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Prediction of Smartphone Users in India using Trend Analysis Looking for Better Planning of E-waste

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ABSTRACT

In India due to the telecom revolution, smartphone users are increasing rapidly. In each family we can see at least one smartphone, in urban families now we can see smartphonesare used by each family member. In villages also we can see multiple smartphone users in a single-family. Due to internet speed and changing entertainment preferences, the number of smartphone users will increase in the future. Based on mobile users, internet users, and other electronic items users we can be happy that India growing fast. But we cannot neglect that electronic items are harming human health and the environment badly. In India electronic waste is increasing rapidly, in 2020 this E-Waste was 3.2 Million Ton, while in 2010 it was 0.4 Million Ton. In India, smartphone users in 2010 were 34 million, while in 2020 total number of smartphone users was 748.32 Million. In this work looking for the impact of E-Waste on earth pollution and human health, a forecast model is developed to predict future smartphone users. Secondary data is analyzed and a polynomial equation is developed to predict future demand.

Key words : *E-Waste, Smart Phones, Forecasting, Polynomial Curve, Forecast Accuracy.*

Introduction

E-Waste is an environmental problem for rapidly developing countries. E-Waste has so many adverse effects on human health and the environment. In the 21st century E-Waste is a big reason for environmental and soil pollution. In 2010 India's E-Waste was 0.4 Million Tons, and in 2020 India's total Electronic Waste was 3.2 Million Tons. India is the third-largest electronically polluted country after China (10.1) and the USA (6.9 Mt Ton). Since India is a rapidly developing country this E-Waste will increase yearly. India has to develop a good infrastructure to recycle this E-Waste. Mostly these E-Wastes are dumped near city landfills, which causes E pollution and damage the environment, earth, and causes water pollution. In India, we can see the telecom revolution for the last some years. Even in villages and in poor families people are using smartphones, TV, Refrigerators, and other electronic items. This will terrifically cause E-Waste in India. These electronic items are not recycled properly in India and a big part of E-Waste is dumped in landfills. Due to landfills of E-Waste, we can see so many negative impacts on soil quality, earth pollution, and water quality degradation. In so many places of India water is poisonous, and causes so many diseases.

Abalansa *et al.,* (2021), studied E-Waste management for developing countries and suggested that practical knowledge should be shared by developing countries for better management of E-Waste. Balabanic *et al.,* 2011, and Bandyopadhyay, 2008; studied that due to economic growth and urbanization demand for electronics items is increasing.

Bhutta *et al.*, 2011 and Puckett *et al.*, 2002 studied that electronic products contain toxic substances, which are very harmful to the environment. Most of the users are unaware of these negative impacts. These products cause a big risk for human health. These products are dumped in landfills, due to the heavy landfills in India, environmental pollution increases. Widmer *et al.*, (2005) and Davis, (2006), in their study found that one of the important reasons for increasing E-Waste is the life span of electronic items. The life of most mobile phones is less than two years. Chen *et al*. 2011; Bosshard *et al.*, (1996); Coram and Rawlings (2002); Bala and Goel, (2012); Clark and Norris, (1996), Studied that electronic items even personal computer consider chemicals like lead, cadmium, mercury, and chromium, which causes fatal disease like, kidney failure, Bone disease, DNA damage, Lung Cancer and long term cumulative poison. Bhutta *et al.*, (2011) studied E-Waste management and suggested tough laws. So important measures should be taken to take care of human health. Needhidasan *et al.*, (2014), studied for impact of E-Waste in Urban India. Gupta *et al.*, (2011) studied E-Waste management in India and found a lack of awareness among manufacturers and users for E-Waste management. They found a lack of policies and infrastructure of E-Waste management in India. Garg, and Adhana, (2019), studied the scenario of E-Waste in India and worldwide. In their study found that computers and mobiles play an important role in E-Waste in India.

In this work, secondary historical data is analyzed and a mathematical model is developed to predict the future demand of smartphones in India using time series analysis.

Table 1. Smartphone users in India (Millions)

Year	Number of Smartphone (Millions)
2010	34
2011	58.73
2012	90.63
2013	129.07
2014	189.95
2015	250.66
2016	304.51
2017	394.82
2018	479.34
2019	634.58
2020	748.32

Source: https://www.statista.com/statistics/467163/forecast-of-smartphone-users-in-india/

Materials and Methods

Forecast Model

In this section, the trend pattern of smartphone users in India will be studied. Historical data of 11 years (2010-2020) is considered. To find the trend, a scatter diagram is plotted using MS excel. The Scatter diagram is shown in Fig. 1.

