Measuring Access and Usage of Digital Services in India: Towards Construction of a Comprehensive Index

38th Annual conference of

Indian Association for Research in National Income and Wealth (IARNIW)

Sub theme: *Identification and Measurement of Digital Economy*

Submitted by

Arindam Laha, Ph.D (Economics)
Associate Professor and Head
Dept. of Commerce
The University of Burdwan
West Bengal, India
Life Member of IARNIW
Cell: 9474601525
Email: alaha@com.buruniv.ac.in

&

Sumit Kumar Maji, Ph.D (Commerce)
Assistant Professor
Dept. of Commerce
The University of Burdwan
West Bengal, India
Cell: 9475939809
Email: 2009sumitbu@gmail.com

Measuring Access and Usage of Digital Services in India:

Towards Construction of a Comprehensive Index

Abstract

The importance of 'Digital Economy' in fostering economic growth and development in the context of present informational age can never be undermined. In this context the study makes a modest attempt to highlight the access and usage of digital services in Asia-Pacific region with a special reference to Indian Economy. Natural grouping of countries suggests that majority of the South Asian countries (India is no exception) are clustered in low access- and low usage category. In addition, the study presents an overview of the state of Digital Economy Infrastructure (DEI) of major Indian States by constructing DEI Index and the changing scenario of such infrastructure during 2011, 2014 and 2017. For this purpose all the necessary secondary sources of data were collected from various reports of Measuring the Information Society and Telecom Statistics in India. 'Use' (demand side) and 'Access' (supply side) dimensions were taken into consideration to measure a comprehensive index of DEI. 'Use' dimension was determined by considering the Fixed Broadband Density and Mobile Broadband Density while Wireline Tele-density and Wireless Tele-density were used to gauge the 'Access' dimension. Principal Component Analysis was first applied to obtain the data driven factor loadings for each of the parameters under 'Use' and 'Access' dimensions and such loadings were scale normalized using OECD Index construction methodology to get the relative weights to get the final 'Use' and 'Access' sub-indices. In order to analyse the changes in the relative positions of major Indian States in terms of such 'Use' and 'Access' dimensions, scatter plots over the period of study were used. Finally, DEI Index was computed using normalized inverse Euclidean distance of the 'Use' and 'Access' dimension indices from their ideal values. Empirical evidences across Indian states suggests that Punjab, Kerala, Tamil Nadu and Karnataka has consistently performed well on the infrastructure of digital economy, whereas the infrastructure was found to be poor for Bihar, Assam, Orissa, Uttar Pradesh and Madhya Pradesh during the entire period of study. However, a significant improvement in the infrastructure of digital economy is observed for Himachal Pradesh, Jammu& Kashmir, Gujarat and North Eastern States.

Key Words: ICT, Digital Economy, DEI Index, Asia-Pacific, Indian states.

JEL Classification: A29; I29, O33; C39

Measuring Access and Usage of Digital Services in India:

Towards Construction of a Comprehensive Index

Introduction:

In the process of transforming an economy, digitalization encompasses a wide range of new applications of information technology in business operations (IMF, 2018). However, measuring digital economy is often difficult as there is no consensus in defining "digital economy" or "digital sector". Following IMF, "digital economy" is sometimes defined narrowly as online platforms, while in a broad sense; all activities that use digitized data are part of the digital economy. The spectrum of digital economy encompasses wide range of ideas such as e-commerce, e-governance, e-payment system, e-banking, e-knowledge processing, internet banking, mobile banking, payment wallets etc. (Quah, 2003; Chakravorti et al, 2016).

Existing research on measurement of the digital economy considered its contribution in GDP and productivity statistics (Bukht & Heeks, 2017; Watanabe et al, 2018; Ahmad & Ribarsky, 2018). However, problems relating to measuring the contribution of digital economy in the growth of the economy often faced three categories of problems: the conceptual boundaries of GDP, prices of new and improved digital products, and unrecorded digital sector output (IMF, 2018). In addressing the problem, G20 toolkit for measuring digital economy developed a methodological framework for digital transformation. The framework compiled indicators, which were earlier developed by various international organizations[1]. Indicators are broadly classified in four main themes: infrastructural, empowering society, innovation and technology, and jobs and growth. In this paper, an attempt is made to measure access and usage indicators of digital services relating to infrastructural and empowering society in the context of Asia-Pacific countries with special reference to Indian economy. Specifically, this paper seeks to examine cross-country evidences in the access and usage of digital services in Asia-Pacific region to identify the relative position of Indian economy. In addition, it also analyses the inter-state variation in Digital Economy Infrastructure in India.

Data Sources & Methodology:

The study utilizes secondary sources of data, which are collected from various sources such as Measuring the Information Society Report (published by International Telecommunication Union, ITU[2], United Nations), Telecom Statistics India-2018 (published by Economics

---

[1] Organizations like International Labour Organization (ILO), the International Monetary Fund (IMF), the International Telecommunication Union (ITU), the Organisation for Economic Cooperation and Development (OECD), the United Nations Conference on Trade and Development (UNCTAD) and the World Bank.

Research Unit – Statistics, Department of Telecommunications, Ministry of Communications, Government of India), Telecom Sector in India: A Decadal Profile 2012 (published by Telecom Regulatory Authority of India).

In the Report on Measuring the Information Society, as published by ITU-United Nations, access (captures ICT readiness, and includes five infrastructure and access indicators), usage (captures ICT intensity, and includes three intensity and usage indicators) and skill sub-indices (captures capability or skills) are considered in measuring ICT development index (IDI). Skill sub-index (as a proxy indicator) retains 20% weight in the overall index, while access and usage are given 40% weightage for each sub-index. In this study, access and usage dimensions are only considered for clustering Asia-Pacific countries. Individual indicators for deriving access and usage sub-index, as highlighted in the conceptual framework for constructing ICT development index[3], are mentioned in table 1. On the other hand, While constructing the DEI Index, both the 'Use' (proxy of the demand side dimension) and 'Access' (proxy of supply side dimension) indicators were taken into account for the years 2011, 2014 and 2017 across major Indian states.

