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Regulatory Bottlenecks of Wireless Expansion of Internet in India

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Regulatory Bottlenecks of Wireless Expansion of Internet in India

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Abstract

The Indian telecommunication market is second largest in the world and is growing rapidly. The government is taking several measures such as National optical fiber network (NOFN) project, public WiFi pilot to bridge the gap of digital divide in order to provide Internet services throughout the country including under reserved regions of India. However, the available licensed spectrum might not be sufficient to fulfill the demand alone given the fact that it is a limited resource and its assignment to operators is highly regulated. Nevertheless, the unlicensed spectrum might be underutilized since it has around 31000 hotspots throughout the country. Community networks is an emerging concept in India, which plays an important role in bridging digital divide by exploiting unlicensed spectrum. The focus of this paper is to examine the availability of licensed spectrum and discuss the need of regulatory support to enable the growth of community networks in India. The paper studies the following hypotheses as the regulatory bottlenecks in the wireless expansion of Internet in India. i) Licensed spectrum is scarce ii) Low spectrum holdings of operators iii) Inadequate market concentration iv) Lack of regulatory incentives for community networks. The results confirm that competition act as a catalyst in the diffusion of Internet and also that the spectrum scarcity is relatively observed in local service areas in the telecom market. Since the diffusion of wireless networks is less in rural regions, support from regulatory bodies is primarily needed to improve it. Hence, we present few regulatory recommendations related to innovative licensing, and engagement of communities to support the growth of community network operators.

Keywords : spectrum availability, community network operators, regulatory bottlenecks

1 Introduction

The telecommunication industry is growing rapidly in India. As the mobile services are adopted, the demand for spectrum is also increasing. Currently, there are 800 million subscribers and an average of 10 operators in the mobile market. It is estimated to have 9,684 million subscribers by the end of 2020. The available licensed spectrum might not be sufficient to serve this huge demand since it is a limited resource and its assignment to the mobile operators is highly regulated. At the same time, we see that the unlicensed spectrum is underutilized in the country. As of 2017, there are only 31,000 WiFi hotspots in India while France has 13 million hotspots [7].

Regulation of spectrum is needed to prevent interference between the users and to maintain a healthy competition between the operators in the market. Spectrum scarcity can be observed with inefficient regulation. The Indian telecom regulatory framework is shown in Appendix A. It consists of Indian government bodies and Independent bodies. Each body is responsible for different activities from licensing to handling issues of the telecom industry.

The research question we address in this paper is ‘*What are the main regulatory bottlenecks for wireless expansion in India?*’ We answer this question by analyzing the below hypotheses.

Hypothesis 1 : Licensed spectrum is scarce

Hypothesis 2 : Low spectrum holdings of operators

Hypothesis 3 : Inadequate market concentration

Hypothesis 4 : Lack of regulatory incentives for community networks

Hypotheses 1,2,3 are associated with the usage of licensed spectrum and Hypothesis 4 with the usage of unlicensed spectrum. We chose India for our study because Indian telecom sector has witnessed remarkable growth in the last decade. It has also emerged as one of the fastest growing telecom markets in the world.

The structure of the paper is as follows. Section 2 introduces the literature review w.r.t community networks and their associated challenges. Section 3 discusses the methods used to analyze the aforementioned hypotheses by analyzing the licensed spectrum availability and also the effect of different variables on mobile network penetration. Section 4 provides the results. Section 5 concludes the paper with policy recommendations and future work.

2 Literature Review

Extensive literature review has been done w.r.t diffusion of wireless networks but however, there is no study performed to analyse the spectrum availability at the telecom circle level in India. In our earlier work [14], we have performed case studies of community network projects in India and discussed the impact of unlicensed spectrum on rural broadband in India. Community network operators usually set up the network for the community's welfare and usually build up the infrastructure with the support of the community, other nonprofit or profit organizations to offer wireless access. It is less expensive and relevant to the local needs of that community. For reference, different community network projects implemented in India is added in Appendix A.

