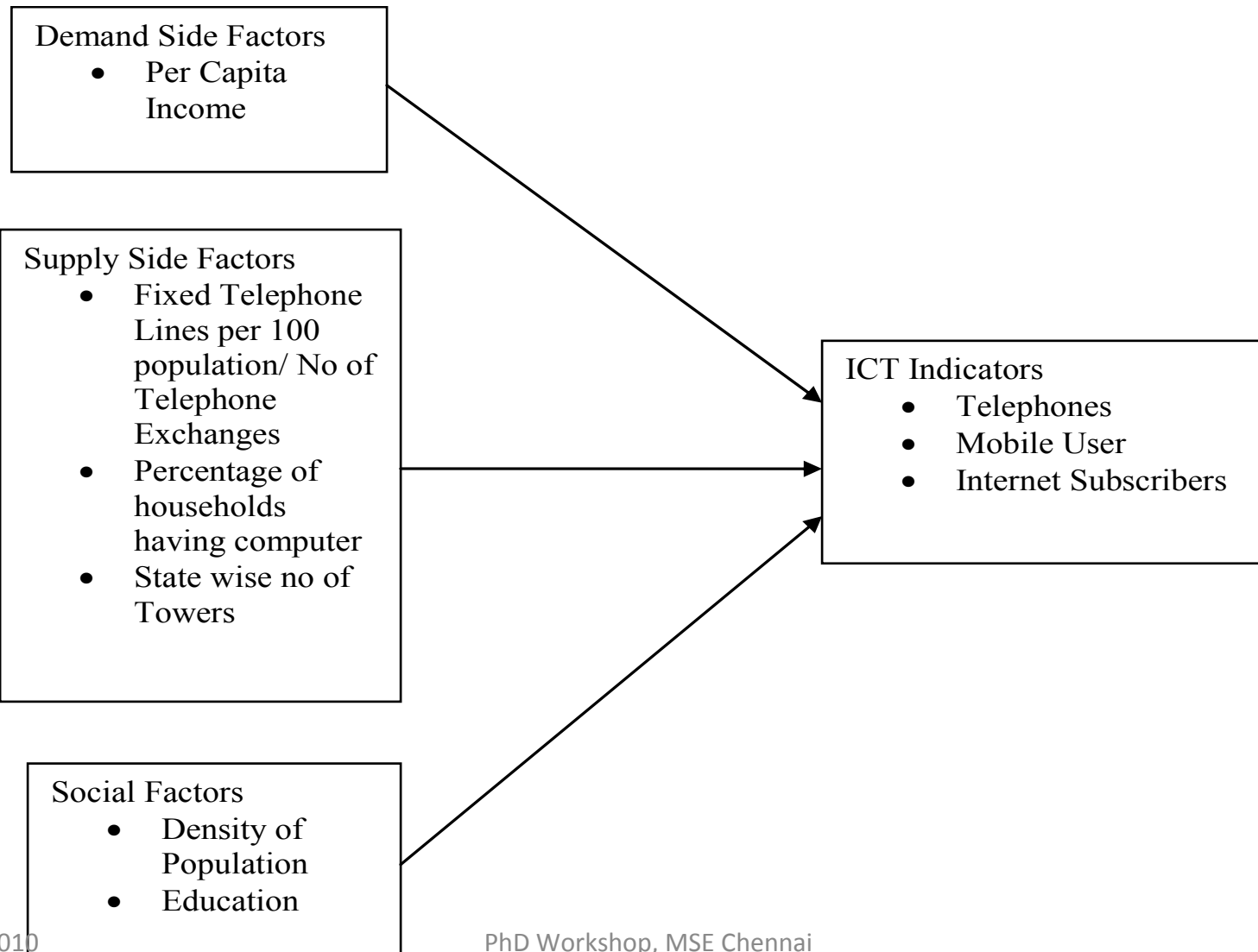
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- Robison and Crenshaw (2001) examine the level of economic development, political openness, mass education, and the presence of a sizeable tertiary or services sector as drivers of internet diffusion. By a cross sectional analysis of per capita internet penetration for 74 countries over 1995 – 1999, they found that the most significant explanatory variables are development level, political freedom, and education.
- Guillen and Suarez (2001): study the number of internet hosts and the number of internet users per capita, by using a set of independent variables in a cross section of 141 countries in 1998-99. 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.