Table 1: Individual Indicators for Measuring Access and Usage of Digital Services

Dimension	Indicators used in Asia-Pacific region	Indicators used in Indian states	Data sources
Access	-fixed telephone subscriptions, -mobile-cellular telephone subscriptions, -international Internet bandwidth per Internet user, -households with a computer, and -households with Internet access	- wire line tele-density per 100 inhabitants - wireless tele-density per 100 inhabitants	-ITU database for Asia Pacific region - Telecom Statistics India-2018 and Telecom Sector in India for Indian states
Usage	-individuals using the Internet, -fixed broadband subscriptions, and -mobile-broadband subscriptions	- fixed broadband density per 100 inhabitants and -mobile broadband density per 100 inhabitants	-ITU database for Asia Pacific region - Telecom Statistics India-2018 and Telecom Sector in India for Indian states

In the construction of DEI index, the following steps are considered:

[2] ITU is a specialised agency of United Nations for disseminating data on ICTs. It is considered as a global source of ICT statistics.

[3] The ICT Development Index (IDI): conceptual framework and methodology, Retrieved from https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis/methodology.aspx

Step I: In constructing the 'Use' and 'Access' sub-indices data driven relative weights were determined using Principal Component Analysis (PCA) by following OECD methodology. In the first instance, the factor loadings were determined using PCA and later on such factor loadings were scale-normalized as per OECD guidelines to get the relative weights for the parameters to get the 'Use' and 'Access' sub-indices.

Step 2: In the construction of DEI Index, the 'Use' and 'Access' dimension indices for the ith dimension,, is first computed by the using the formula() where = actual value of dimension i, = minimum value of dimension i, = maximum value of dimension i. Minimum and maximum values of each dimension is empirically determined from the given dataset[4]. Higher the value of, greater would be the achievements of the country in dimension i.

Step 3: DEI Index was computed using normalized inverse Euclidean distance of the 'Use' and 'Access' dimension indices from their ideal values. In other words, DEI Index is measured by the normalized inverse Euclidean distance of the position of the states from the ideal situation. Algebraically,

On the basis of 43 individual country performance, a natural grouping of countries in the Asia-Pacific region is made by using clustering-a widely used data mining method (Ramachandran et al, 2018). Selection of 43 countries is solely based on the availability of data for all the indicators of access and usage dimensions in 2017. Based on Euclidian distance method, hierarchical and non-hierarchical (e.g. k-means clustering) cluster methods are employed.

Results & Discussion:

Access and Usage of Digital Services: Asia-Pacific Experience

Asia-Pacific region marked a distinct regional variation in the ICT development, specially in the access (left panel) and usage (right panel) of digital services (see appendix table A.1). It truly reflects the stark differences in the level of economic development in the region (ITU, 2014). Korea, Japan, Singapore, Cyprus, excel in the progress of digital transformation and comparable to be developed country average. On the other hand, South Asian countries (along with Palestine, Cambodia, Lao PDR, Syria, and Palestine) lie below the global average.

---

[4]The methodology of using data driven minimum and maximum values in our study, in fact, deviates from UNDP Goal Post Method of calculating prefixed values for minimum and maximum values.

In this paper, we simply examine natural groupings of countries in Asia-Pacific region, based on their relative positioning in access and usage of digital services. Dendrogram plots relating to hierarchical cluster are presented in appendix figures A.2 and A.3. In k-means cluster, three clusters out of 43 countries are purposively chosen depending on low, medium and high level of development. Country level natural grouping is made for access and usage dimensions separately. In other words, depending on the relative position of the countries, six clusters are grouped under low access, medium access, high access, low usage, medium usage, and low usage. From there a distribution of countries in access and usage dimensions is tabulated in a bi-matrix (table 2). It highlights the fact that majority of the countries lies in diagonal elements: low access-low usage (11 countries), medium access-medium usage (9), and high access-high usage (8) trajectories. It also demonstrates a variation in individual country experiences from this general trend: five countries in medium access-low usage category, and nine countries in high access-medium usage category. Majority of the South Asian countries (except Sri Lanka and Maldives) experiences a similar kind of development in digital economy. The relative positive of Indian economy (low access-low usage) is no exception in this regard.

Table 2

Classification of Asia Pacific Countries in Access and Usage Dimensions (k-means Cluster)

Usage → Access ↓	Cluster 1 (Low usage)	Cluster 2 (Medium usage)	Cluster 3 (High usage)
Cluster 1 (Low access)	Afghanistan, Bangladesh, Bhutan, Cambodia, India, Myanmar, Nepal, Pakistan, Palestine, Timor-Leste, Lao PDR		
Cluster 2 (Medium access)	Indonesia, Philippines, Sri Lanka, Syria, Kyrgyzstan	Armenia, China, Georgia, Jordan, Maldives, Mongolia, Thailand, Turkey, Uzbekistan	
Cluster 3 (High access)		Azerbaijan, Brunei Darussalam, Kazakhstan, Kuwait, Lebanon, Malaysia, Oman, Russia, Saudi Arabia	Bahrain, Cyprus, Israel, Japan, Qatar, Singapore, Korea (Rep.) United Arab Emirates (UAE)

Access and Usage of Digital Services: Inter-State Experience in India

Table 3 highlights the position of the major Indian states during the period from 2011 to 2017 in accordance with 'Use' and 'Access' dimensions. Graphical representation of these dimensions has also been presented in Figure A.4 and A.5 in Appendix. The analysis of Table 3 clearly suggests that Punjab and Bihar obtained top and bottom positions respectively in terms of 'Use' dimension during 2011. Although Punjab lost its top position in 'Use' parameter during 2014 but again the state was found to be at the top during 2017. However, in terms of 'Access' dimension the state of Kerala was observed to be at the top during all the three years under observation. Holding the top position in 'Access' dimension and consistent good performance in 'Use' dimension (2nd position in 2011 and 2014 and 3rd position in 2017) during the period of study has enabled the state of Kerala to be most advanced state in terms of DEI in all the years under observation.