Community networks are a bottom up approach which is arising throughout the world. Community network operators set up their own network by using unlicensed spectrum to serve their communities. It can be technically defined as architectures that are distributed in which users implement a decentralized network through the decentralization of the hardware supporting the network. The Telecom Regulatory Authority of India (TRAI) understands the value of public WiFi networks and have initiated support to a project called 'public WiFi pilot'. Through the project, the government supports small entrepreneurs and private entities in the community to sell WiFi networks. The backhaul is supported by the fiber connectivity through National Optical Fibre Network (NOFN) project .

The sustainability of community networks is inhibited by a lot of challenges on various levels of policy, regulatory challenges, spectrum management and regulations, availability of the spectrum, licensing processes, minimal support from the transit providers and many more. The main challenge is that these projects are implemented in rural regions and the literacy level is low in rural regions. It is difficult for them to understand the role of the Internet in day-to-day life. Building and managing a community network with community members in rural region becomes a challenge with illiteracy level being high. Because of this, it becomes impossible for them to understand and follow the regulatory processes to set up a community network. Being aware of sch processes is also highly questionable. Some of the community network operators were also unaware of maintaining the tower height when built, for example, a tower needs a clearance from the Standing advisory committee on Radio Frequency Allocation (SCAFA) which is a part of DoT (Department of Telecommunications). But a community network operator

who does not have an ISP license, needs to use the tallest structure to set up a tower. So, the challenges that arise with these as well is really high and complicated. From the table in the Appendix A, we see that there is very minimal support provided by the telecom network operators. They have less interest in investing on infrastructure in these places since it demands high investments with low returns. Funding these projects have been from international organizations like ISOC(International society) and through some funds of Microsoft and other international companies. Even though these projects are inexpensive when compared to mobile networks, they do require funding for the initial setup. Other challenges arise with maintaining and managing the network. When highly motivated people are involved in bringing up the network, it becomes easy to manage. But this comes again at a higher cost. The networks are easily managed until and unless the funding entity supports the project, but becomes very difficult without the support of these funding entities.

3 Method

Indian telecom market is divided into 22 telecom circles (TCs) which is grouped under 4 local service areas (LSAs). The classification is based on population density, subscriber base and revenue potential. Table 1 depicts the above classification. The population density and subscriber density decreases along the LSA metro, A, B and C. Due to the possibility of one person holding multiple subscriptions, the values of subscriber density is projected to be greater than that of population density in the table. Market penetration can be distorted due to this. Hence, mobidensity which is calculated as mobile cellular subscribers per hundred inhabitants is calculated. It does not imply the percentage of people holding the subscription but gives us a reality of subscriptions in the local service areas. And as we see, mobidensity is greater in local service area Metro and lowest in LSA C. From the data collected, we see that LSA B has the highest amount of cellular subscribers and Metro has the least. This is relevant to the number of telecom circles each service area has. India has 11 operators operating in different telecom circles. This has changed in the recent few months after the disruptive entry of Reliance Jio.

Hypotheses 1-3 is studied by analysing the availability and utilisation of licensed spectrum per telecom circle. Hypothesis 4 is answered by studying the challenges of community network projects implemented in India. The

Variables \ LSA	METRO	A	B	C
No. of telecom circles	3	5	8	6
No. of subscribers (millions)	107.5	377.8	430.7	162.2
Population density (population/km ²)	18137.26	1440.27	1221.04	392.12
Subscriber density (subscriber/km ²)	36612.19	1646.43	1552.27	556.43
Mobidensity (%)	240	100	75	60
Penetration	2.29	1.01	0.88	0.70
W.Avg Operators	8.6	9.1	8.9	8.3

Table 1: Different variables across local service areas

availability of licensed spectrum is estimated using ‘spectrum per subscriber’ (Hz). The concentration of markets per telecom circle is taken into consideration by using weighted average as a metric for the evaluation of Herfindahl-Hirschman Index (HHI)¹, operator spectrum holdings, and spectrum holding per subscriber. Regression analysis is performed to study the diffusion of mobile Internet across telecom circles and local service areas. Market penetration is taken into account as a dependent variable. Specifically, it is modelled to indicate the degree to which the market conditions such as number of operators, competition, subscriber density, population density, and operator spectrum holdings affect mobile network penetration. Through this, we interpret the bottleneck for the diffusion of mobile Internet across the country. The tools we have used for the analysis are ‘R’ and ‘MATLAB’.

