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INTERNET DIFFUSION IN INDIA: A STUDY BASED ON GROWTH CURVE MODELLING

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Abstract

The Internet, which was introduced to the Indian public in the mid-1990s, has become the dominant means of communication and revolutionizing the communication environment like nothing before. As a result, Internet demand in India is increasing at a tremendous rate; in the year 2019-20 alone, 190 million new Internet users were added. Due to this, Internet-penetration in the country surpassed the mark of 40 percent in the same year. The main aim of this paper is to assess the pattern and rate of diffusion of the Internet in India in order to contribute towards the larger dialogue on managing the services and evaluating the impact of Internet on various aspects of socio-economic dimensions in India. The study uses *S*-shaped growth curve models, logistic, Gompertz, and simple modified exponential ones, for the same. We find that India is likely to achieve universal Internet access by the year 2028-29. Thus, 2028-29 may be a turning point in the socio-economic trajectory of the country. Further results, implications and future research scope are also discussed.

Keywords: Internet diffusion, technology diffusion, digital divide, forecasting, growth model

1. INTRODUCTION

The modern information technology revolution is majorly channelized through the power mechanism of Internet. Internet is a world-wide broadcasting capability, a platform for information dissemination, an interaction and networking medium, and a marketplace for goods and services (Buera and Oberfield, 2020; Bloom et al., 2021). The internet is an empowering infrastructure being able to facilitate or enhance productivity throughout industries, sectors and business domains (Bamford et al., 2021). Both individuals as well as large to small communities have a conferred interest in the current and future access of internet services in order to remain competitive players in the global information economy (Canh et al., 2020). Hence, understanding the diffusion of Internet usage is highly relevant to economic development agencies and local governments across the globe (Mack and Grubesic, 2009; Johansson, 2021).

Since Internet is a powerful tool for development socially as well as economically, assessing the diffusion of the Internet is significant because it has potential to change many aspects of socio-economic life (Sanchez-Robles, 1998; Roller and Waverman, 2001; Kenny, 2003). The diffusion of the Internet has been extensively studied in high and upper middle-income countries (see, for example, Beilock and Dimitrova, 2003; Chong and Micco, 2003; Xue, 2005; Egea et al., 2007; Akiyoshi and Ono, 2008; Chu and Pan, 2008; Li and Shiu, 2012; Lin, 2013; Salman et al., 2013; Martínez-Domínguez and Mora-Rivera, 2020). However, there are few such studies for lower middle-income countries (see, for example, Estache et al., 2002; and Mbarika, 2002; Ojuloge and Awoleye, 2012; Owusu-Agyei et al., 2020) and very few for India (e.g. Fletcher et al., 2014; Chauhan et al., 2018; Mital et al., 2018). Chauhan et al.'s study (2018) focused on the factors inhibiting the adoption of internet in India while Fletcher et al. (2014) and Mital et al. (2018) studied the particular case of broadband diffusion, and adoption patterns of Internet of Things in India, respectively.

This paper uses *S*-shaped growth curve models to depict the development in Internet penetration (Internet access per 100 people) and Internet demand (number of Internet users) in India. The models are built on two explanatory variables - per capita gross national income (GNI) and time. Models are estimated using the relevant data from 1999-00 to 2019-20. Source of the Internet penetration and demand data is International Telecommunication Union (ITU) published World Telecommunication/ICT Indicators Database 2021 whereas GNI data is taken from the Economic Survey 2021-22 (Statistics Appendix) published by the Ministry of

Finance, Government of India, New Delhi. The remaining of the paper is organized as follows: section 2 outlines the historical data of Internet demand, in terms of number of Internet users, and Internet penetration in India; section 3 discusses the diffusion models; section 4 presents the estimated models, model selection, results, and discussions; and section 5 deliberates on the conclusion of the study, implications of the findings, and future research in the area.

2. ADOPTION PATTERN OF INTERNET USERS IN INDIA: 1999-00 TO 2019-20

India got introduced to the Internet in 1986, though Internet was available to the public only after a decade when Videsh Sanchar Nigam Limited (VSNL) launched the internet on August 15, 1995. As per the International Telecommunication Union (ITU) data, there were only 0.45 million internet users in India in 1995-96. The dotcom bubble burst of the new century was accompanied with the launch of online ticketing system for Indian railways and airlines. Google started operating in India in 2004, and around the same time Bharat Sanchar Nigam Limited (BSNL) launched broadband services. The social network sites were launched in 2005 with Orkut, followed by Facebook a year later. Further, 2G spectrum came in 2008, followed by 3G in the next year. Bharti Airtel was the first operator to market dongle-based 4G services in 2012, followed by mobile 4G services in 2014. Next, Reliance launched its Jio mobile offering customers three months of free services followed by free calls and data plans, becoming the world's cheapest network provider. Soon, the Indian railway stations were equipped with free WiFi services. In 2019-20, India had a count of 500 million internet users, marking an important milestone (Figure 1). On October 1, 2022, 5G services are also launched in the country. 5G services, presently provided by the Bharti Airtel and Reliance Jio, are expected to increase not only data consumption but also internet penetration further.