Table 3
Ranking of the Major Indian States according to 'Use' & 'Access'

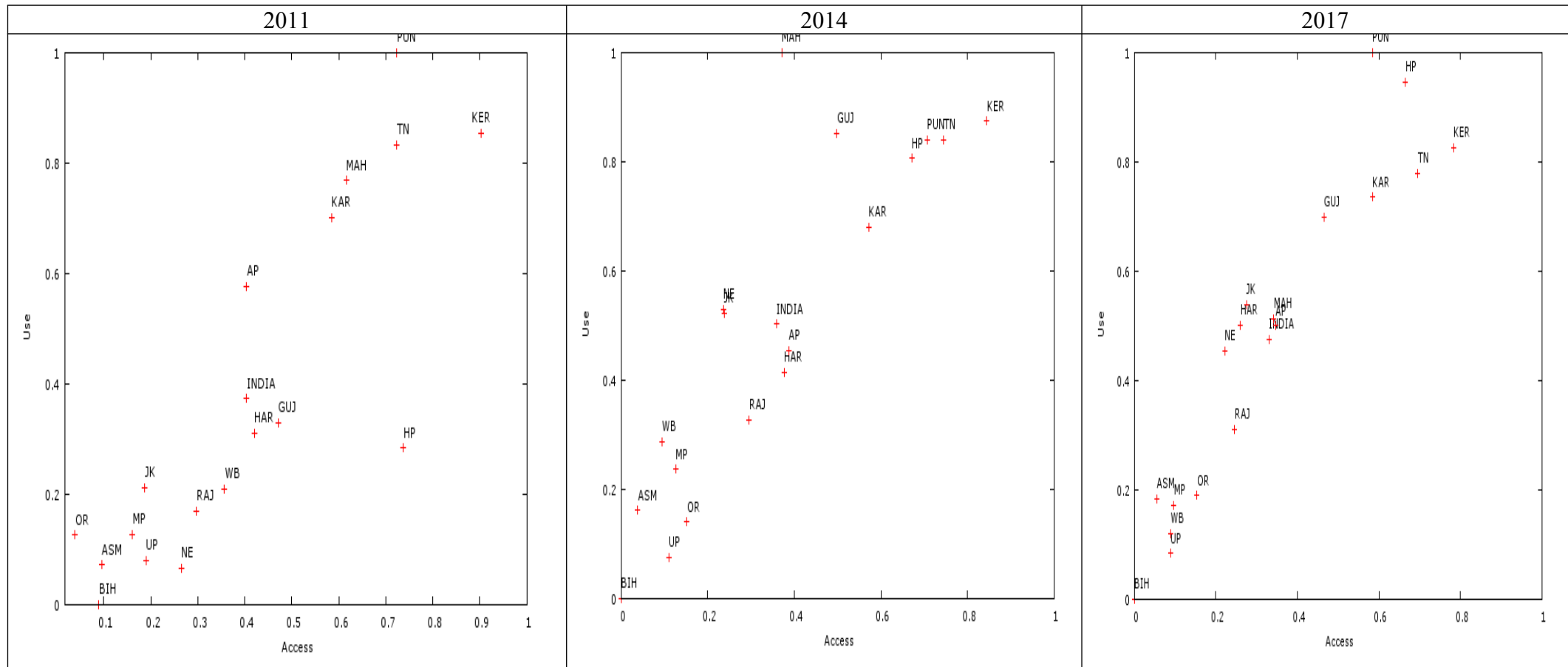| States	2011				2014				2017			
	Use	Rank	Access	Rank	Use	Rank	Access	Rank	Use	Rank	Access	Rank
AP	0.58	6	0.4	9	0.45	10	0.39	7	0.5	10	0.35	7
ASM	0.07	16	0.1	16	0.16	15	0.04	17	0.18	14	0.06	17
BIH	0	18	0.09	17	0	18	0	18	0	18	0	18
GUJ	0.33	7	0.47	7	0.85	3	0.5	6	0.7	6	0.47	6
HAR	0.31	8	0.42	8	0.41	11	0.38	8	0.5	9	0.26	10
HP	0.28	9	0.74	2	0.81	6	0.67	4	0.95	2	0.66	3
JK	0.21	10	0.19	14	0.52	9	0.24	11	0.54	7	0.27	9
KAR	0.7	5	0.58	6	0.68	7	0.57	5	0.73	5	0.58	4
KER	0.85	2	0.9	1	0.87	2	0.84	1	0.82	3	0.78	1
MP	0.13	13	0.16	15	0.24	14	0.13	14	0.17	15	0.1	14
MAH	0.77	4	0.62	5	1	1	0.37	9	0.51	8	0.34	8
NE	0.07	17	0.27	12	0.53	8	0.24	12	0.45	11	0.22	12
OR	0.13	14	0.04	18	0.14	16	0.15	13	0.19	13	0.15	13
PUN	1	1	0.72	3	0.84	5	0.71	3	1	1	0.58	5
RAJ	0.17	12	0.3	11	0.33	12	0.3	10	0.31	12	0.25	11
TN	0.83	3	0.72	4	0.84	4	0.75	2	0.78	4	0.7	2
UP	0.08	15	0.19	13	0.07	17	0.11	15	0.08	17	0.09	15
WB	0.21	11	0.36	10	0.29	13	0.09	16	0.12	16	0.09	16
IND	0.37	-	0.4	-	0.5	-	0.36	-	0.47	-	0.33	-
Source: Author's own calculation												