The data for the analysis has been gathered from different sources such as the spectrum holdings of the telecom service providers from the Wireless Planning and Coordination (WPC) wing. The data corresponds to the year 2015. The wireless subscriber base has been taken from TRAI reports and is also from the year 2015. The other variables such as population corresponds to the year 2011.

The equations for the calculation are as follows.

$$s_i^2 = \frac{\text{No. of subscribers of MNO}_z \text{ in } TC_n}{\text{No. of subscribers of all MNO in the } TC_n} \quad (1)$$

¹HHI is commonly accepted measure of market concentration. The lower HHI index nearing 0 indicates high competition and the higher HHI index indicates low competition.

$$HHI \text{ in } TC_n = \sum_{i=1}^z s_i^2 \quad (2)$$

$$w.avg \text{ HHI of } TC_n = HHI \text{ of } TC_n * \frac{\text{No. of subscribers in } TC_n}{\text{No. of subscribers in } LSA_m} \quad (3)$$

$$w.avg \text{ HHI of } LSA_m = \sum_{i=1}^n w.avg \text{ HHI}_i \quad (4)$$

$$SH \text{ per subscriber} = \frac{\text{No. of SH of all operators in } TC_n}{\text{No. of subscribers in } TC_n} \quad (5)$$

where, s_i^2 = market share of MNO in TC_n ,
 TC_n = n -th telecom circle ($n = 1...22$),
 MNO_z = mobile network operator ($z = 1...10$),
 LSA_m = local service area ($m = A, B, C$ or Metro),
 SH = spectrum holdings.

Hypothesis 4 is analysed by discussing the challenges of community network operators.

4 Results

4.1 Licensed spectrum - availability

Licensed spectrum availability is analyzed by spectrum holdings of operator and per subscriber and is shown in the Figure 2. From Figure 2a, it is seen that the operators hold approximately 210MHz - 290MHz spectrum across telecom circles. Operators in LSA 'B' holds the highest amount of spectrum compared to others. The variable 'spectrum availability per subscriber' helps us determine spectrum scarcity and is shown in Figure 2b. It is a relative variable. With the current number of subscribers and the amount of spectrum available per operator, which is a cumulative summation of all the bands to serve different services, we see from that the subscribers in the local service area A have the least amount of spectrum per subscriber. Each subscriber in LSA 'A' gets an average of 3.29Hz of the spectrum. The subscribers in LSA

‘C’ get an average of 9.38Hz of spectrum for their services. The reason is that the LSA ‘C’ has a lot of telecom circles consisting of the rural areas and that the subscriber numbers are low. It is also evident that the spectrum associated to LSA ‘C’ is almost the same as with the other telecom circles that we have seen in the graph in Figure 2a. These figures are an approximation and allow us to understand the extent of spectrum scarcity across the local service areas.

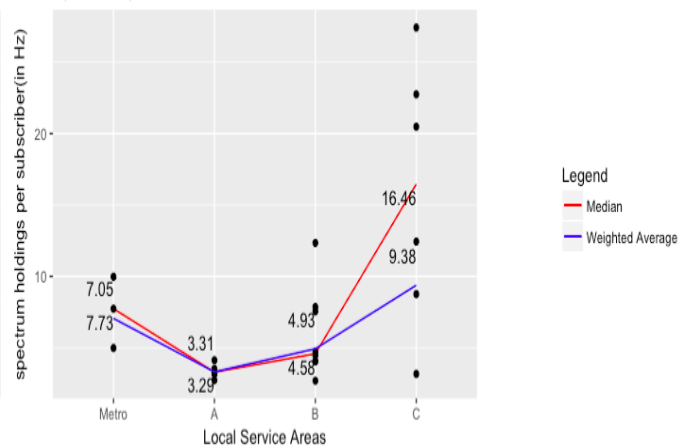
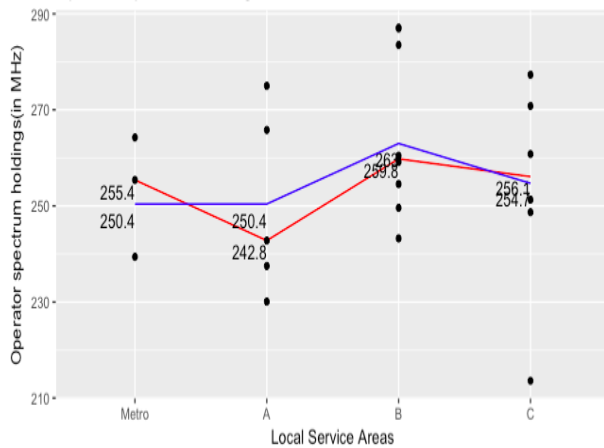


