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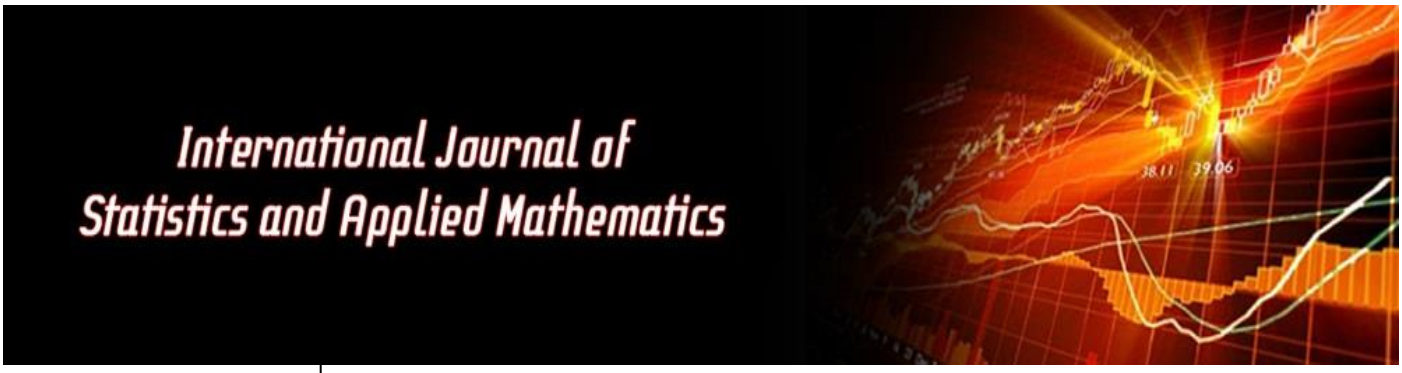


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# An empirical mathematical study of mobile phone subscribers in India

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**Abstract**
Earlier the mobile phone subscribers were very small in number. But latter on the users kept on increasing. Now a days billions of mobile phone subscribers are there world wide. Previous 2 decades has seen the rapid increase in mobile phone subscribers. The present paper work tries to analysis this phenomena focusing on the mobile phone users in India, with the help of mathematical model.

**Keywords:** Logistic model, growth rate, carrying capacity, mobile phone users

## Introduction
Mobiles phones have become very essential part of our every life. Mobile wireless industry has started its technology creation revolution and evolution since early 1970s. In the past few decades, mobile wireless technology have experienced $4^{th}$ and $5^{th}$ generation of technology revolution and evolution, namely from the mobile radio telephone to 4G. The cellular concept was introduce in the first generation technology which made the large scale mobile wireless communication possible. Digital communication has replaced the analog technology in the 2G which significantly improved the wireless communication quality [5]. Data communication in addition to the voice communication, has been the main focus in the 3G technologies and converted network for both voice and data communication is emerging. First generation refers to the first generation of wireless telecommunication technology, more popularly known as cellphones. A set of wireless standards developed in the 1980 s, IG technology replaced mobile radio telephone technology, which featured mobile radio telephones and such technologies as Mobile Telephone System (MTS). Advanced Mobile Telephone System (AMTS). Improved Mobile Telephone Service (IMTS), and push to talk (PTT).Its successor, 2G, which made use of digital signals, IG wireless networks used analog radius signals.
Second-generation not only normally transfer data. Such as email or software, other than the digital voice all itself but also other basic ancillary data such as time and date. Nevertheless, SMS messaging is also available as a from of data transmission for some standards. Second generation 2G cellular telecom networks were commercially launched on the GSM [4]. GSM service is used by over 2 billion people across more than 212 countries and territories. 3G technologies enable network operators to offer users services like wide area wireless telephony, video calls and broadband wireless data, all in a mobile environment. Additional features also include data transmission capabilities able to deliver speeds up to 14.4 Mbit/s on the downlink and 5.8 Mbit/s on the uplinks.
Fourth generation is the extansion in the 3G technology with more bandwidth and services offers in the 3G. The expectation for the 4G technology is basically the high quality audio/video streaming over end to end internet Protocol (IP) multimedia subsystem.
The first cellular technology adopted in India in 1995. In 1995, the first mobile telephone service begin operating in certain cities of India, after the telecom sector was opened up by the government for private investment, as a part of Privatization and Globalization policy. A year later, the services spread towards the rest of the geographical areas of India. During the mitial five to six years the averages growth of mobile phone subscribers was very little. Primly the cost of mobile phone was very high and airtime charges of the service providers were also high. The New Telecom Policy in 1999, the mobile phones services operators use the GSM

and CDMA technologies. Christian M. Dippon [1]. Define necessily are penetration rate of 3G service in India, Mexico and Thailand by using the Comperty model [2]. Mobile Banking is the second largest growing since acquiring new customers [3]. The social, technological economic and partial factors that have influenced the different process f mobile phone [4].

The purpose of this study is to use mathematical model to predict the mobile phone subscribers of India. For empirical analysis, we divided the data into two periods estimated period 2014 to 2016 and forecasting period 2017 to 2025. The availability of 09 observation is consider to fit the curve for estimation of diffusion model perform well. Estimation of initial parameter of based on transformation formula. The estimated parameter are substitute in the logistic model, substitute the value of $t$ for forecasting the values of mobile phone subscribers in India.