7

In fact most of the Southern states were found to be outperforming other states in both the dimension over the period of study. For example it can be observed that the value of 'Use' of Karnataka had improve to 0.73 in 2017 from 0.70 in 2011 with overall DEI Index value increasing from 0.64 to 0.65 during 2011 and 2017 respectively. The position of DEI was also found to be in a very strong position in the case of Tamil Nadu. The state of Tamil Nadu was able to maintain a very high value of 'Use' and 'Access' during 2011 such as 0.83 and 0.72 respectively, 0.84 and 0.75 respectively during 2014 and 0.78 and 0.70 respectively in 2017. Amongst the southern states, the state of Andhra Pradesh was found to be an odd state out as the values of 'Use' and 'Access' dimensions were found to be much lower than that of other southern states during the entire period of study such as in 2011 the 'Use' value was 0.58 and 'Access' value was 0.40 and the same were 0.50 and 0.35 respectively in 2017. As far as the North Eastern states cluster (excluding Assam) is concerned, the 'Access' dimension was found to be 0.24 on average during the period of study whereas the same was found to be very poor for Assam exclusively (0.07). However, there had been a significant improvement in terms of the 'Use' parameter for the states in North East cluster i.e. 0.07 in 2011 to 0.45 in 2017. Although, such value for the state of Assam also increased (from 0.10 in 2011 to 0.18) but still the state was amongst the poor performing states following 'Use' dimension. The improvement in overall DEI rank of North East cluster from 13th in 2011 to 10th in 2014. The positions of eastern states (Bihar and West Bengal) were also found to be in a poor condition during the period of study. Bihar has consistently been at the bottom for 'Use' both in 2014 and 2017. Like 'Use' dimension, Bihar was again found to at the bottom even in the 'Access' parameter during both in 2014 and 2017. The 'Use' and 'Access' scores for West Bengal had declined from 0.21 (11th rank) and 0.36 (10th rank) respectively in 2011 to 0.12 (16th rank) and 0.09 (16th rank) respectively in 2017. Likewise, the supply side of DEI as well as the demand side of DEI was found to be poor in the states in central India (Uttar Pradesh and Madhya Pradesh). However, the picture is opposite if we look at the Western state such as Gujarat. There had been a very significant improvement in terms of people using the DEI for Gujarat as evidenced from the increase the 'Use' value from 0.33 in 2011 to 0.70 during 2017. However it must be pointed out that the state did not experienced similar improvements in access dimension during the period of study leaving a scope for further improvement in this domain. In contrast, decline in both 'Use' and 'Access' dimensions (from 0.77 and 0.62 respectively in 2011 to 0.51 and 0.34 respectively in 2017) over the

period of study could be observed from another western state, Maharashtra. Apart from Punjab which had been one of the top ranking states in both 'Use' and 'Access' amongst the Northern states, tremendous improvement was observed in case of Himachal Pradesh and Jammu & Kashmir. The 'Use' of DEI by the people of the states stepped up remarkably from 0.28 (2011) to 0.95 (2017) for Himachal Pradesh and the same was found to be enhancing from 0.21 (2011) to 0.54 (2017) leading to notable improvement in the overall position of the states in terms of DEI index. The state of Haryana could maintain almost status quo in terms of 'Use' and 'Access' dimension during the period of the study. The 'Use' and 'Access' rank of Haryana was 8th (2011) which marginally altered to 9th and 10th respectively during 2017. The performance of another northern state, Rajasthan was found be dismal which was ranked 12th and 11th under 'Use' and 'Access' dimensions respectively.

Figure 1

Scatter Plots of Inter-state Variation according to 'Use' and 'Access'

Source: Author's own representation

In Figure 1 the change in the relative position of major Indian states in terms of considering both 'Use' and 'Access' together is highlighted using scatter plots during 2011, 2014 and 2017. For simplicity in analysis the scatter plots are clustered into four dimensions such as High (Use) –High (Access) category, High (Use) –Low (Access) category, Low (Use) –High (Access) category and Low (Use) – Low (Access) category. The analysis of the scatter plot for reveals that majority of the Indian states (11) were found to be in the Low–Low category. Few states such as Punjab, Maharashtra, Kerala, Tamil Nadu and Karnataka were found to be on the High-High quadrant in 2011 and all these states (except) Maharashtra were able to be position in the High-High quadrant during the entire period of study. Andhra Pradesh and Himachal Pradesh were found to be falling under High–Low and Low-high categories respectively during 2011. Due to the presence of huge number of states in the Low-Low quadrant lead the overall position of Indian to be Low 'Use'- Low 'Access' country in terms of digital economy during 2011. The situation has altered to a great extent in 2014 and further in 2017 as it can be observed that the concentration of major Indian States has reduced in Low-Low quadrant and more dispersed in other ones. The number of states in Low-Low quadrant had reduced to 9 in 2014 and 8 in 2017 from 11 states during 2011. It can be observed from the evaluation of the scatter plots that the states of Jammu & Kashmir and North East Cluster had shifted from Low-Low to High-Low segment in 2014 signifying the demand side driven improvement. The only state Himachal Pradesh which was in the Low-High quadrant in 2011 had changed its position to High-High situation both in 2014 and 2014. Therefore, it can be deduced that there had been a significant improvement 'Use' parameter for Himachal Pradesh which along with 'Access' further improved during 2017. The state of Gujarat had also moved from Low-Low category to a High-Low category during the period of study. However, Maharashtra which was one of the High-High states in 2011 could not maintain its position and slipped into High-Low potion on account of worsening digital infrastructure creation in 2014. Further, deterioration in terms of 'Use' was observed for Maharashtra during 2017. On an average the position of India improved a little from a Low-Low in 2011 to High-Low in 2014. However, in 2017 the position of India was again found to be on low-Low quadrant which speaks about the improvement required for majority of the Indian states in creating adequate DEI.