Fig 2a: Operator spectrum holdings

Fig 2b: Spectrum per subscriber

Figure 1: License spectrum availability across TCs and LSAs

4.2 Licensed spectrum - utilization

Spectrum utilization is discussed in terms of penetration and competition as in Figure 3. From Figure 3a, the penetration level is highest in the metro region and the lowest in local service area C. The low penetration values in local service C is an evidence that there are a lot of opportunities to increase penetration in that service area. Figure 3b depicts the competition between the mobile network operators and it is highest in the metro region and decreases across LSAs A, B, and C. The number of operators does matter to the competition between the network operators to a certain extent but the addition of the number of operators doesn't change the competition in the market after a certain number of players. However, the competing operator firm size matters for the increase in the competition. Meaning, two small sized companies will not increase the competition with a player having the highest market size.

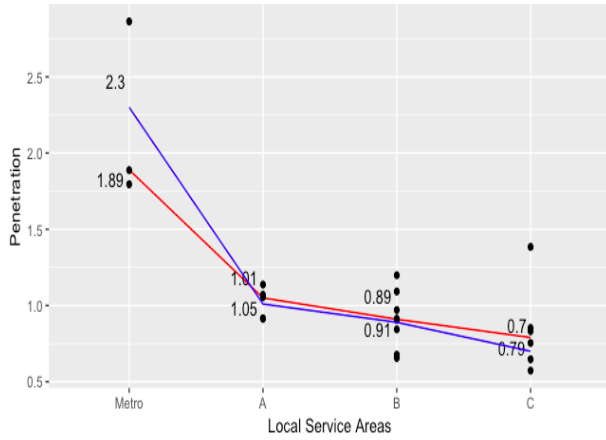


Fig 3a: Penetration

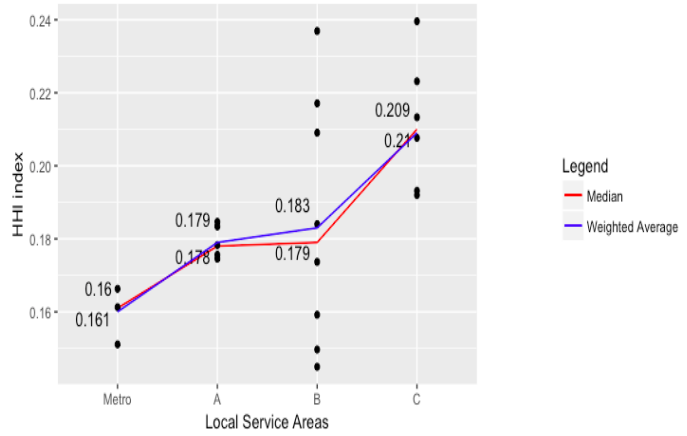


Fig 3b: Competition

Figure 2: Licensed spectrum utilization across TCs and LSAs

Regression model helps us find the correlation between mobile market variables and mobile network penetration. The primary goal of it is to test the hypotheses 2 and 3 which states that competition and low operator spectrum holdings are a bottleneck for the expansion of wireless Internet in India.

Our modeling approach on the effect of network penetration with these independent variables is discussed below. The impact of the independent variables such as the number of network operators, competition between the network operators (HHI), subscriber density, population density, and spectrum holdings by the operator on the network penetration is expected to be positive, but the degree of impact is of our interest.

We present the regression results of the impact due to single independent variables in the below Table 2. It depicts that the operator spectrum holdings has a very low impact directly on the penetration of the network. It shows the correlation factor, r-square of 0.0109. This is contradictory to what we thought of initially. It might not be that the penetration increases with the increase of quality of service. People seem to be late adopters of technology in India and this result proves that to increase the penetration, they do not really need the latest technology. However, population density has a positive greater impact on the penetration of the mobile Internet. We have considered negHHI in the above model since the value of HHI is inversely proportional to the competition. From the results, it is so that competition as a single variable also has a negligible impact on the penetration.