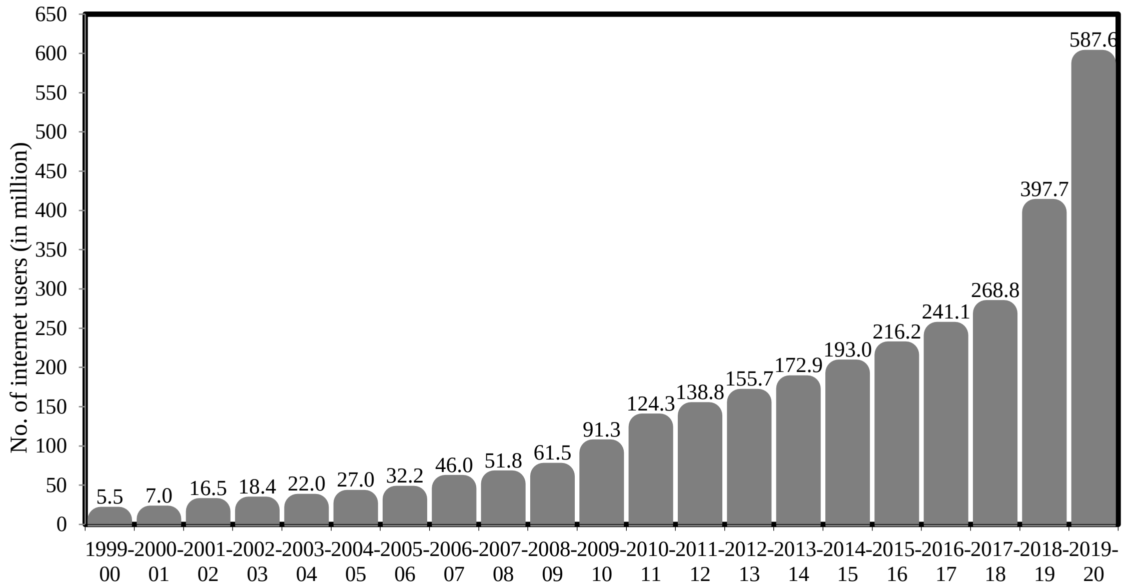


FIGURE 1 - NUMBER OF INTERNET USERS IN INDIA
Source: Authors' calculation

The demand for Internet in India has increased tremendously since its introduction in the country, particularly during the 21st century; total number of Internet users in the country increased more than 100 times in a span of just twenty years from 5.5 million in 1999-00 to 587.6 million in 2019-20 (Figure 1). Internet evolution in India has skyrocketed in recent years; number of internet users have increased at the rate of almost 50 percent per year during 2017-18 to 2019-20. The phenomenal growth in number of Internet users in the country has been possible on account of macroeconomic factors such as deregulation, liberalization, and market competition. With rising competition, internet tariffs fell dramatically. The UK-based http://cable.co.uk, consistently finds India's mobile internet rate per GB among the lowest in the world. Comparing mobile data charges of 230 countries, their study in March 2020, finds that the average price of $ 0.09 for one gigabyte (GB) compares to

$ 0.61 in China, $ 1.39 in the UK, and $ 8.00 in the US. Apart from the impetus of low and falling tariff rates, also the average income of the people has been rising in India. As per the Economic Survey 2021-22, per capita GNI (at 2011-12 prices) in the nation has risen, on an average, at 4.99 percent per year during 1999-00 to 2019-20 whereas it increased at the rate of 5.63 percent per year in the last five years (2014-15 to 2019-20). Thus, the Internet demand in India is stimulated by reduced tariffs and increasing average income levels.

Although India's Internet demand with nearly 588 million users, ranks among the highest in the world, its Internet-penetration, i.e., the number of Internet users per 100 inhabitants, is less than the world average (43 percent vs 59 percent in 2019-20 as per the ITU). Nevertheless, growth in Internet-penetration has been remarkable in the recent years. From 2014-15 to 2019-20, Internet-penetration in the country grew at the rate of 24.93 percent per year against the per capita GNI growth of 5.63 percent per year. It is worth noting that the growth in Internet-penetration during the last two years has been even higher. Between 2017-18 and 2019-20, in light of around 4.28 percent per year growth in per capita GNI,

3. THE INTERNET DIFFUSION MODEL

The adoption of technology and its diffusion process has been expansively studied in the past and is also relevant in recent times in view of rapid pace of technological changes and advancement (For example, refer, Rai and Samaddar, 1998; Caselli and Coleman, 2001; Keller, 2001; Kiiski and Pohjolo, 2002; Jahanmir and Cavadas, 2018; Taherdoost, 2018; Buera and Oberfield, 2020; Takahashi et al., 2020; Bloom et al., 2021; Johansson, 2021). Research has found commonly that in the context of successful innovations, an *S*-shaped curve emerges for cumulative innovation adoption (Rogers, 1995). Numerous interpretations are offered for the form of such curve. For instance, individual characteristics are normally distributed in a population, example, the threshold (i.e., innovativeness, Rogers, 1995) and reservation price (Goolsbee and Klenow, 2002) for adoption. Therefore, initially the curve rises slowly; then increases rapidly at an exponential rate; but then declines in a negative acceleration phase until at zero growth rate the stability is realized at the saturation level (Wu and Chu, 2010).

Since Internet is a key tool of economic and social development, understanding and projecting the growth pattern of Internet demand is of paramount importance. The demand for Internet depends on various socio-economic factors, such as, average income, income distribution, average age, age distribution, household composition, educational level, Internet tariff, quality of Internet services, technological development, regulatory mechanism, government policy towards the sector, etc. For aggregate level, the association of Internet-penetration with determinants affecting it, can be written as,

$$I_P = f(X) \qquad (1)$$

where I_P is Internet-penetration (in percent) and X is a vector of factors determining the same.

