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Growth of mobile services across regions of India

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Penetration of mobile services is not uniform across the country. While some areas of the country have experienced exponential growth, the other areas, especially economically disadvantaged, have very low mobile density. This mobile divide is a serious concern for government, policy makers and telecom operators. Predicting growth of subscriber base across regions of the country is critical for all stakeholders. The study aims to better forecast the penetration of mobile services across regions of the country so that their effect on economic development can be further explored and policies can be formulated to reduce the mobile divide.

Keywords: Growth models, Mobile communication

Introduction

Indian mobile subscriber base continues to grow and has reached about 105 million in June 2006 from about 57 million a year ago. The compounded annual growth rate of mobile subscriber base has been 91.5 % over the last five years. Revenue from cellular mobile services[1] touched Rs. 35,879 crores for the fiscal year ending March 2006. Despite this substantial growth of mobile services, penetration of mobile services is not uniform across different areas of the country. While the urban teledensity in India has touched 31, the rural teledensity stands at about 1.94 per 100 population[2]. Qualitative narratives and descriptive statistics[3,4] of the mobile sector for many countries are available from a variety of industry sources. However, empirical studies[5-7] of cellular market growth are much more limited in number. This study aims to model growth of mobile services across different regions of India so that appropriate policies can be formulated to the development of low-growth regions.

Licensing of Mobile Services in India

Cellular Mobile Service Providers (CMSPs) are licensed to operate in designated geographical operating areas, referred to as “circles”. In India, there are 23 circles, which include four metro areas (Chennai, Delhi, Kolkata and Mumbai). Other circles are normally defined by state boundaries, except in case of large states such as UP [UP (East) and UP (West)]. Some of the smaller states were combined together as a single circle (North East covering all north eastern states such as Mizoram, Tripura, etc.). These circles are categorized (A, B and C) based on the expected revenue potential with category C circles in the lower end of the scale (Table 1). Indian cellular market adopted a duopoly market with licenses given to two CMSPs. Global Systems for Mobile[8] (GSM) was mandated as the technology to be adopted licensing process for cellular mobile services started in India in 1992, initially for the four metro areas. Metro licenses were issued and the first digital cellular service started in metros in 1995. In August 1995, licenses were awarded to 2 CMSPs in each of the other 19 circles. The rentals[9,10] were fixed as the same for metros. The amount of license fee bid[11] for 19 circles amounted to a total of Rs. 27,037 crores (Table 2).

In 1999, the government realized that most of the operators were not able to even pay the annual fee towards the bid amount. The government proposed a revenue sharing regime by fixing an entry fee equivalent to 2.8-2.9 years of license fees. All the operators paid the arrears and migrated to a revenue sharing scheme, except for one operator who could not pay the entry fee and subsequently lost its license in UP(E), UP(W), Bihar and Orissa. Subsequently, third operator license was awarded to government owned operator, Mahanagar Telephone Nigam Ltd (MTNL) for Mumbai and Delhi metros, and Bharat Sanchar Nigam Ltd (BSNL) for rest of the circles in

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Table 1—Circles for mobile services

Metros	Category A	Category B	Category C
Delhi	Maharashtra	Kerala	Himachal Pradesh
Mumbai	Gujarat	Punjab	Bihar
Chennai	Andhra Pradesh	Haryana	Orissa
Kolkata	Karnataka	Uttar Pradesh (W)	Assam
	Tamil Nadu	Uttar Pradesh (E)	North East
		Rajasthan	Jammu & Kashmir
		Madya Pradesh	
		West Bengal, Andaman & Nicobar	

Table 2—License fee commitments in select circles[11]

Circles	1st Round (1995)		2nd Round (2001)	
	No. of licenses	Aggregate license fee Rs crores	No. of licenses	Aggregate license fee Rs crores
Maharashtra	2	3,315	1	189
Gujarat	2	3,588	1	109
Andhra Pradesh	2	2,002	1	103
Karnataka	2	2,786	1	207
Tamil Nadu	2	1,672	1	79
Kerala	2	1,034	1	41
Punjab	2	2,532	1	152
Haryana	2	480	1	22
Uttar Pradesh (W)	2	422	1	31
Uttar Pradesh (E)	1	812	1	45
Rajasthan	2	7764	1	32
Madya Pradesh	2	102		18
West Bengal, Andaman & Nicobar	1	42	0	No license issued
Himachal Pradesh	2	30	1	1
Bihar	2	273	0	No license issued
Orissa	2	178	0	No license issued
Assam	1	1	0	No license issued
North East	2	4	0	No license issued
Total		27,037		1,029