Regression Model	Estimate	SE	Tstat	Pvalue	R-squared	RMSE
Penetration ~1 + negHHI	9.8008	3.5795	2.738	0.012676	0.273	0.453
Penetration ~1 + No.Of Operators	0.084545	0.14555	0.58085	0.56783	0.0166	0.527
Penetration ~1 + Osh	-0.00286	0.00612	-0.46839	0.64457	0.0109	0.528
Penetration ~1 + sub- subscriberden- sity	3.2458e- 05	4.9254e- 06	6.5899	2.0282e- 06	0.685	0.298
Penetration ~1 + popula- tiondensity	5.6209e- 05	1.2056e- 05	4.6624	2.000014	0.521	0.368

Table 2: Regression results on single independent variables

Regression Model 1 is depicted in Figure 3. It has a higher rsquare of 0.71 due to the linear relationship between subscriber density and penetration holds. We use coefficient pValues to determine which variables need to be retained in the model. A predictor which has a low pValue could be an effective addition to the model, since the changes in the predictor value is directly proportional to the changes in the response variable. In this model, we could probably use subscriber density as the predictor variable, but since it holds a linear relationship with penetration, it is quite obvious that its inclusion will lead to a significant model.

Regression model 2 is represented by Figure 4 and variables such as number of operators and the competition between them is considered. It explains the network penetration in terms of competition. It is intuitive that with competition, there is innovation in the market. Model 2 has a low value of R-square, but is still a significant model if the slope coefficients and the coefficient pValues of the predictor variables are considered. It is seen that the HHI factor which determines the competition has a positive slope co-efficient of approximately 11 and a lower pValue of 0.012201. This shows the benefits of competition in the outcome of the mobile market. Results prove that competition acts as a positive catalyst in the increase of the network penetration.

Linear regression Model 1:

Penetration ~ 1 + NumberOfOperators + negHHI + subscriberdensity + Osh + populationdensity

This model is taken into combination of all independent variables.

Estimated Coefficients:

	Estimate	SE	tStat	pValue
(Intercept)	1.6219	1.2585	1.2888	0.21581
populationdensity	-0.00013741	3.3374e-05	-4.1174	0.00080658
subscriberdensity	9.5802e-05	1.6763e-05	5.7152	3.1903e-05
NumberOfOperators	-0.0039594	0.07477	-0.052955	0.95842
OSH	0.00066079	0.0026914	0.24552	0.80917
negHHI	4.1305	2.4007	1.7206	0.10461