Equation (1) can be used to estimate the future Internet-penetration, provided data is available for all the explanatory variables. But time series data for most of the variables is not easily obtainable for India. Therefore, it is vital to utilize the available time series data in determining the Internet-penetration. Kridel et al. (1999), Estache et al. (2002), Mbarika (2002), Beilock and Dimitrova (2003), Canh et al. (2020), Chiou and Tucker (2020), Tewathia (2020), and several studies have found a positive relationship between average income and Internet-penetration. The positive relationship between average income and Internet-penetration is demonstrated for both cross-sectional as well as time-series data. This relationship, i.e., the positive association of Internet-penetration with per capita GNI, for India is shown in Figure 2. Thus, we choose per capita GNI as the main determining factor to estimate the future Internet-penetration in India. Further, supposing that time incorporates the influence of omitted variables, equation (1) can hence be written as,

$$I_P = f(\frac{GNI}{cap}, t) \qquad (2)$$

where I_P is Internet-penetration, $\frac{GNI}{cap}$ is per capita GNI, and t is time.

As stated earlier, in the early adoption stage, because of few members in the society opting for internet services, Internet-penetration is likely to grow slowly, however, with time, it rises rapidly as more people adopt the services on account of network externality, information dissemination, higher income, etc. Gradually, the rate of growth declines during the maturity stage, with eventual convergence to maximum or universal coverage (Singh, 2008). Therefore, if we plot Internet-penetration against the time or per capita GNI, the graph is likely to look like an *S*-shaped curve. The *S*-shaped curve can be depicted by various functional forms, such as, the logistic, logarithmic logistic, log reciprocal, simple modified exponential, general modified exponential, and Gompertz functions.[1] Amongst these, the logistic, Gompertz, and simple modified exponential functions are the most popular ones. This study uses these three functions to estimate and project the Internet-penetration in India.

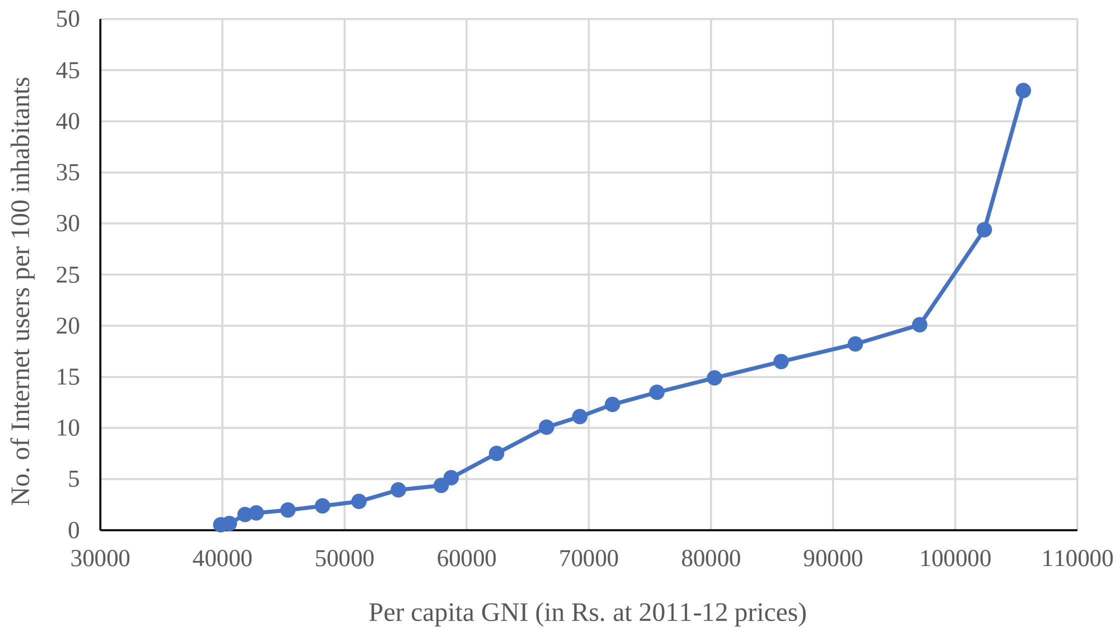


FIGURE 2 - GNI PER CAPITA AND INTERNET-PENETRATION IN INDIA FROM 1999-00 TO 2019-20
Source: Authors' calculation

3.1. The logistic model

Internet-penetration, I_P, can be presented by the logistic form as,

$$I_P = \frac{\alpha}{1+\beta e^{f(\frac{GNI}{cap},t)}} \tag{3}$$

where both the parameters, α (saturation level) and β, are positive.
Equation (3) can be re-written as,

$$\frac{\alpha}{I_P} - 1 = \beta e^{f(\frac{GNI}{cap},t)} \tag{4}$$

We can convert equation (4) in a linear form as,

$$ln(\frac{\alpha}{I_P} - 1) = ln\,\beta + f(\frac{GNI}{cap},t) \tag{5}$$

where *ln* represents natural logarithm.