Table 4
DEI Index & Ranks of Major Indian States

States	2011		2014		2017	
	DEI Index	Rank	DEI Index	Rank	DEI Index	Rank
AP	0.48	6	0.42	8	0.42	8
ASM	0.08	16	0.10	16	0.12	15
BIH	0.04	18	0	18	0	18
GUJ	0.4	8	0.63	5	0.57	6
HAR	0.36	9	0.39	9	0.37	10
HP	0.46	7	0.73	4	0.76	2
JK	0.2	12	0.36	11	0.39	9
KAR	0.64	5	0.62	6	0.65	5
KER	0.88	1	0.86	1	0.80	1
MP	0.14	14	0.18	14	0.13	14
MAH	0.68	4	0.56	7	0.42	7
NE	0.16	13	0.37	10	0.33	11
OR	0.08	17	0.15	15	0.17	13
PUN	0.80	2	0.76	3	0.71	4
RAJ	0.23	11	0.31	12	0.28	12
TN	0.77	3	0.79	2	0.73	3
UP	0.13	15	0.09	17	0.09	17
WB	0.28	10	0.18	13	0.10	16
IND	0.39	-	0.43	-	0.4	-
Source: Author's own calculation						

Table 4 exhibits the DEI Index of major Indian states and their relative ranks during the period of study (2011, 2014 and 2017). The graph of DEI index for various states during 2011 to 2017 is presented in Figure A.6 in Appendix. In 2011, Kerala obtained the first rank in terms of DEI index followed by Punjab, Tamil Nadu, Maharashtra, Karnataka, Andhra Pradesh, Himachal Pradesh, Gujarat, Haryana, West Bengal, Jammu & Kashmir, North East, Madhya Pradesh, Uttar Pradesh, Assam, Orissa and Bihar. In the same manner in 2014 too, Kerala took the 1st position followed by Tamil Nadu, Punjab, Himachal Pradesh, Gujarat, Karnataka, Maharashtra, Andhra Pradesh, Haryana, North East, Rajasthan, Madhya Pradesh, West Bengal, Orissa, Assam, Uttar Pradesh and Bihar. Likewise, the state of Kerala has again obtained the top most position in terms of DEI index followed by Himachal Pradesh, Tamil

Nadu, Punjab, Karnataka, Gujarat, Maharashtra, Andhra Pradesh, Jammu & Kashmir, Haryana, North East, Rajasthan, Orissa, Madhya Pradesh, Assam, West Bengal, Uttar Pradesh and Bihar. The analysis of the data suggests that the state of Kerala has scored highest in terms of DEI index in all the years under observation. On the contrary, the DEI index of Bihar was found to be lowest during the period of study and has obtained last rank (18th) during 2011, 2014 and 2017. There are certain states which have maintained almost status quo in DEI index during the period of study. For example in cases of Assam, Karnataka, Andhra Pradesh, Haryana, Madhya Pradesh, Rajasthan and Tamil Nadu the relative position has not altered significantly during the period of study. It must be kept in focus that the DEI of Tamil Nadu, Haryana and Karnataka were found to be in a prominent position during the period of study whereas the digital economy of Assam, Andhra Pradesh, Madhya Pradesh and Rajasthan were not found to be in a good position during the period of study. Significant improvements in the digital economy were observed in case of Gujarat, Himachal Pradesh, Orissa, North-Eastern cluster States and Jammu & Kashmir during the period of study. Amongst, these states, the improvement in the relative position of Jammu & Kashmir and Gujarat could be attributed to the significant improvement in both 'Use' and 'Access' parameters which signifies that the along with the betterment of the supply situation the demand for digital economy had also augmented during the period of study leading to a overall improvement in DEI. On the other hand, the remarkable improvement in DEI index for Himachal Pradesh was primarily due to the improvement in the 'Use' dimension. Unlike other states the improvement of the rank of Orissa in DEI index was mainly because of the improvement in the 'Access' dimension during the period of study. However, the DEI of the states of West Bengal and Uttar Pradesh has detoriated during the period of study. The underlying reason may be the gradual deterioration of these states in terms of both 'Use' and 'Access' dimensions.

Table 5
Classification of Major Indian States according to DEI Index Values

Category	2011	2017
High	Karnataka, Kerala, Maharashtra, Punjab, Tamil Nadu	Karnataka, Kerala, Punjab, Tamil Nadu, Gujarat, Himachal Pradesh
Medium	Andhra Pradesh, Gujarat, Haryana, Himachal Pradesh, Rajasthan, West Bengal	Andhra Pradesh, Haryana, Jammu & Kashmir, Maharashtra, North East, Rajasthan.
Low	Assam, Bihar, Jammu & Kashmir, Madhya Pradesh, North East,	Assam, Bihar, Madhya Pradesh, Orissa, Uttar

	Orissa, Uttar Pradesh	Pradesh, West Bengal
Source: Author's own compilation		

In Table 5 the major Indian states have been classified according to their respective DEI Index values during 2011 to 2017. The classification of the states have been made in three categories such as High (, Medium () and Low. From the analysis of Table 3, it is very much evident that Karnataka, Kerala, Maharashtra, Punjab and Tamil Nadu have fallen under the high DEI Index category suggesting that the digital economy of these states are in an advanced position in terms of both 'Use' and 'Access' during 2011. Similarly, Andhra Pradesh, Gujarat, Haryana, Himachal Pradesh, Rajasthan, West Bengal were found to be falling under the medium category and rest of the major Indian states (Assam, Bihar, Jammu & Kashmir, Madhya Pradesh, North East, Orissa, Uttar Pradesh) were classified low DEI states during the year 2011. In 2017 amongst the major Indian states Karnataka, Kerala, Punjab, Tamil Nadu, Gujarat, Himachal Pradesh were found to be falling in the high DEI quadrant. As compared to 2011, two new additions in this category were Gujarat, Himachal Pradesh. These two states were in the Medium category in 2011 whereas Maharashtra which was a high DEI states was found to be shifting to medium category in 2017. Andhra Pradesh, Haryana and Rajasthan were found to be classified as medium DEI states both in 2011 and 2017. However, the states of North East and Jammu & Kashmir showed improvement in DEI index as these states were shifted in the medium category in 2017 from low category in 2011. The state of West Bengal which was in a medium category in 2011 has lost its position and was classified as a state having low DEI in 2017. Assam, Bihar, Madhya Pradesh, Orissa, Uttar Pradesh states were found to be classified as low DEI states during the entire period of study. Interestingly, it can be noted that majority of the Southern states were found to be performing very well in terms of DEI index whereas most of the Eastern states were observed to be performing poorly in terms development of DEI.

Conclusion:

This paper made an attempt to shed some lights on the access and usage of digital services across Asia-Pacific countries with a special reference to the Ind. Indian economy broadly follows the trend of South Asian countries, which can be clustered under low access-low usage category. Changing scenario of digital economy infrastructure is a special interest of this paper. A comprehensive index of digital infrastructure (DEI) is constructed to highlight inter-state variation in such DEI over 2011 to 2017 in India. In doing so DEI index was determined by taking into account both the demand side (use factor) and supply side (access

14

factor). The outcome of the study suggested most of the southern states in India excel in DEI whereas the eastern states were laggards in this direction.