Table 3: Regression results of Regression Model 1

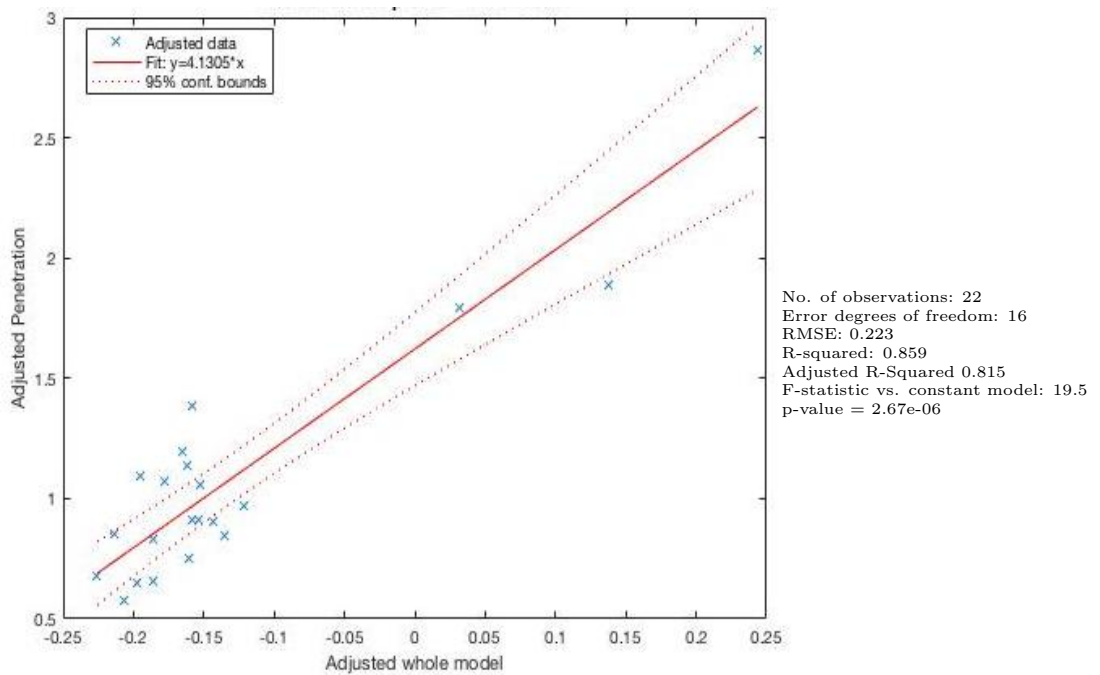


Figure 3: Linear regression model 1

Linear regression model 2:

$$Penetration \sim 1 + NumberOfOperators + negHHI$$

Estimated Coefficients:

	Estimate	SE	tStat	pValue
(Intercept)	4.3519	1.8093	2.4052	0.026515
NumberOfOperators	-0.1254	0.14708	-0.85263	0.40449
negHHI	11.649	4.2058	2.7697	0.012201

Table 4: Regression results of Regression Model 2

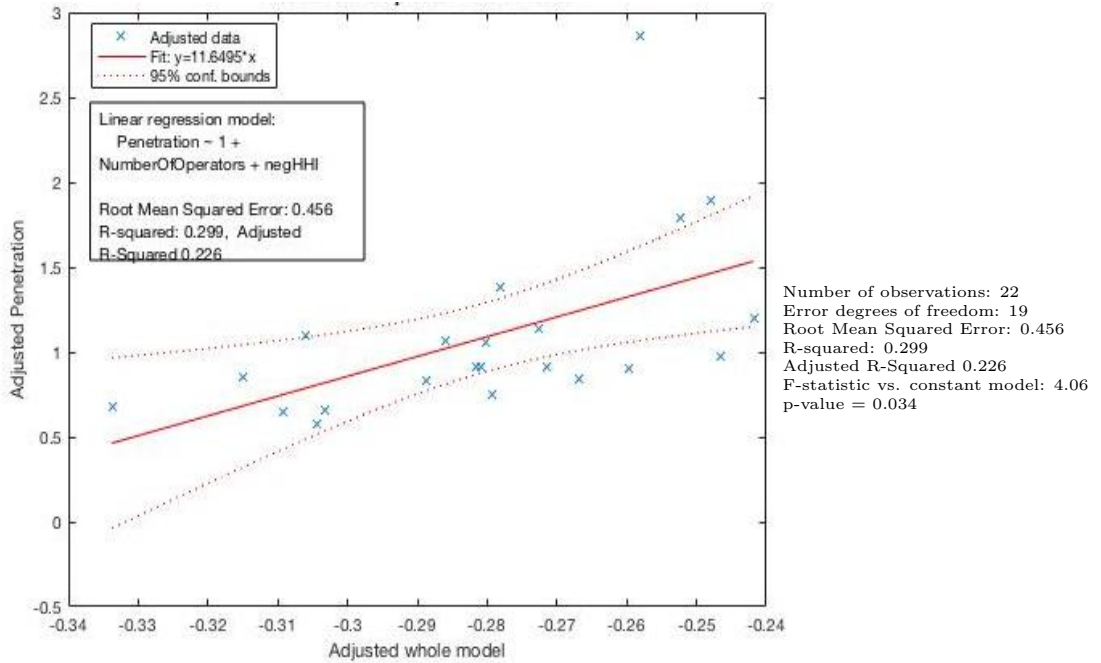


Figure 4: Linear regression model 2

4.3 Validation of Hypotheses

Hypothesis 1 : Licensed spectrum is scarce

From Figure 2b, the availability of licensed spectrum is lower in LSA A compared with LSA C. From this, we can conclude that the scarcity of licensed

spectrum is higher in LSA A. Metro region has a significant amount of spectrum per subscriber even though the competition in that region is the highest compared to any other local service area. It has densely populated cities and the competition is well regulated.