[1] A summary of such functional forms can be seen in Meade and Islam (1998); one may also see Griliches (1957), Mansfield (1961), Chow (1967), Chaddha and Chitgopekar (1971), Tanner (1978), Bewley and Fiebig (1988), Meade and Islam (1995), Dargay and Gately (1999), Singh (2000, 2008), Franses Philip Hans (2002), Botelho and Pinto (2004), Mohamed and Bodger (2005), Jahanmir and Cavadas (2018), Taherdoost (2018), Buera and Oberfield (2020), Takahashi, Muraoka, and Otsuka (2020), Bloom et al. (2021), and Johansson (2021).

Equation (5) needs to be simplified further to estimate the model using the Ordinary Least Squares (OLS) method. The simplified version of equation (5) is as follows,

$$ln(\frac{\alpha}{I_P}-1)=\beta_1+\beta_2 t+\beta_3(\frac{GNI}{cap})+\beta_4(\frac{GNI}{cap})^2+\varepsilon \qquad (6)$$

where ε is an error term, independent and identically distributed, with an expected value of zero and a constant variance, and parameters, β_1, β_2, β_3, and β_4, are be estimated using the OLS method.

3.2. The Gompertz model

The Gompertz function is,

$$I_P=\alpha e^{-\beta e^{f(\frac{GNI}{cap},t)}} \qquad (7)$$

where all the variables and parameters have their previous meaning, and both the parameters are positive.

We can write equation (7) in a linear form as,

$$ln[\,ln(\frac{\alpha}{I_P})]=ln\,\beta+f(\frac{GNI}{cap},t) \qquad (8)$$

where *ln* represents natural logarithm.

Equation (8) can be simplified further to estimate the model using the OLS method as,

$$ln[\,ln(\frac{\alpha}{I_P})]=\beta_1+\beta_2 t+\beta_3(\frac{GNI}{cap})+\beta_4(\frac{GNI}{cap})^2+\varepsilon \qquad (9)$$

where ε is an error term, independent and identically distributed, with an expected value of zero and a constant variance, and parameters, β_1, β_2, β_3, and β_4, are be estimated using the OLS method.

3.3. The simple modified exponential model

Equation (10) depicts the simple modified exponential function as,

$$I_P=\alpha(1-\beta e^{f(\frac{GNI}{cap},t)}) \qquad (10)$$

where all the variables and parameters have their previous meaning, and both the parameters are positive.

Equation (10) can be transformed in a linear form as,

$$ln(\frac{\alpha-I_P}{\alpha})=ln\,\beta+f(\frac{GNI}{cap},t) \qquad (11)$$

where *ln* represents natural logarithm.
Equation (11) can be simplified further to estimate the model using the OLS method as,

$$ln(\frac{\alpha-I_P}{\alpha})=\beta_1+\beta_2 t+\beta_3(\frac{GNI}{cap})+\beta_4(\frac{GNI}{cap})^2+\varepsilon \qquad (12)$$

where ε is an error term, independent and identically distributed, with an expected value of zero and a constant variance, and parameters, β_1, β_2, β_3, and β_4, are be estimated using the OLS method.

Equations (6), (9), and (12) can easily be estimated if α is known. Saturation level, α, is likely to be 100 since, in the long run, all people will have access to the Internet. High-income countries are already close to the universal Internet access; for example, as per the ITU, Internet-penetration in Australia, Belgium, Spain, Switzerland, United Kingdom, South Korea, Qatar, and United Arab Emirates is 89.6, 91.5, 93.2, 94.2, 94.8, 96.5, 99.7, and 100, respectively in the year 2020. Therefore, saturation level, α, is assumed to be 100. All the three equations (6), (9), and (12) are estimated using the OLS method for $\alpha = 100$.

Performance of estimated equations, representing the logistic, Gompertz, and simple modified exponential models, can be assessed using their mean absolute percentage error (MAPE) and Durbin-Watson (DW) statistic (Singh, 2008; Franses, 2002). The DW statistic between 1.5 and 2.5 can be inferred to indicate that there is no autocorrelation (Wooldridge, 2002). We can use F-test to test the validity of restriction on coefficients. For example, whether $\beta_2 = 0$ or not can be tested by performing F-test. If estimated F value is more than the tabulated one, we reject the null hypothesis of restriction on coefficients (Wooldridge, 2002). Thus, this study utilizes the MAPE, DW and F-test to find out the most suitable model to project the future Internet-penetration and Internet adoption pattern in India.

4. MODEL ESTIMATION, RESULTS AND DISCUSSION

Parameters of equations (6), (9), and (12) are estimated using the data of Internet-penetration and per capita GNI at constant 2011-12 prices (Rs. in one hundred thousand) from 1999-00 to 2019-20 by OLS method. Data on Internet-penetration is taken from the ITU published World Telecommunication/ICT Indicators Database 2021 whereas GNI data is taken from the Economic Survey 2021-22 (Statistics Appendix) published by the Ministry of Finance, GoI, New Delhi. Data for India's population is taken from the World Population Prospects 2019 published by the Department of Economic and Social Affairs, United Nations. The variable time, t, is taken as 1 for 1999-00, 2 for 2000-01, 3 for 2001-02,……, and 21 for 2019-20. As explained earlier, all the models, logistic (6), Gompertz (9), and simple modified exponential (12), are estimated assuming that $\alpha = 100$.