**Mathematical Model**

Support $n(t)$ can be interpreted as the number of mobile phone subscribers in time $t$. Its development over time $n(t)$ depends on initial value $n_0$ and the two parameters $\alpha$ and $N$ where $\alpha$ is called rate of mobile phone subscribers and $N$ is referred to as the carrying capacity of the mobile phone users (Saturated level). The rate [7] of change of $n(t)$ can be written as.

$\frac{dn}{dt} = \alpha n\left[1 - \frac{n}{N}\right], \alpha > o$

$$\frac{dn}{dt} = \alpha n - \frac{\alpha}{N}n^2$$

$$\frac{dn}{dt} = \alpha n - \beta n^2$$

$$\frac{dn}{n(\alpha - \beta n)} = dt$$

$$\int \frac{dn}{n(\alpha - \beta n)} = \int dt + K$$

$$\frac{1}{\alpha}\ln\frac{n}{\alpha - \beta n} = l + k$$

$$\frac{1}{\alpha}\ln\frac{n_0}{\alpha - \beta n_0} = k$$

$$\frac{1}{\alpha}\ln\left(\frac{n}{\alpha - \beta n}\right)\left(\frac{\alpha - \beta n_0}{n_0}\right) = t$$

$$\left(\frac{n}{\alpha - \beta n}\right)\left(\frac{\alpha - \beta n_0}{n_0}\right) = e^{\alpha t}$$

$$\frac{n}{\alpha - \beta n} = \left(\frac{n_0}{\alpha - \beta n_0}\right)e^{\alpha t}$$

$$\frac{\alpha - \beta n}{n} = \frac{(\alpha - \beta n_0)}{n_0}e^{-\alpha t}$$

$$\frac{\alpha}{n} - \beta = \left(\frac{\alpha - \beta n_0}{n_0}\right)e^{-\alpha t}$$

$$\frac{\alpha}{n} - \beta = \left(\frac{\alpha}{n_0} - \beta\right)e^{-\alpha t}$$

$$\left[\frac{\frac{\alpha}{\beta}}{n} - 1\right] = \left(\frac{\frac{\alpha}{\beta}}{n_0} - 1\right)e^{-\alpha t}$$

$$\frac{\frac{\alpha}{\beta}}{n} = 1 + \left(\frac{\frac{\alpha}{\beta}}{n_0} - 1\right)e^{-\alpha t}$$

$$\frac{n}{\alpha/\beta} = \frac{1}{1 + \left[\frac{\alpha/\beta}{n_0} - 1\right]e^{-\alpha t}}$$

$$n = \frac{\alpha/\beta}{\left[1 + \frac{\alpha/\beta}{n_0} - 1\right]e^{-\alpha t}}$$

$$\lim_{t\to\infty} n = \lim_{t\to\infty} \frac{\alpha/\beta}{\left[1 + \frac{\alpha/\beta}{n_0} - 1\right]}e^{-\alpha t}$$

$$\lim_{t\to\infty} n = \frac{\alpha}{\beta}$$

$$\therefore n_{max} = \lim_{t\to\infty} n = \frac{\alpha}{\beta} = N$$

| $t$ | 0 | 1 | 2 |
|---|---|---|---|
| $n(t)$ | $n_0$ | $n_1$ | $n_2$ |

$$e^{-\alpha} = \frac{n_o(n_2 - n_1)}{n_2(n_1 - n_o)}, \frac{\beta}{\alpha} = \frac{n_1^2 - n_o n_2}{n_1(n_o n_1 - 2n_o n_2 + n_1 n_2)}$$

$$\therefore \quad n_{max} = \frac{n_1(n_o n_1 - 2n_o n_2 + n_1 n_2)}{(n_1^2 - n_o n_2)}$$

**Analysis**

The data [8] consider for the study was mobile phone subscribers in India for the period 2014 to 2016 presented in following table 1.

**Table 1:** Mobile Phone Subscribers

| Year | Mobile Subscribers Million |
|---|---|
| 2014 | $904 \cdot 52$ |
| 2015 | $969 \cdot 54$ |
| 2016 | $1034 \cdot 11$ |

The Logistic model parameters values were estimated as following table 2.

**Table 2:** Logistic Model Parameters

| | |
|---|---|
| $\alpha$ | $2 \cdot 3835$ |
| $N$ | $1847 \cdot 80$ |

$$n(t) = \frac{1847 \cdot 80}{1 + (1 \cdot 042)(\cdot 8686)^t}$$

The forecasting models of mobile phone subscribers as given below using the estimated logistic model the diffusion theory of mobile phone subscribers was projected for the provided between 2017 to 2025 in table 3.

**Table 3:** Mobile Phone Subscribers Projections in India

| Year | Mobile Subscribers (Million) |
|---|---|
| 2017 | 1098 · 57 |
| 2018 | 1159 · 94 |
| 2019 | 1219 · 66 |
| 2020 | 1276 · 98 |
| 2021 | 1331 · 26 |
| 2022 | 1382 · 04 |
| 2023 | 1428 · 85 |
| 2024 | 1472 · 70 |
| 2025 | 1513 · 10 |

## Conclusion

In this study we consider logistic model in telecommunication sector analysis forecasts that were will be a large number of people nearly 1513.10 million by 2025 in India. Hence there is a huge scope for market capitalization of telecommunication sector in India.

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