References:

Ahmad, N., & Ribarsky, J. (2018, September). Towards a framework for measuring the digital economy. In *16th Conference of the International Association of Official Statisticians (IAOS), Paris, France*.

Bukht, R., & Heeks, R. (2017). Defining, conceptualising and measuring the digital economy. *Development Informatics working paper*, (68).

Chakravorti, B. (2016). Where the digital economy is moving the fastest. *Harvard Business Review*, 19, 1-7. Retrieved from https://www.digital-economy-lebanon.org/wp-content/uploads/2017/01/16259.pdf

G20 (2018). *Toolkit for Measuring the Digital Economy,* Retrieved from http://www.oecd.org/g20/summits/buenos-aires/G20-Toolkit-for-measuring-digital-economy.pdf

Quah, D. (2003). *Digital goods and the new economy*.Retrieved from http://eprints.lse.ac.uk/2236/1/Digital_Goods_and_the_New_Economy.pdf

Ramachandran, V., Shah, M. K., & Moss, T. J. (2018). How do African firms respond to unreliable power? Exploring firm heterogeneity using k-means clustering. *Center for Global Development Working Paper*, (493).

IMF (2018). *Measuring the digital economy*, Retrieved from https://www.imf.org/en/Publications/Policy-Papers/Issues/2018/04/03/022818-measuring-the-digital-economy

ITU (2016). *Measuring the information society report.* Retrieved from https://web. archive. org/web/20170605134129/http://www. itu. int/en/ITU-D/Statistics/Documents/publications/misr2016/MISR2016-w4.pdf

Watanabe, C., Naveed, K., Tou, Y., & Neittaanmäki, P. (2018). Measuring GDP in the digital economy: Increasing dependence on uncaptured GDP. *Technological Forecasting and Social Change*, *137*, 226-240.