Table 1 presents the estimation results. As per R^2, DW statistic, and MAPE values, all the three models, logistic, Gompertz, and simple modified exponential, fit the data very well. Estimated parameters are not only statistically significant but also have the expected signs. Figure 3 presents projected Internet-penetration in India based on all the three models. When we compared the estimated values of Internet-penetration with the actual ones for all the three models, we found that the MAPE is the lowest for the logistic model. We also tested, using the F-test, the null hypotheses of $\beta_2 = 0$, $\beta_3 = 0$, $\beta_4 = 0$, and $\beta_3 = \beta_4 = 0$. The null hypotheses are rejected at five percent level of significance not only for the logistic model but also for the other two models. That's why, we used the estimated logistic model as given in **equation (13) to** project the Internet-penetration in India up to the year 2030-31.

$$ln(\frac{100}{I_P} - 1) = -6 - 0.941t + 40.113(\frac{GNI}{cap}) - 14.635(\frac{GNI}{cap})^2 \qquad (13)$$

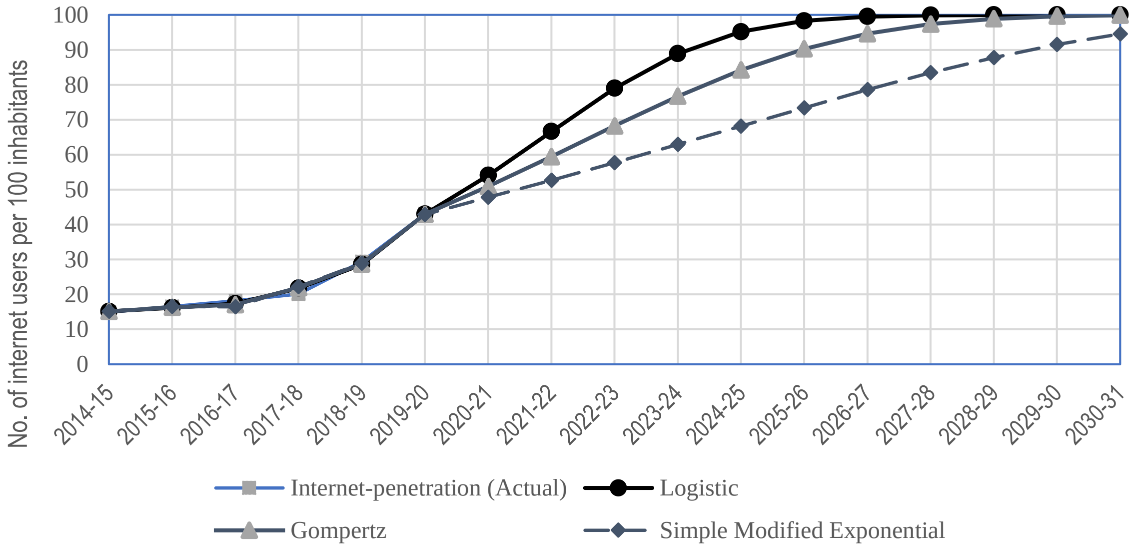
To forecast the future Internet-penetration in India, we need to make rational assumptions about the per capita GNI growth rate. Per capita GNI (at constant 2011-12 prices) in India increased, on an average, at the rate of 5.63 percent per year during the last five years of the sample period, i.e., from the year 2014-15 to 2019-20. Assuming that $\frac{GNI}{cap}$ will increase at this rate up to the year 2030-31, Internet-penetration has been estimated for the future.[2] Figure 4 demonstrates the same using the estimated logistic model (13).

TABLE 1- ESTIMATION RESULTS (WITH T-STATISTIC IN PARENTHESES).

[2] It's possible that the per capita GNI growth rate may vary across the years; since we're interested in long-term forecast, say five or seven years from now, short-term variation in per capita GNI growth rate is unlikely to have any significant impact on long-term forecasted values of Internet-penetration in India.

Model	Estimate
Logistic **(6)**	β_1 = -6.000 (2.7), β_2 = -0.941 (2.3), β_3 = 40.113 (3.2), β_4 = -14.635 (2.6); R^2 = 0.989; MAPE = 3.19; DW = 2.1
Gompertz **(9)**	β_1 = -3.399 (2.7), β_2 = -0.630 (2.7), β_3 = 23.882 (3.5); β_4 = -7.856 (2.5); R^2 = 0.989; MAPE = 5.42; DW = 2.1
Simple Modified Exponential **(12)**	β_1 = -1.819 (2.8), β_2 = -0.392 (3.4), β_3 = 12.676 (3.7), β_4 = -3.493 (2.4); R^2 = 0.989; MAPE = 4.6; DW = 2.2