Fig. 1. Shows the scatter diagram of smartphone users in India for the last 11 years. From the scatter diagram we can see that smartphone users in India follow a polynomial pattern.

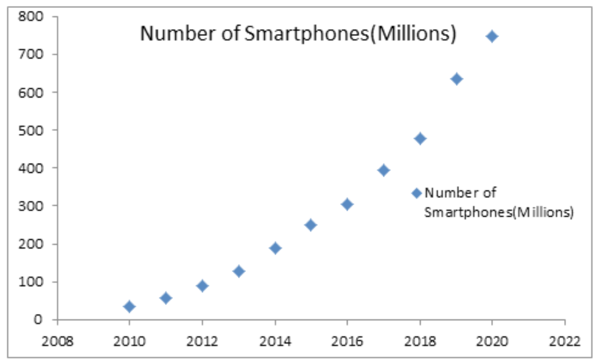

Fig. 1. Scatter Diagram for Mobile Users

Trend Analysis

To predict future demand a mathematical equation will be developed. To develop a trend equation, year codes are provided for each year starting from 2010. Year codes are represented by x and are in increasing order. The very first year is known as the base year and the year code for the base year will be 1. Trend equation is developed using MS Excel. In Fig. 2 polynomial trend equation of fourth order is developed. From Fig. 2. We can see that the R squared value is 0.9984, the maximum or closed to 1 value of R squared shows the accuracy of the trend equation. So from the R squared value, we can say that the 4th order polynomial trend equation will be the best fit curve to predict future demand.

So Trend equation for smart phone users will be

$$y_e = 0.021x^4 - 0.173x^3 + 4.1368x^2 + 14.861x + 13.982 \quad .. (1)$$

With base year 2010.

Where y_e, is the expected or predicted demand of smartphones and x is the year code. So expected or predicted demand of smartphones can be found by putting corresponding values of x in Equation (1).

Table 2. Yearly Smartphones users in India

Year	X=Year Code	Y(Smart Phone Users) (Millions)
2010	1	34
2011	2	58.73
2012	3	90.63
2013	4	129.07
2014	5	189.95
2015	6	250.66
2016	7	304.51
2017	8	394.82
2018	9	479.34
2019	10	634.58
2020	11	748.32

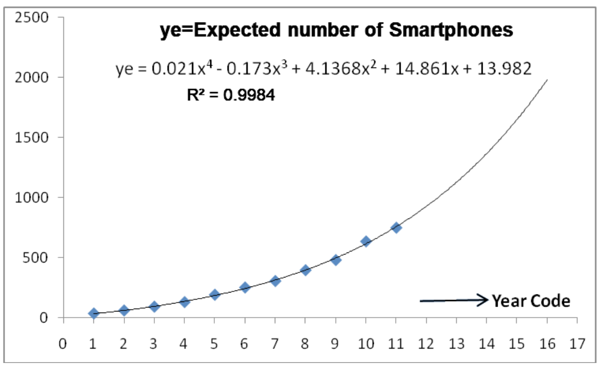

Fig. 2. Trend Analysis

Forecast accuracy

In this section, the forecast model will be verified using forecast accuracy concepts. Mean Absolute Deviation(MAD), Mean Absolute Percentage Error(MAPE), and Mean Forecast Error(MFE) will be applied to check forecast accuracy.

Following notations are used

y_e: Expected smartphone users (Millions)

y: Actual smartphone users (Millions)

Error or Deviation= Actual -Expected

n: Number of values or time

MAD: Mean absolute deviation= Average of total deviations

$$MAD = \frac{\Sigma Absolute\ deviations}{n}$$

MAPE= Mean absolute percentage error

$$MAPE = \frac{100}{n}\sum \frac{|Actual - Forecast|}{Actual}$$

Mean forecast error

$MFE = \frac{\sum Deviations}{n} = \frac{-.90}{11} = .08$, which is almost 0 so we can say that model is good.