Appendix

Figure A.1: Cross-Country Variation in the Access and Usage Dimensions of Digital Services
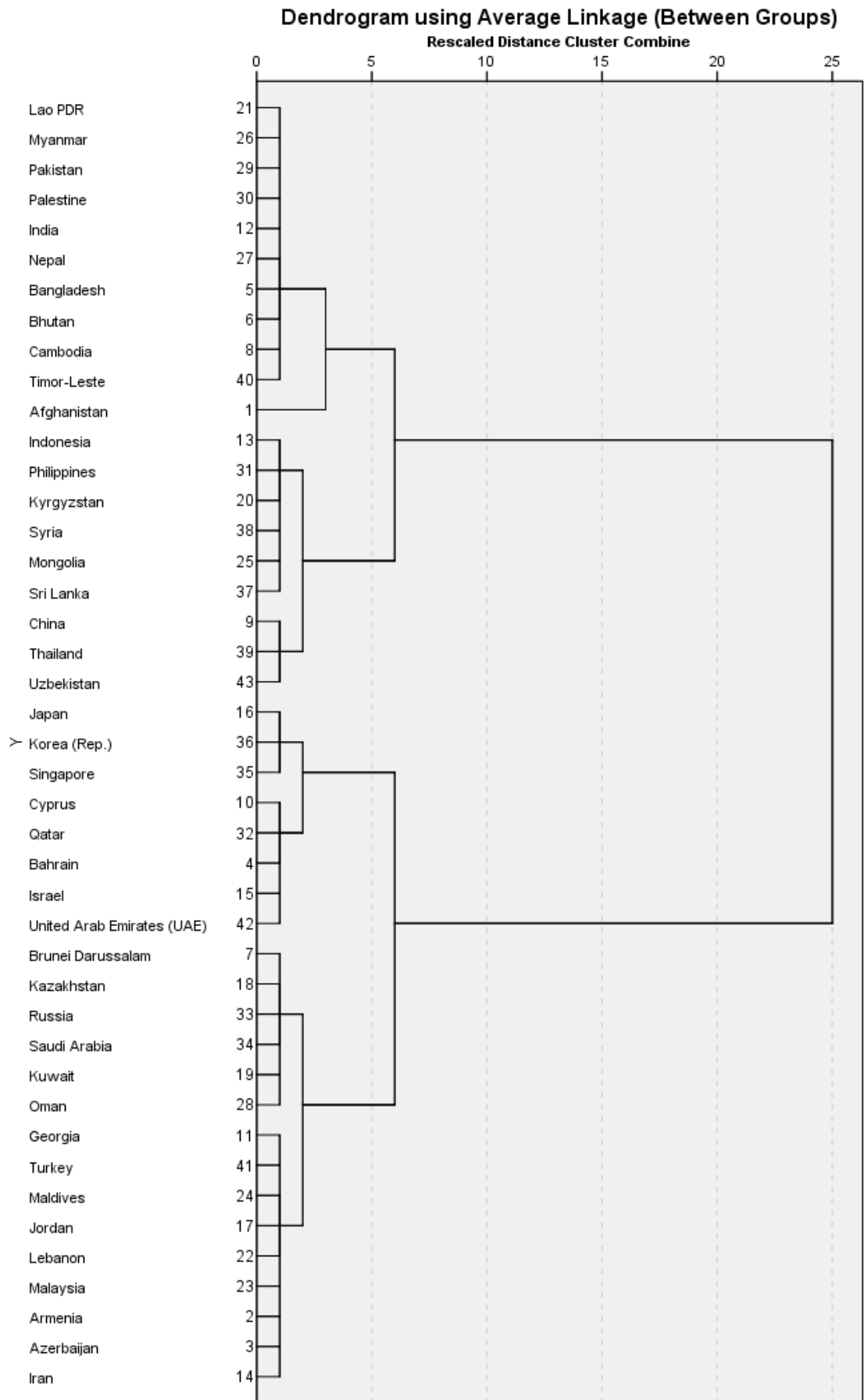
Figure A.2: Dendrogram showing Clustering of Asia-Pacific Countries in Digital Access
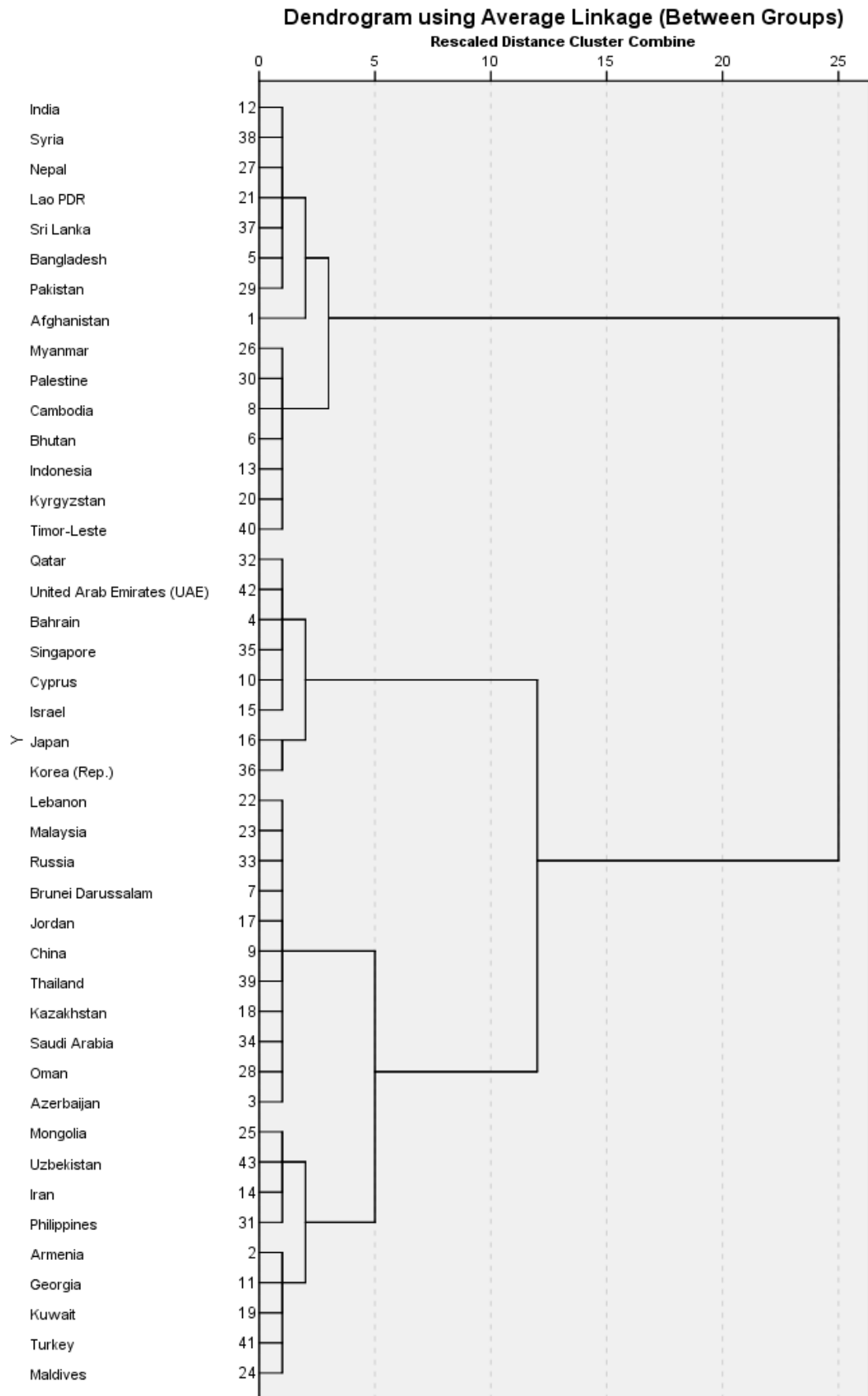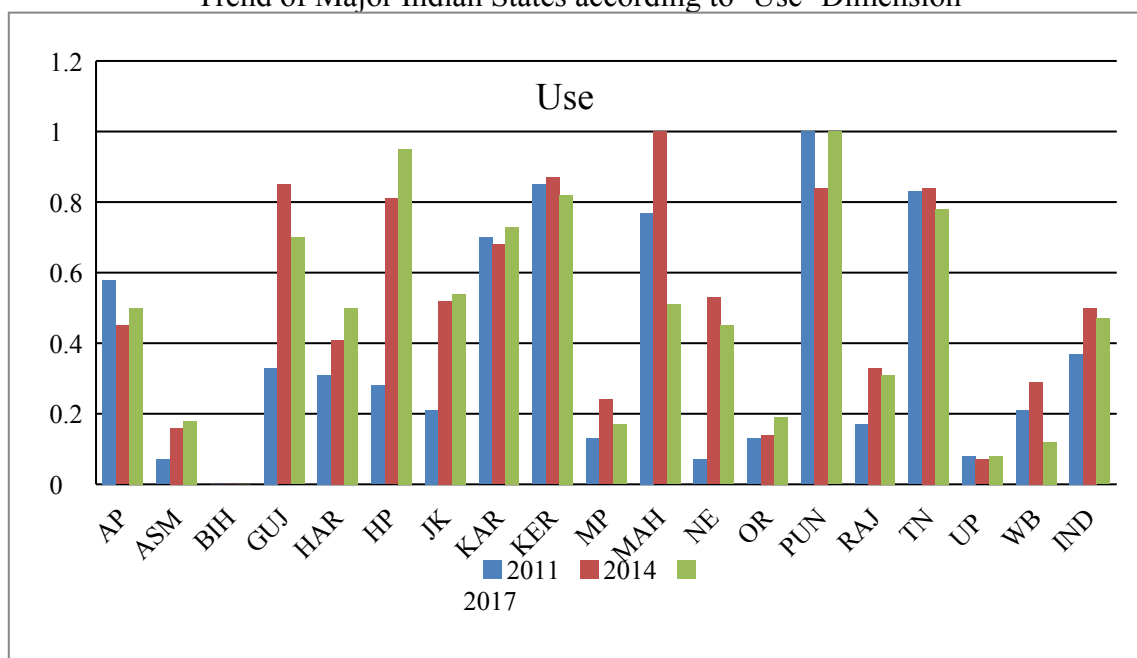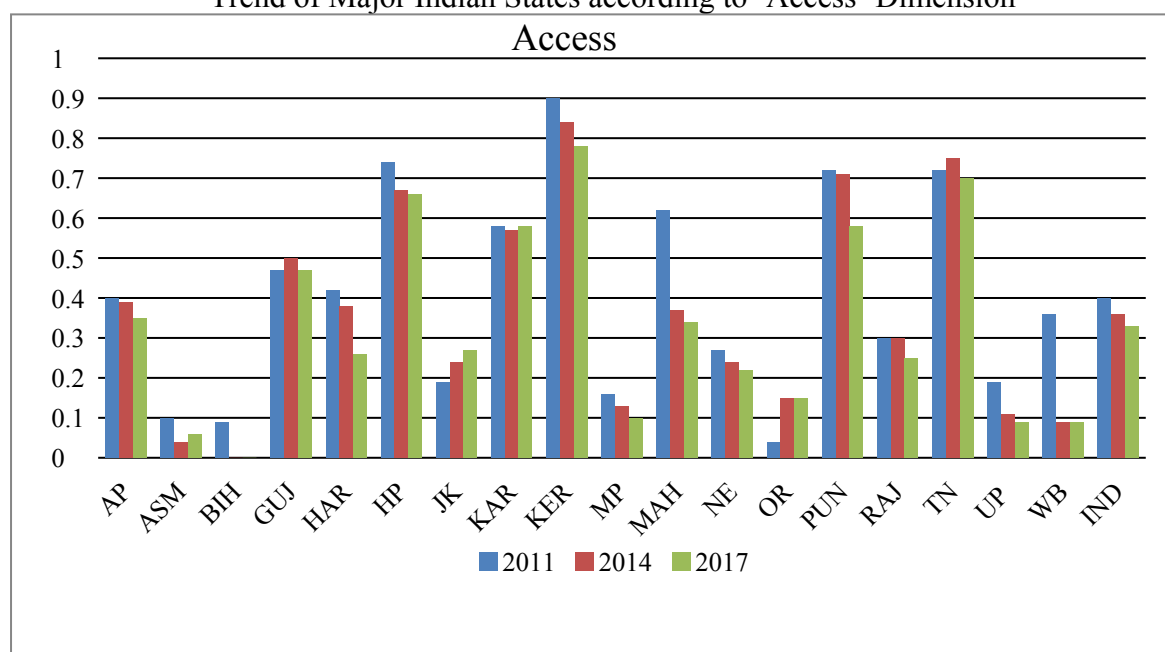
Figure A.3: Dendrogram showing Clustering of Asia-Pacific Countries in Digital Usage