Source: Authors' computation



Source: Authors' calculation

FIGURE 3 - PROJECTION OF INTERNET-PENETRATION BASED ON LOGISTIC, GOMPERTZ, AND SIMPLE MODIFIED EXPONENTIAL MODELS

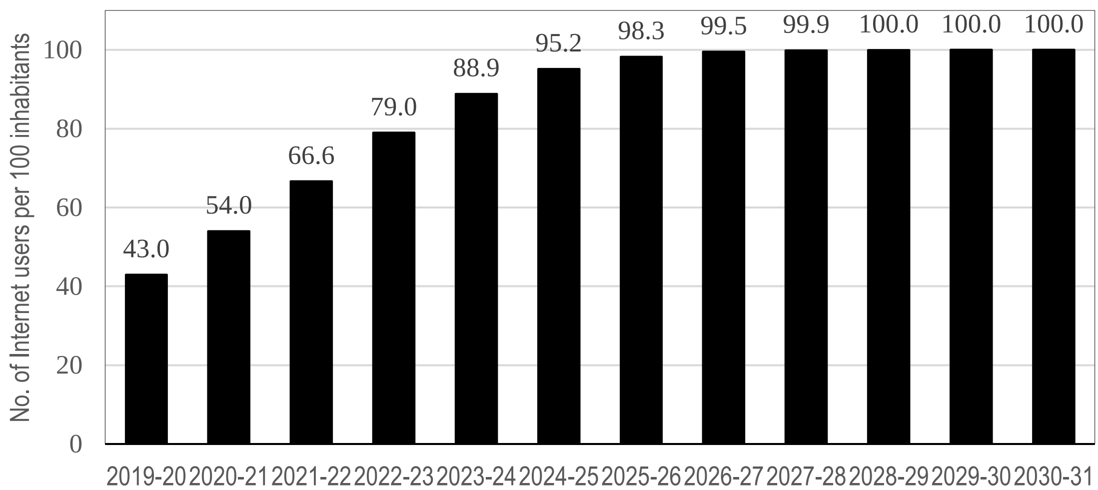


FIGURE 4 - PROJECTION OF INTERNET-PENETRATION IN INDIA USING THE LOGISTIC MODEL (ROUNDED OFF TO ONE DECIMAL PLACE)

Source: Authors' calculation

Internet-penetration in India has increased, on an average, at the rate of 23.6 percent per year during the last five years, i.e., from 14.9 in March 2015 (2014-15) to 43 in March 2020 (2019-20). It is expected to grow, on

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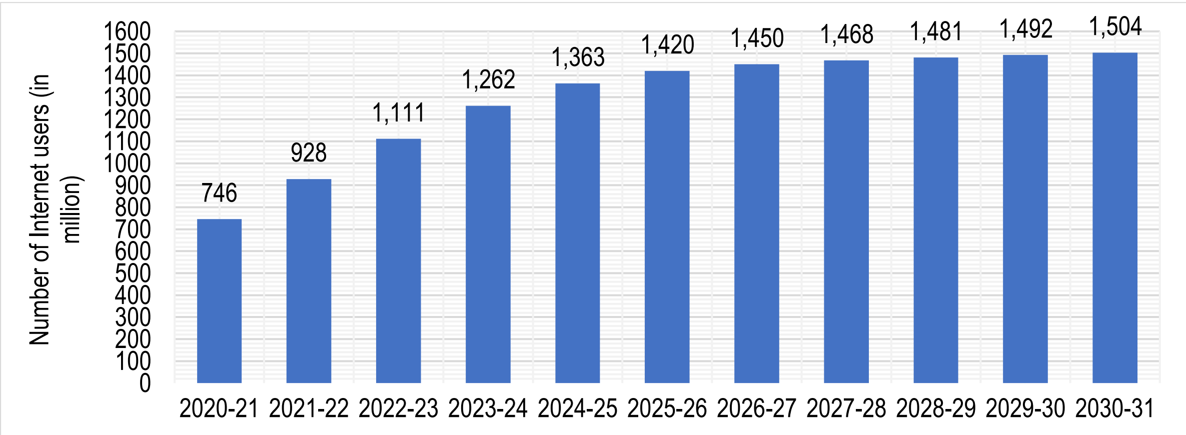
an average, at the rate of 17.2 percent per year during the next five years. As a result, 95 out of 100 Indians will have access to the Internet by March 2025. Figure 4 clearly reveals that India is likely to achieve universal Internet access by the year 2028-29. Thus, 2028-29 may be a turning point in the socio-economic trajectory of India. Universal internet access will immensely reinforce and support the attainment of all the Sustainable Development Goals (SDGs), such as, the human development through quality education (SDG4), gender equality (SDG5) to industry, innovation and infrastructure targets through SDG9 - economic growth (Bamford et al., 2021). Universal internet access will surely target SDG10 - Reduced Inequalities – through addressing inequality and inclusivity. Large number of people yet not having bank accounts in India will get advantage from fintech via sending and receiving payments and accessing credit online. Further, fintech is likely to address the gender inequalities (SDG5) towards financial inclusion. Universal Internet access will also improve educational outcomes. Educational Access to quality education (SDG4) would be greatly enhanced on account of emerging education technology applications that are more adaptive and receptive to individual learner needs, also helping bridge the shortfall of teachers in the country. These are just few means through which internet penetration growth and access would be transformational for development. In fact, digital solutions could usually be highly transformative and most cost-effective way to address the challenges faced by utility sectors as well, be it water, electricity, sanitation, or health sector. In general, universal Internet access will benefit everyone; it is not only about eradicating poverty, but Internet access will also improve the lives of people and drive economic growth (Bamford et al., 2021).