2001. The licensing process for the fourth cellular license was initiated in 2001. Bids for the fourth operator licenses were invited for a lump sum to be paid as entry fees. Subsequently, licenses issued in August 2001, using a three-stage auction procedure. The winning bid amount for the fourth cellular licenses is given in Table 2. The reduction in bid amount compared to the first round is evident due to the following reasons: 1) The cellular mobile service market had grown and showed certain maturity level and hence made it possible for the operators to bid realistically considering the market potential; and 2) The 3-stage auction procedure allowed the bidders to revise their bids at each stage, thus reducing the probability of winners curse.

Though government removed the requirement of GSM as technology to be adopted in the fourth cellular license guidelines, license winners adopted GSM to make their network inter-operable with existing networks. No operator picked up most of the category C circles (Table 2). During this period, government also liberalized the Basis Telecom Services (BTS) market, which typically provided traditional landline based Plain Old Telephone Service.

In 2000, Basic Telecom Services[12] (BTS) operators approached the government with a proposal that they could provide local access loop at lower cost using Code Division Multiple Access (CDMA) wireless technology. BTS operators argued that quick deployment of wireless CDMA service provide high spectral efficiency and lower per line cost compared to landline services, and hence is definitely a better alternative compared to wired access loop for certain areas of the country[8]. This proved to be a direct competition for GSM based CMSPs. At this situation, government intervened[13] and Wireless Local Loop with Limited Mobility (WLL-LM) was specified in the basic service license.

Today, mobile services in India is split between 4 CMSPs and Unified Access Service Providers (UASPs). About 80% of them are GSM cellular mobile subscribers while the rest are with CDMA based service provided by UASPs[14] (Tables 3 and 4).

Spectrum Allocation for Mobile Services

A 900 MHz of GSM band was allotted to first three CMSPs, while 1800 MHz was allotted to the fourth operator. UASPs were allotted 800 MHz band for their CDMA service. In India, licensing is coupled with spectrum allocation. CMSPs get 2 × 4.4 MHz as soon as they receive their license. For CDMA, initial spectrum allocation along with license was 2 × 2.5 MHz. Further allocation of spectrum was based on network rollout and subscriber base of the operators. Operators have to pay spectrum charges[2,15] depending on the amount of spectrum allotted (Table 5). UASPs are awarded half the amount of spectrum compared to CMSPs for an equivalent subscriber base (Table 5), due to government's decision to treat CDMA technology used by UASPs to be a spectrum efficient that can support more number of subscribers for a given spectrum compared to GSM. Hence, if more spectrum is allotted for UASPs, that might lead to hoarding of spectrum and hence an inefficient use of scarce spectrum.

Table 3—Mobile subscriber base in various circles[14] (As on June 2006)

Circles	GSM subscribers	CDMA subscribers	Total subscribers
Delhi	6,137,943	2,854,206	8,992,149
Mumbai	5,938,463	2,330,597	8,269,060
Chennai	2,649,803	675,398	3,325,201
Kolkata	2,377,811	1,277,475	3,655,286
Maharashtra	5,613,317	2,138,657	7,751,974
Gujarat	5,808,101	1,463,213	7,271,314
Andhra Pradesh	5,463,547	2,684,208	8,147,755
Karnataka	5,619,488	1,506,416	7,125,904
Tamil Nadu	5,308,763	1,276,399	6,585,162
Kerala	3,720,683	1,097,630	4,818,313
Punjab	4,713,323	1,058,256	5,771,579
Haryana	1,757,203	614,221	2,371,424
Uttar Pradesh (W)	3,510,754	1,365,488	4,876,242
Uttar Pradesh (E)	4,289,206	1,703,255	5,992,461
Rajasthan	3,047,126	1,249,259	4,296,385
Madya Pradesh	2,676,909	1,226,519	3,903,428
West Bengal, Andaman & Nicobar	25,951,290	8,916,914	34,868,204
Himachal Pradesh	701,694	71,597	773,291
Bihar	2,777,531	937,727	3,715,258
Orissa	1,474,299	358,601	1,832,900
Assam	1,127,005	0	1,127,005
North East	587,232	0	587,232
Jammu & Kashmir	948,328	0	948,328

Table 4—Region-wise break-up of mobile subscribers in India[14] (as on June 2006)