Hypothesis 1 is true.

Hypothesis 2 : Low spectrum holdings of operators

Regression analysis of independent variables and also regression model 1 from Section 3, states us that the operator spectrum holdings do not have a significant impact on the mobile penetration. The data obtained from Indian telecom market, the operator spectrum holdings across the local service areas is similar and also frequency is reused and the cumulative spectrum holdings are similar. It might not be that the penetration increases with the increase of quality of service. People seem to be late adopters of technology in India and this result proves that to increase the penetration, they do not really need the latest technology. Intuitively, operator spectrum holdings has an effect on mobile penetration but from our analysis, it is not a bottleneck in India.

Hypothesis 2 is false.

Hypothesis 3 : Inadequate market concentration

From the regression model analysis in Section 3, it is seen that the market concentration does have an impact on the penetration of the mobile Internet in India.

Hypothesis 3 is false

Hypothesis 4 : Lack of regulatory incentives for community networks

From Section 2, we see that community networks has the potential to close the digital divide in the country and to expand wireless Internet throughout India. In rural regions, mobile network operators do not invest on infrastructure due to low returns. but community networks act as an alternative approach and it is easy to flourish with less investment. The success of the community networks depends on a lot of factors like the involvement of the community members, the strategy of the organization and also on the policy environment. Even though the regulations do not directly affect the community networks, it affects them indirectly. The regulator has a significant role to play in the proliferation of broadband services as in public wifi pilot initiative.

Hypothesis 4 is true

5 Conclusion and recommendations

Spectrum scarcity can be managed with efficient methods of spectrum distribution to the operators by the regulator. Maintaining a healthy competition in the market is important to promote the operators business and also to expand mobile Internet in India. The unlicensed spectrum is definitely undervalued. The community network operators face a lot of challenges, but their intention to increase the wireless network in the rural areas is clear and would help in bridging the digital divide. Understanding that regulating unlicensed spectrum is not an option, the government's initiative on public WiFi pilot does not directly address the challenges faced by the community network operators in the rural region currently. It is very important that the government promotes activities in the rural region to increase the network connectivity and help the community network projects.

We propose some recommendations to the regulatory bodies since regulation plays a very important role in the success of the telecom industry and the growth of community networks. It is very important for the policy makers and regulatory bodies to understand the benefits of community networks, and ensure that these network operators have access to spectrum. Below are some of the proposed recommendations.

1. Innovative Licensing – Innovative approaches to spectrum management like granting spectrum at a reasonable rate exclusively to the unreserved areas can increase the opportunities for community networks to gain access to the spectrum. Experimental licenses are another set of license to the spectrum which could be provided to the rural regions or the community network operators.
2. Increase transparency in the regulatory decisions – The rules and the decisions need to be available to the public in a form that the layman understands. The rules are complicated and hence, communities prevent increasing their knowledge in this area of operation.
3. Flexibility in regulation – The Regulatory bodies need to be flexible enough with their operation and ensure that they follow best practices. This could help a lot in terms of spectrum sharing, in offering unlicensed/licensed free spectrum etc.
4. Creating public private partnerships – Projects that create public private partnerships needs to be increased.

5. Increase in the engagement with the communities – The challenges faced by the communities in the rural region are very different and requires more engagement of the government with the rural communities in order to understand the basic problems. Training could be provided to the communities to set up their own network, etc.