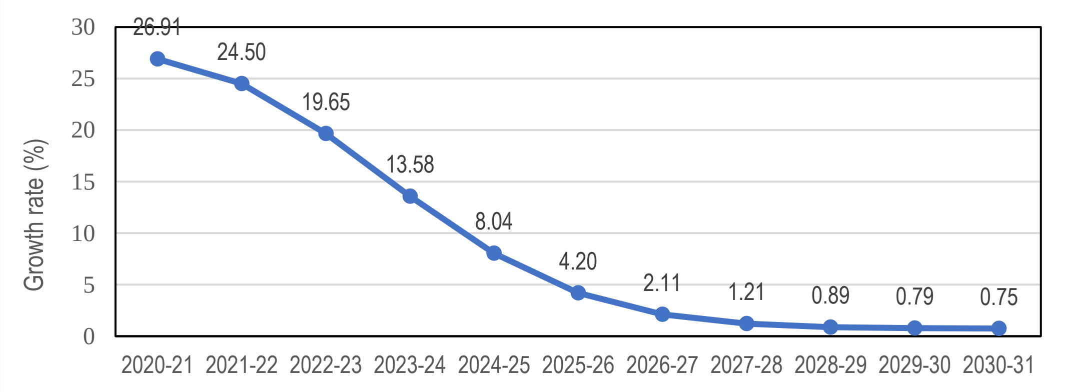
Rapid increase in Internet-penetration in India will lead to ballooning of Internet users in the country. It is projected that there will be more than 1 billion Internet users in India by the end of March 2023 (Figure 5). One may note that the number of Internet users in India increased at the rate of 47.75 percent from March 2019 to March 2020; number of users are likely to increase at the rate of 26.91 percent from March 2020 to March 2021, 24.50 percent from March 2021 to March 2022, 19.65 percent from March 2022 to March 2023, and 13.58 percent from March 2023 to March 2024 (Figure 6). Number of Internet users in India is projected to increase in single digit from 2024-25 onwards. Figure 6 clearly reveals that the increase in number of users will be less than 1 percent per year from 2028-29 onwards till population of the country reaches saturation point. Nevertheless, India is likely to have 1.5 billion Internet users by the year 2030-31 (Figure 5).



Source: Authors' calculation

FIGURE 5 - PROJECTED NUMBER OF INTERNET USERS IN INDIA FROM 2020-21 TO 2030-31

Projected rapid growth in total number of Internet users in India will have important implications for service providers as well as the government. As per the TRAI, from 2013-14 to 2020-21, data consumption per user in India increased from 3 GB to 176.8 GB whereas data cost decreased from Rs. 269 per GB to Rs. 9.5 per GB (Table 2). The Covid-19 pandemic played an important role in boosting the data consumption in 2020-21 vis-à-vis 2019-20; average data consumption in 2020-21 was 25 percent more than that in 2019-20. This is mainly because schoolchildren, college students, and workers of many sectors worked remotely during the pandemic. Moreover, data cost also decreased significantly during the pandemic, from Rs. 10.9 per GB in 2019-20 to Rs. 9.5 per GB in 2020-21, a fall of almost 13 percent. However, despite the significant fall in cost of data, Average Revenue per User (ARPU) has increased over the years. The ARPU doubled in a span of just seven years, from Rs. 807 in 2013-14 to nearly Rs. 1685 in 2020-21 (Table 2). As a result, Internet service providers' revenue increased by 9-fold in the same span from nearly Rs. 140 billion in 2013-14 to Rs. 1256 billion in 2020-21.



Source: Authors' calculation

FIGURE 6 - PROJECTED ANNUAL GROWTH RATE IN NUMBER OF INTERNET USERS IN INDIA FROM 2020-21 TO 2030-31

As stated earlier, revenues generated by the Internet service providers in India during the year 2020-21 is estimated to be Rs. 1256 billion, amounting to 0.64 percent of the country's gross national income. India's GNI at current prices is on the rise, at around 10 percent per year while ARPU has grown at the level of nearly 11 percent per year during the last seven years or so. Presuming that the increase in GNI at current prices will be at the same rate till the year 2030-31, India's nominal GNI will be about Rs. 337 trillion in 2025-26 and Rs. 543 trillion in 2030-31 (Table 3). Similarly, ARPU is likely to be Rs. 2839 in 2025-26 and Rs. 4783 in 2030-31.[3] Thus, Internet spending in India is projected to be around Rs. 4031 billion in 2025-26 and Rs. 7194 billion in 2030-31. As a result, India's Internet service providers' revenue will be equivalent to 1.19 percent of GNI in 2025-26 and 1.32 percent of GNI in 2030-31 (Table 3). The high growth in Internet users and revenues generated by the service providers has important implications for Internet service providers, mobile phone operators (since, as per TRAI, 97 percent of Internet users use mobile devices), infrastructure providers and smartphone manufacturers. Mobile operators need to be prepared in advance with exigency plans to install and operate internet infrastructural requirements for services including customer care, billing, applications, etc., at a rapid pace than initially planned. Other related infrastructure providers and smartphone suppliers should also be ready to service and respond to such plans.

TABLE 2 - COST AND CONSUMPTION OF DATA OVER THE YEARS

	Data consumption per user (GB)	Cost per GB (Rs.)	ARPU per year (Rs.)	No. of Internet users (million)	Revenues from Internet services (Rs. in billion)	GNI (Rs. in trillion at current prices)	Internet revenue as a percentage of GNI
2013-14	3.0	269.0	807.0	172.9	139.5	110.9	0.13
2014-15	5.0	227.0	1135.0	193.0	219.1	123.3	0.18
2015-16	14.0	75.6	1058.4	216.2	228.8	136.1	0.17
2016-17	49.0	19.3	945.7	241.1	228.0	152.2	0.15
2017-18	91.0	11.8	1073.8	268.8	288.7	169.1	0.17
2018-19	118.0	11.1	1309.8	397.7	520.9	186.9	0.28
2019-20	141.0	10.9	1536.9	587.6	903.0	201.6	0.45
2020-21	176.8	9.5	1684.5	745.7	1256.1	195.6	0.64