Service area	Mobile subscribers		Compounded annual growth rate (CAGR) in last 2 years
	Number	%	%
Metros	24,241,696	23.09	51.09
A	36,882,109	35.13	63.73
B	34,868,204	33.22	81.11
C	8,984,014	8.56	143.23
Total	104,976,023		65.79

Price of Mobile Services

Department of Telecom (DoT) had fixed the maximum rental at Rs 156 a month for metros during the first stage of licensing. DoT also placed a ceiling on call charges – a standard rate of Rs 8.40 per call per minute, peak rate as high as twice the standard rate and off-peak rate as high as half the standard rate. However, realizing that the high call charges discouraged the callers, Telecom Regulatory Authority (TRAI) raised monthly rate from Rs 156 to Rs 600 per month in May, 1999. The standard peak-time call charge was also reduced from Rs 16.80 per minute to Rs 6 per minute. The pulse rate was reduced to 20 seconds, thus reducing the minimum call charges to Rs 2. The introduction of third and fourth CMSPs increased competition leading to drop in prices.

In 2002, TRAI again reviewed[9] and metro rentals were reduced to Rs 475 and other circles to Rs 500. The standard rate for metros was reduced to Rs. 4 per minute in metros (Rs 4.50 for other circles) and Rs 2 (Rs 2.25 for other circles) for each subsequent minute. However, concession rates were subject to forbearance. Introduction of WLL-LM in 2002 by the then BTS operators increased amount of competition. TRAI announced Calling Party Pays regime in January 2003, which fuelled drop in prices. Until then the Mobile Part Pays scheme was in existent wherein the receiver of a mobile call also shared part of the call charges.

Telecommunication Interconnection Usage Charges[16] (IUC) regulation, notified by TRAI, decided that mobile callers had to pay additional Access Deficit

Charges (ADC) to wire-line BTS operators towards maintenance of rural phone lines. This increased per minute call charges. Over the years, TRAI[17] has been reducing ADC, which currently is 1.5% of Adjusted Gross Revenue (AGR) of the operators, including CMSPs and UASPs (Fig. 1).

Competition in Mobile Services

Though DoT introduced more and more competition in mobile services, the competition is not uniform across all regions of the country. In metros and category A circles, active competition has been existing since 1996 (Table 5). Some of the category B circles and most of the category C circles had monopoly until 2001. However, most of these circles have been able to attract service providers with some circles having up to 6 operators. Maximum number of operators is in Punjab with 7 operators (Table 6).

Fig. 1—Effective mobile call charges[17]

Revenue of Mobile Operators

India's mobile services are one of the cheapest in the world. Though low prices have fuelled demand, Average Revenue Per User (ARPU) per month continues to be well below the world average (Fig. 2). CMSPs reported Rs 366 and UASPs reported Rs 256 for mobile services as per their ARPU by March 2006[18]. This is a reduction from Rs 394 a year back.

Taxes and Levies

Taxes and levies on telecom operators are very high in India. There is the annual license fee (6-10 %) levied on the AGR of the operator, an additional spectrum charges (2-6 %) as per the spectrum allotted and ADC (1.5 %) of AGR. Apart from these, telecom subscribers pay (12.24%) towards service tax and education cess. There is also lack of transparency in the use of these levies for telecom related projects. For example, all TELCOs contribute Universal Service Levy (5 %) to Universal Service Obligation (USO) fund, set up in April, 2002 to provide financial support to Basic Telecom operators, especially

Table 5—Spectrum allocation and charges for mobile services[2,15]

Type of Operators	Minimum subscriber base required, millions	Quantum of spectrum MHz	Annual spectrum charges % of adjusted gross revenue
CMSPs	-	2×4.4	2
	-	2×6.2	3
	0.5	2×8	3
	1.0	2×10	4
	1.2	2×12.5	5
	Not yet decided	2×15	6
UASPs	-	2×2.5	2
	Delhi & Mumbai, 0.3 Chennai & Kolkata, 0.2 Category A circles, 0.4 Category B circles, 0.3 Category C circles, 0.15	2×3.75	2
	Delhi & Mumbai, 1.0 Chennai & Kolkata, 0.6 Category A circles, 1.2; Category B circles, 1.0 Category C circles, 0.5	2×5.00	2