5.1 Future Work

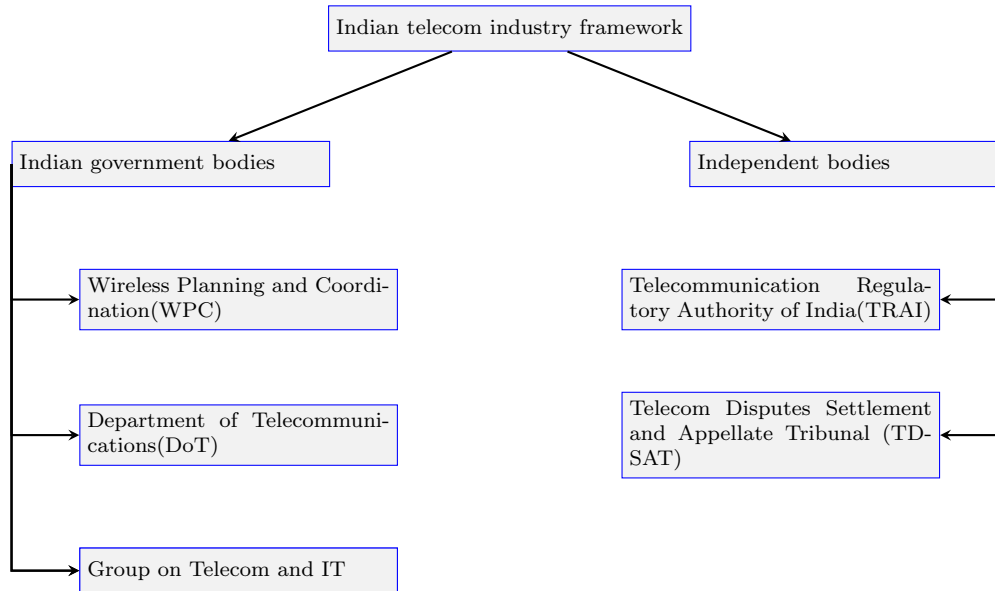
Estimation of spectrum availability per subscriber combined with spectral efficiency of a certain technology gives us the bits/sec/Hz. This would provide the data speed for a subscriber which is a good metric to check if there is licensed spectrum scarcity. The future work of the second part of the research in the thesis can be extended to frame business models for the ‘public WiFi pilot’ initiative by the government. This would help us understand if the government is an actor among the other operators or just wants to provide the necessary support to the expansion of Internet in India.

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Appendix A Framework of Indian Telecommunication Industry



Appendix B Community network projects

Projects names	Project Duration	Deployment regions in India	Telecom Circle	Implementing / Funding entity	Transit Provider	Technologies employed	Coverage Size	Usecase Scenarios
W4C Phase 1	2010-2011	Chanderi in Madhya Pradesh	B	NGO (DEF) / ISOC		Wireless mesh setup (one relay station, 5 point to point nodes)	20-30kms wide	Schools, government
W4C Phase 2	2011-2012	Baran in Rajasthan	C			25 hotspots (3 point to point nodes with base station)	10km wide	NGO's, Schools
		Tilonia in Rajasthan	B					School
W4C Phase 3	2012-2013	Giriridh in Jharkhand	C	NGO (DEF), Local community partner (Nav, Jagtri, Yuva Mandal) / ISOC		Tower for wireless network has been set up and wireless mesh network has been deployed. 5 point to point nodes with a base station		
		Mandla in Madhya Pradesh	B	NGO (DEF)/ ISOC		5 point to point nodes have been established with wireless mesh network		Government
		Nangaon in North Tripura	C			5 nodes have been established		Government
W4C Phase 5	2015-2016	Shivpuri, Baran, Guna	B			Mesh network was set up		intranet connectivity to 3 communities
W4C 6	2016-2017	Narayanpet in Mahbubnagar district of Telangana	C		BSNL (state owned) / 4Mbps			schools, health centers
		Tham in Koderma district of Jharkhand	A		Airtel (private owned) / 4 Mbps			Government, schools
W4C Phase7 (Zero Connect)	2017-2018	Little Rann of Kutch, Manish Rann, Kharagodah Rann, Patadi and Surendrangar in Gujarat	A			Connected vans via unlicensed spectrum, to lend Internet-enabled devices	100 meters	Schools
AirJaldi	2010	Ranchi Network in Jharkhand	C	close co-operation with NGO/support from the Ford Foundation			1000 sq.km	Services offered to educational institutions, businesses and individuals.
	2016	Harisal in Amravati in Maharashtra	A	Microsoft's Affordable Access Initiatives Grant		NOFN Project & using TV White Spaces Technology (link)		Schools, health center and WiFi services to the villagers.
Gram Marg		Palghar in Maharashtra	A	IIT Bombay/Tata Teleservices		Using TV White spaces (500-520MHz)		Broadband connectivity to villagers