Source: Authors' calculation

Projected boom in Internet industry in India will also boost government's revenue, especially revenue generated through GST (goods and services tax) and spectrum charges. Digital services including Internet services

[3] Average revenue per user in coming years will depend on various factors such as market concentration, technological change, productivity and efficiency of Internet service providers, general inflation in the economy, income of consumers, etc., however, income and inflation effects are likely to be strong enough to increase the average revenue per user at the prevailing rate from 2020-21 onwards at least up to 2030-31.

provided to consumer residents in India are subject to 18 percent GST. In the likelihood of this rate persisting in the future, government's revenue from the GST on Internet services is likely to increase from Rs. 192 billion in 2020-21 to Rs. 615 billion in 2025-26 and Rs. 1098 billion in 2030-31. As far as spectrum charges are concerned, government is expecting to earn Rs. 1 trillion to Rs. 1.5 trillion by auctioning 5G airwaves. It is noteworthy that in spite of the highs tax rates (including GST), Internet tariff in India is amongst the least in the world. Nonetheless, there is a need to further reduce the levied taxes so that quality Internet services are affordable and accessible to every section of the Indian society.

TABLE 3 - ESTIMATES OF INTERNET SERVICE PROVIDERS' REVENUE

	No. of Internet users (million)	ARPU per year (Rs.)	Revenues from Internet services (Rs. in billion)	GNI (Rs. in trillion at current prices)	Internet revenue as a percentage of GNI
2020-21	746	1685	1256.1	195.6	0.64
2025-26	1420	2839	4030.7	337.3	1.19
2030-31	1504	4783	7193.7	543.3	1.32

Source: Authors' calculation

5. CONCLUSION, IMPLICATIONS AND FUTURE RESEARCH

The telecommunication industry[4] in India has undergone the most fundamental structural and institutional change since mid-1990s. The industry is now very competitive in almost all its segments which has resulted in fall in tariffs and acceleration in growth. As compared globally, current Internet tariffs in the country are amongst the least, while rise in subscriber base is amongst the highest. Due to this, Internet-penetration in the country is improving rapidly particularly during recent time. For example, in 2014-15, only 15 out of 100 people had access to Internet whereas now more than half of country's population have Internet access.

Results of this study indicate that the internet-penetration in India has increased, on an average, at the rate of 23.6 percent per year during the last five years; it is projected to increase, on an average, at the rate of 17.2 percent per year during the next five years. Consequently, 95 out of 100 Indians are likely to have access to the Internet by March 2025. Also, India is likely to achieve universal Internet access by the year 2028-29. Rapid increase in Internet-penetration will lead to ballooning of Internet users in the country. It is projected that there will be more than 1 billion Internet users in India by March 2023 and almost 1.5 billion by the year 2030-31. This will have significant implications in terms of revenues collected by both service providers and the government. Revenues generated by the Internet service providers is forecasted to increase from Rs. 1256 billion in 2020-21 to Rs. 4031 billion in 2025-26 and Rs. 7194 billion in 2030-31. Therefore, government's revenue from the GST on Internet services is likely to rise from Rs. 192 billion in 2020-21 to Rs. 615 billion in 2025-26 and Rs. 1098 billion in 2030-31.

To conclude, this study estimates the adoption pattern of internet usage and also projects the future Internet-penetration, Internet demand, and Internet service providers' revenue in India up to the year 2030-31. The paper also discusses the implications of projected internet growth on the government's revenue. However, there are certain limitations. For example, the macroeconomic indicator – the GNI per capita is used in the study as an income proxy, but not the actual income of the consumers. Also, instead of yearly data, future studies on internet adoption can use monthly data to offer further insights. Similarly, future research can choose alternative growth curve models such as the Bass model or generalised logistic model to get a more comprehensive output due to inclusion of multiple factor analysis (Turk and Trkman, 2012). Moreover, future research can also investigate the differential internet diffusion in India in terms of its spatial heterogeneity, e.g., between the rural and urban contexts and understand regional trends in spatial econometric forecasting of internet growth. Similarly, the government and enterprises will be aided in knowing about the comparative differential diffusion and projected growth between mobile internet versus broadband internet in order to

[4] The industry includes firms that make communication possible, whether it is through phone or Internet, through cables or airwaves, through wires or wirelessly.

understand market size and plan resources for the timely development of internet related products and services.

It is implied that the internet operators would be challenged economically, logistically and strategically due to the projected rapid expansion of Internet service penetration in the country. As internet operators expand into countryside, they will have to tackle the challenging tasks of creating a nationwide infrastructure as well as improve and maintain service quality. The projected rapid growth of Internet users will have important implications for Internet service providers, Internet infrastructure providers, and smartphone suppliers as they ought to be prepared with contingency strategies to install and implement infrastructural services, like customer care, billing, applications, etc., at a rapid pace than that initially planned. Further, it is quite likely that the universality of Internet access by the year 2028-29 will bring huge benefits; it will hugely support the attainment of almost all the SDGs, example, quality education, gender equality, financial inclusion and economic growth on account of industry, innovation, and infrastructure targets. The Internet is already changing the world, but the big changes that the Internet will bring still lie ahead. Its real history has just begun.

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