Table 6—Number of operators in each circle

Circles	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Delhi	2	2	2	2	2	3	5	6	6	6	6
Mumbai	2	2	2	2	2	3	4	4	6	6	2
Chennai	2	2	2	2	2	2	3	4	6	6	6
Kolkata	2	2	2	2	2	2	3	3	5	6	6
Maharashtra	0	2	2	2	2	2	4	6	6	6	6
Gujarat	0	2	2	2	2	2	6	6	6	6	6
Andhra Pradesh	0	2	2	2	2	2	5	6	6	6	6
Karnataka	0	2	2	2	2	2	5	6	6	6	6
Tamil Nadu	2	2	2	2	2	2	5	6	6	6	6
Kerala	0	2	2	2	2	2	4	5	5	6	6
Punjab	0	1	1	1	1	2	4	5	6	7	7
Haryana	0	2	2	2	2	2	4	5	5	6	6
Uttar Pradesh (W)	0	2	2	2	2	2	3	4	4	6	6
Uttar Pradesh (E)	0	2	2	2	2	2	2	3	4	5	6
Rajasthan	0	2	2	2	2	3	4	5	5	6	6
Madya Pradesh	0	1	2	2	2	2	4	5	5	6	6
West Bengal, Andaman & Nicobar	0	0	1	1	1	1	2	3	5	6	6
Himachal Pradesh	0	1	2	2	2	2	3	4	4	5	6
Bihar	0	1	2	1	1	1	2	3	4	5	5
Orissa	0	1	1	1	1	1	2	3	5	6	6
Assam	0	0	1	1	1	1	1	1	2	4	4
North East	0	0	1	1	1	1	1	2	2	4	4
Jammu & Kashmir	0	0	0	0	0	0	0	0	2	2	3

Fig. 2—Variation in ARPU[2,18]

government owned BSNL for providing rural area connectivity. So far, telecom operators have paid around Rs 9,000 crores, out of which only about Rs 1,700 crores have been disbursed. Apart from USO fund, more than Rs 18,000 crores have been paid by mobile, national and international callers in the last 3 years through ADC. This is supposed to be distributed to BSNL for the upkeep and maintenance of rural fixed lines. Though TRAI reduced ADC substantially in February 2006, estimated ADC accrual to BSNL this year alone is about Rs 3,335 crores. There is again non-transparency on the utilization of these charges[2]. Higher tax burden (30-35 %) in India, as compared to tax burden in single digit in Pakistan, Sri Lanka and China, increases annual expenditure and hence acts as a deterrent for further investment.

Growth Models

For any individual subscriber, utility derived from communication system increases correspondingly with an increase in the set of users. This relationship is especially strong for various telephone[19] and computer networks[20]. When cellular network system was introduced in India in 1995, there were already 10 million landline subscribers. Those who subscribed to cellular services at that time derived a positive net utility as being able to talk to existing landline subscribers. As more and more started subscribing to cellular services, utility of the system increased which resulted in marginal number of non-users subscribing to the system. However, when population of potential

Table 7—Regression results (Logistic Model) for subscribers in metro, category A and B circles

Parameter	Estimates K	A	b	Saturation limit, 1/K
Metros (R^2 = 0.9957, N=37)	2.2503×10^{-8}	0.00001105	0.8474	44,437,927
Category A (R^2 = 0.9900, N=37)	1.2454×10^{-8}	0.00001312	0.8390	80,297,422
Category B (R^2 = 0.9963, N=37)	5.1421×10^{-9}	0.00001945	0.8386	194,474,210

subscribers is finite, resulting pattern of growth tends to be S-shaped[20]. A typical growth curve that has an S-shape has three distinct phases. In the initial stages, growth is less as subscribers are not fully informed and aware about the utility they derive by joining the system. However, as the number of subscribers attains a "critical mass", number of subscribers in the system is large enough for the growth process to become self-sustaining. Growth increases near exponentially in the second phase. The last stage indicates stability in growth as the saturation level of subscribers is reached.

Applicability of network externalities is very much evident in the mobile services in India. After first cellular licenses were issued in 1995, subscriber base shot up from nothing to more than 300,000 in just one year. Cellular subscribers could connect and talk to the then existing 12 million landline users and therefore critical mass was achieved almost instantaneously resulting in good growth in cellular service adoption in the country. Introduction of UAS license and the associated CDMA service gave further fillip to the growth of mobile services in India, resulting in a near exponential growth.