Empirical Framework



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Data & Methodology

- Telephones per 100 populations, mobile user per 100 populations, internet subscribers per 100 populations, fixed telephone lines per 100 populations and proportion of households with a computer are used as the alternative indicators for ICT adoption.
- Data are for two years: 2001-02 & 2005-06

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- Data Source: Indian Telecommunication Statistics, 2004 (2001-02 state wise internets per 100 population and fixed telephone lines per 100 population), Ministry of Statistics and Programme Implementation (State wise telephones per 100 population), Annual Report of Telecom Regulatory Authority of India, 2006-07 (2005-06 state wise fixed telephone lines per 100 population), Lok Sabha Unstarred Question No. 3162 (2005-06 internet subscribers) and Starred Question No. 469 (2005-06 mobile subscribers), Rajya Sabha Unstarred Question No 1733 (2001-02 mobile users) and NSSO 61st Round (Households with a computer).

Methodology

- The analysis will be three fold analysis
- To measure the interstate differences, ICT Diffusion Index (ICTDI) has been constructed
- First the proportions are normalized by using the formula

$$\frac{\text{Actual} - \text{Minimum}}{\text{Range}}$$

- Symbolically

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

Here IDI is the ICT Diffusion Index

w_i is the weighted average

NP_i is the normalized proportion

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- Orbicom (2003) Methodology; later ITU (2009)
 - I. Grouping of States
 - II. Computation of average index values for each group
 - III. Normalization of 2002 average index values
 - IV. Subtracting the normalized 2002 values from corresponding 2006 values

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- Empirical Model: The diffusion of the ICT is analyzed 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 by **Baliamoune-Lutz** (2003). To find out the determinants of ICT diffusion across the states, **GOMPERTZ** Model of technology diffusion has been used.
- The Gompertz model of diffusion specifies the rate of change in the ICT adoption as

$$\ln ICT_{ijt} - \ln ICT_{ijt-1} = a_{ij} (\ln ICT_{ij}^s - \ln ICT_{ijt-1}) \dots \dots \dots (1)$$

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- Here 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, α_{ij} represents speed of adjustment taken to be constant in our analysis
- The equilibrium level of ICT adoption will be a function of at least the basic demand and supply side variables.

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- With demand and supply factors, the paper has considered other socio economic variables for equilibrium or targeted level of ICT. The equation for the equilibrium 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 and Z_{ijt} is describing the other socio economic factors in state (j).

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- The estimable equation is obtained by inserting equation 2 into 1:

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

- 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 and ϵ is the error term .

Table 1: State wise Different ICT performance of different ICT Indicators

ICT Indicators →	Telephone		Mobile		Internet		DEL		% HHS having Computer
	States ↓	2001-02	2005-06	2001-02	2005-06	2001-02	2005-06	2001-02	
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: Special Issue of Time Series Data, Volume 1, Lok Sabha 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

Table 2: Result of ICT Diffusion Index

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	

Table 3: Measuring the magnitude of Interstate Differences over the time

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

Table 4: 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

Table 5: Magnitude of Interstate Divide

Difference	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 4

Table 6: Diffusion of Internet

Dependent Variable →	$\ln ICT_{ij06} - \ln ICT_{ij02}$		
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)
R^2	0.86	0.88	0.86
Adjusted R^2	0.82	0.84	0.81
Number of Observations	15	15	15

Table 7: Diffusion of Telephone

Dependent Variable →	$\ln ICT_{ij06} - \ln ICT_{ij02}$		
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)
R^2	0.64	0.73	0.69
Adjusted R^2	0.55	0.63	0.58
Number of Observations	16	16	16

Table 8: Diffusion of Mobile

Dependent Variable →	$\ln ICT_{ij06} - \ln ICT_{ij02}$		
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

Summary and Conclusion

- To sum up, the paper is broadly focused on the ICT diffusion across selected Indian states and its determinants.
- 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 Utter Pradesh have come down from their positions. In contrast to these states, Haryana and Himachal Pradesh have gained in their positions.

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- Further, it is also found that, the interstate divide among the states is widening over the period. From all these three groups, the magnitude of differences between medium and low group is -0.002, which implies that digital divide between these two groups are slightly declining.
- 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 and all the models fail to capture the process of diffusion. This may be due to wide substitution of mobile phones for fixed telephones.

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- For internet only, supply side factors have the statistically significant influence on the diffusion of internet.
- Further, it is observed that density of population has positive impact diffusion of fixed telephone.
- Though, it is argued in literature 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.
- 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 speed of adjustment $\alpha = 0.636$ suggests that the diffusion of mobile phone will increase from $ICT_{ij} / ICT_{ij}^* = 0.1$ to $ICT_{ij} / ICT_{ij}^* = 0.9$ in about 39 years.

THANK YOU