Table 3. Expected smartphone users (Millions)

Year	x=Year Code	y_e(Expected Smart Phone Users) (Millions)
2010	1	32.8278
2011	2	59.2032
2012	3	92.8262
2013	4	133.9188
2014	5	183.207
2015	6	241.9208
2016	7	311.7942
2017	8	395.0652
2018	9	494.4758
2019	10	613.272
2020	11	755.2038
2021	12	924.5252
2022	13	1125.994
2023	14	1364.873
2024	15	1646.927
2025	16	1978.427

Results and Discussion

In Fig. 1 scatter diagram is shown to find the trend pattern of smartphone users in India. From the Scatter diagram, we can see that the trend pattern follows a polynomial curve. To find the best suitable curve data is analyzed using MS Excel and the 4th orderpolynomial curve is found best-fit curve. Since the R squared value of the 4th order polynomial is almost 1 (.998), we can consider the 4th order model as the curve of best fit for given data of smart phone users in India. So a trend equation ($y_e = 0.021x^4 - 0.173x^3 + 4.1368x^2 + 14.861x + 13.982$) is developed with base year 2010. Future demand is also predicted by putting corresponding values of x in the trend equation. The forecast model is verified using various forecast accuracy concepts.

In table 4 forecast accuracy is checked using the MAPE concept. MAPE measure cumulative forecast error in percentage. The maximum percentage error is only for the first year 2010, for all other years cumulative percentage forecast error is near 0, so we can say that the forecast model is working correctly. In table 4 percentage forecast error is also checked for each year individually. And we found that the percentage error for each year is also very low (around 3%), so we can consider the developed forecast model as a best-fit model.

In Table 5 forecast error is checked using MAD. MAD check forecast error in quantities. The maxi-

Table 4. Forecast accuracy using MAPE

Year	x	y(Actual)	y_e (Expected)	Abs Deviations	MAPE	Yearly % Error
2010	1	34	32.83	1.17	3.45	1.17
2011	2	58.73	59.20	0.47	2.13	0.24
2012	3	90.63	92.83	2.20	2.23	0.73
2013	4	129.07	133.92	4.85	2.61	1.21
2014	5	189.95	183.21	6.74	2.80	1.35
2015	6	250.66	241.92	8.74	2.91	1.46
2016	7	304.51	311.79	7.28	2.84	1.04
2017	8	394.82	395.07	0.25	2.49	0.03
2018	9	479.34	494.48	15.14	2.56	1.68
2019	10	634.58	613.27	21.31	2.64	2.13
2020	11	748.32	755.20	6.88	2.49	0.63

Table 5. Forecast accuracy using MAD

Year	x	y(Actual)	y_e (Expected)	Deviations	Abs Dev	Sum OfAbs Dev	MAD
2010	1	34	32.83	1.17	1.17	1.17	1.17
2011	2	58.73	59.20	-0.47	0.47	1.65	0.82
2012	3	90.63	92.83	-2.20	2.20	3.84	1.28
2013	4	129.07	133.92	-4.85	4.85	8.69	2.17
2014	5	189.95	183.21	6.74	6.74	15.43	3.09
2015	6	250.66	241.92	8.74	8.74	24.17	4.03
2016	7	304.51	311.79	-7.28	7.28	31.46	4.49
2017	8	394.82	395.07	-0.25	0.25	31.70	3.96
2018	9	479.34	494.48	-15.14	15.14	46.84	5.20
2019	10	634.58	613.27	21.31	21.31	68.15	6.81
2020	11	748.32	755.20	-6.88	6.88	75.03	6.82

mum MAD value is around 6(For 2019 and 2020) and for all other years, it is either 5 or below 5. So using MAD we can also say that the forecast model is under control.

Conclusion

In this work, a forecast model for smartphone users in India is developed using MS Excel and a curve of best fit. Historical secondary data for the years 2010 to 2020 is analyzed and a fourth order polynomial equation is developed.Future demand is also predicted for the next five years. Using the above model we predict that smartphone users in India in 2025 will be 1978.427(Millions). Since the population of India is also increasing, the number of smartphone users will also increase. Since in developing countries like India yet a good infrastructure is not developed for better E-Waste management, this will be an alarming condition for the environment and human health. Concerned authorities should develop infrastructure and technologies to manage E-Waste to save the earth, environment, and humans.

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