Logistic Model of Growth

The approach to modelling the growth of such processes that exhibit S-curve pattern assumes that demand for communications access is limited by a saturation level. It is also assumed that the rate of growth in number of subscribers is positively influenced by: 1) number of existing subscribers; and 2) difference between saturation level and the number of existing subscribers. Mathematical function of growth model (logistic curve) is given as

$$\frac{dy}{dt} = qy\left(y^{*} - y\right) \qquad \ldots (1)$$

which can also be written as

$$y_T = \frac{1}{K + Ab^T} \quad A > 0, 0 < b < 1 \qquad \ldots (2)$$

where y_t is the subscriber base at time t; K, A and b are various constants.

Eq. (2) represents an increasing S-curve, which tends to the limit $1/K$ as $T \rightarrow \infty$. Eq. (2) is non-linear and parameters can be estimated using a non-linear regression method.

Analysis of Data

It was hypothesized that the growth of mobile services as measured by the number of subscribers follows the S-curve pattern. Quarterly data was analysed on Indian mobile subscriber base (including GSM and CDMA subscribers) from first quarter of 1997 until the second quarter of 2006 and fitted logistic non linear regression model of S-curve as in Eq. (2).

Subscriber Growth in Metros, Category A and B Areas

Regression results (Table 7) were derived using non-linear least squares for different category of service areas for metros (Fig. 3), category A (Fig. 4), and B circles (Fig. 5). A closer analysis of the growth pattern leads to predict that the subscriber base in metros will reach saturation at about 44 million (current 24 million), category A circles at 80 million and category B circle at 194 million.

Subscriber Growth in Category C Areas

For category C circles, logistic curve cannot be fitted due to: 1) Operators have started deploying their infrastructure in most of the category C circles only in 2002; and 2) Category C circles have been witnessing very high Compounded Annual Growth Rate (143%) recently (Table 4). Hence, most of the category C circles are witnessing early stages of diffusion of mobile services and hence cannot be represented appropriately using a logistic model[21]. Hence, an alternative exponential model (EM)[21] that assumes a constant rate of growth and does not involve either an inflection point in growth rate or a finite saturation limit, is explored. EM provides closest fit to the growth of Internet and is described as[19]

$$y_t = Ae^{bt} \quad A, b \geq 0 \qquad \ldots (3)$$

Eq. (3) can be alternatively represented as

Fig. 3—Actual and fitted values of mobile subscriber base in metropolitan areas

Fig. 4—Actual and fitted values of mobile subscriber base in category A service areas

$$\log(y_t) = C + bt \qquad \dots (4)$$

where, y_t is the subscriber base at time t; C is a constant and is the intercept in the regression equation; b is the coefficient of time t in the regression equation.

Regression results using parameters of model shown in Eq. (4) using Ordinary Least Squares estimation were (R^2 = 0.9360, N = 37): C, 7.6040; and

Fig. 5—Actual and fitted values of total mobile subscriber base in category B service areas

Fig. 6—Actual and fitted values of total mobile subscriber base in category C service areas

b, 0.2240. EM shows a very good fit with the actual number of subscribers until now (Fig. 6). However, due to lack of upper limit, EM is expected to fail in its prediction during later stages of mobile growth. However, since mobile growth has been higher in category B and C circles as compared to metros and category A circles, operators should seriously consider these circles for expanding their subscriber base.