Figure A.4
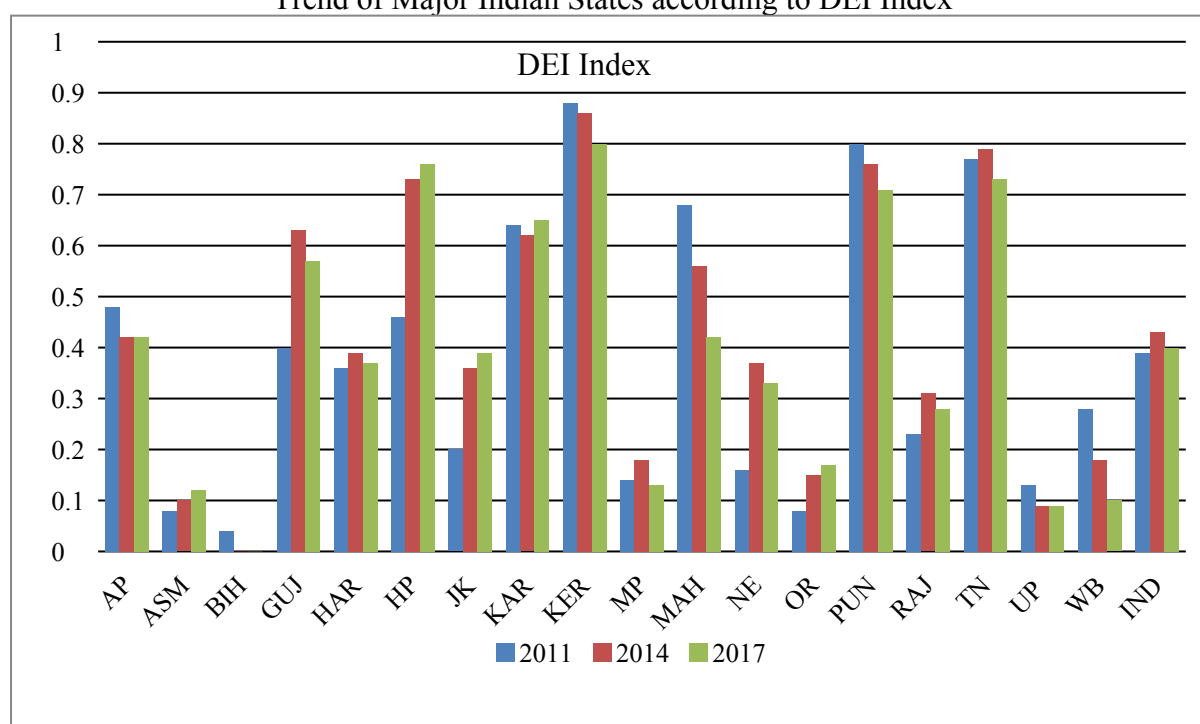Trend of Major Indian States according to 'Use' Dimension

Source: Author's own representation

Figure A.5
Trend of Major Indian States according to 'Access' Dimension

Source: Author's own representation

Figure A.6
Trend of Major Indian States according to DEI Index

Source: Author's own representation