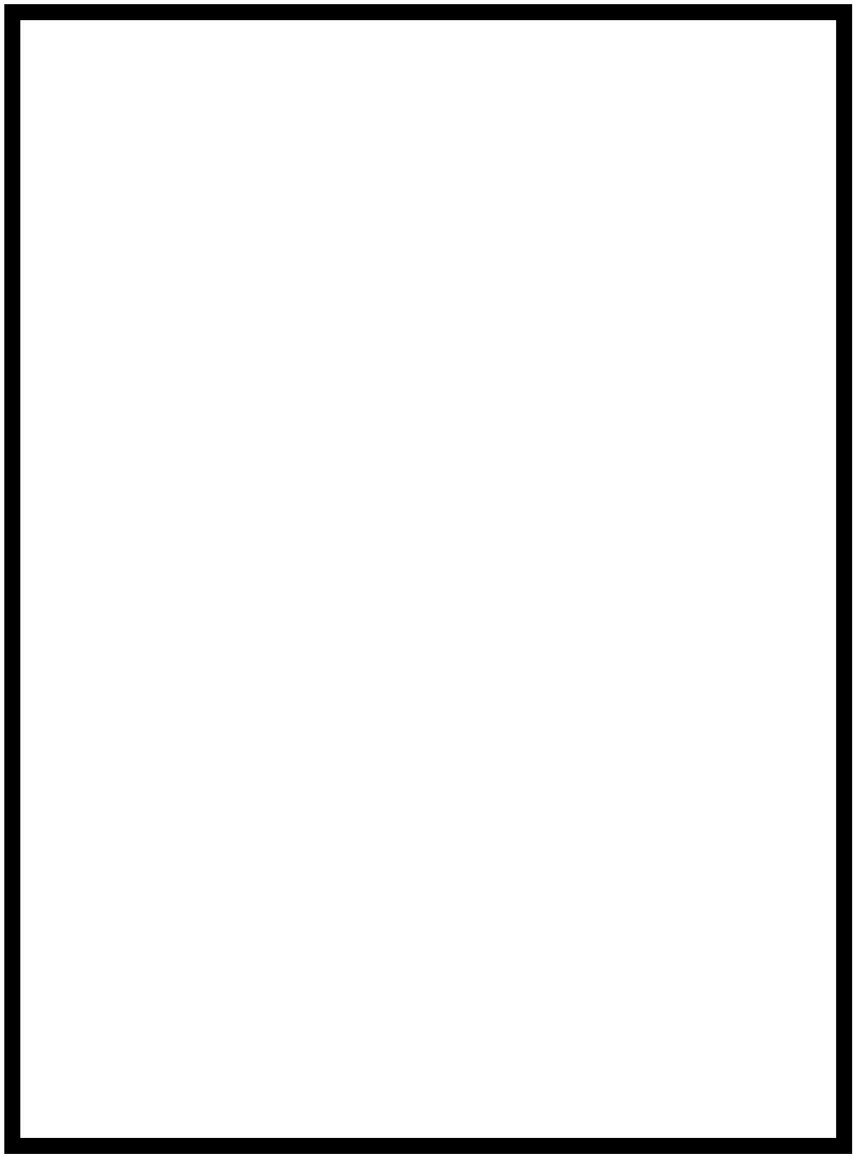

Fig. 7—Causal factors that affect mobile penetration

Other Factors that Affect Mobile Growth

There are critics of the S-curve growth pattern, prominent ones being those who proved that Internet growth is still exponential and the saturation point as predicted by previous researchers has been surpassed[21]. Specifically, S-curve theories ignore such external factors as government policies, technological advancements, and service innovations. Saturation limit[22,23] depends on a number of factors including growth in disposable income of potential subscribers, price of services, competition in the market place, price and availability of alternative communication channels, such as the Internet and regulatory policies regarding spectrum allocation and interconnection. A causal model[22] (Fig. 7) that illustrates the various factors that affect telecommunication penetration was built.

Existence of all major cause-and-effect links indicates the direction (cause -> effect) of each relationship, which is positive (or negative) if a change in the causal factor produces a change in the same (or opposite) direction in growth. A closed sequence of causal links represents a causal loop, which is positive if it has all positive links or even number of negative links. Otherwise, it is a negative loop. The demand side of causal loop diagram indicates that increased economic growth (as measured by per capita GDP) increases disposable income of population and hence affects demand for telecom services positively. Competition in the market place reduces the effective prices of telecom services, which in turn fuels demand, as indicated by price elasticity of demand. Increased land area increases demand for telecom services. Population has a positive effect on demand for telecom services.

On supply side, competition in the market place has a positive association with telecom investment, which in turn, increases the supply of telecom services. However, lower prices acts as disincentives for telecom investment, which in turn, has a negative effect on telecom penetration. Demand has a positive effect on telecom investment. With increased telecom penetration, the economic development area also improves. Taxes and levies by government have a negative effect on telecom investment. Competition in the marketplace also increases the level of telecom investment in the area. The dual causation[22,24] between telecom penetration and economic development are also shown in the causal loop diagram.

Future Research Directions

Though forecast using S-curve theory does not take in to account any external exogenous factors, present forecasts indicate possible directions for future growth. The policy makers, regulator and industry have to work together to promote positive effects and reduce negative effects (Fig. 7) so that telecom penetration in the country can sustain its momentum. Future research could be carried out to empirically test the causal model (Fig. 7) within S-curve framework so that more valid projections of growth can be performed. Madden *et al*[25] modelled the growth of global mobile telephony taking into account the effect of economic factors using panel date of 56 countries. Rouvinen[26] extended Madden *et al*[25] model taking into account other socio-economic factors. Extension of S-curve logistic model of growth across different regions of the country taking into account the effects of economic development of the region, extent of competition, investment in telecom, and price of services will provide useful insights into the mechanics of growth of mobile services across India.

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