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Forecasting Laptop Sales Growth in Industries in India: An Analytical Approach

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Abstract:- The electronic market industry has indeed been a significant contributor to India's economy, not only in terms of GDP but also as a generator of employment and technological advancement. India has witnessed a steady growth in its electronic market, driven by a combination of factors like rising domestic demand, favourable government policies, and increased integration into the global market. The industry's development has certainly played a pivotal role in India's economic landscape. This study attempts how some purchasing parameter effects the growth of product so that the market gets best due to the lack of experimental data. With the development of information and communication technology, one of the recent methods to assist in technology, forecasting is text world data from various sources such as patents journals, and search awards. The information extracted from diverse sources can be implied in technology. Diffusion models, such as Bass model, where emerging technologies substitute older ones. The study uses Bass model and modified this model so that we can forecast the growth of next generation at Indian electronic market industry.

Keywords*:* Growth rate, Technological Substitution , Bass Model, Bass Diffusion Model.

1. Introduction

The electronics sector is divided between consumer electronics, electronics equipment, and electrical components, its consumer electronics are key to the sector's growth the development of new technology, consumer electronics has evolved and intersects with multiple industries and sectors, including software, app development, robotics, artificial intelligence, and personalized healthcare. Within the consumer electronics sector, companies that focus on emerging technology are driving significant growth and include manufacturers of smart watches, smart home products, and smart speakers and laptops. The India consumer electronic loss market size was valued at USD 73.73 billion in 2022 and is expected to grow at a compound annual growth rate (CAGR) of 6.8 percent from 2023 to 2030. India provides a worldwide opportunity for short to medium-term growth in consumer electronics spending. Minimal penetration rates, as against other upcoming markets, portray a better prospect to sell to first-time buying households, along with replacement devices to the middle class. Due to the COVID-19 pandemic, the demand for consumer electronics has been significantly impacted. Manufacturing plant shutdown and supply chain disruptions resulted in substantial component shortages. Increased counterfeiting, shipping delays, customer behaviour, and environmental concerns had a significant impact on the market growth. Due to the pandemic, manufacturers of consumer electronics have witrimsed component shipment delays of at least five weeks from suppliers but we saw during this time the demand of laptops and desktop are increasing meanwhile although the manufacturing during this period are not very high but many new laptops and desktop companies are evaluated in this period the manufacture by which this company are evaluate is due to rating on e-commerce website. India is likely to emerge as a potential future manufacturing hub for the region, provided the government shows adequate support and focus towards this sector. Specific factors anticipated to push manufacturing in India are inclusive of a reduction in borrowing costs, export incentives, reduction of customs duties on raw material and components, and improvement in the ease of doing business.

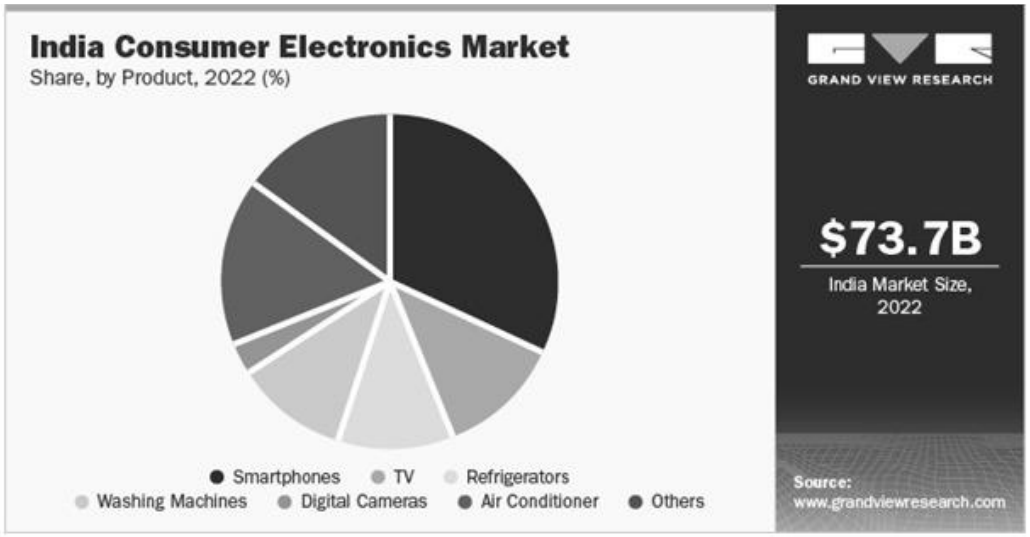

Fig (1)

The Impact of Emerging Technologies on the Electronics Sector Product differentiation and development of emerging technologies is a significant driver of change in the electronics sector. In addition to artificial intelligence, other products adding to the continued growth include wearable (e.g., smart watches), smart home, automotive automation, connectivity technology/Smartphone health and fitness technology, and tablets PC laptop market.

Tablet PC Market Size was valued at USD 62.65 billion in 2022. The Tablet PC market industry is projected to grow from USD 67.00 billion in 2023 to USD 97.47 Billion by 2030, exhibiting a compound annual growth rate (CAGR) of 5.5 percent during the forecast period (2023- 2030). The Increasing popularity of the laptops and tablets owing to their smaller sizes and less weight and convenient tool for users due to long battery life and overall performance are major key drivers of market the market.

Fig (2)

The global laptops market is projected to reach dollar 257.4 billion by 2031, growing at a CAGR of 4.4 percent from 2022 to 2031. The majority of people use laptops for a wide range of tasks, including work, education,

gaming, Internet browsing, personal entertainment, and everyday home computer use. Increase in levels of internet usage, more disposable incomes, an expanding world population, and greater consumer knowledge of emerging technologies are some of the main factors which drive the growth of the laptop market.

But in this time, there were a substantial surge the demand for laptops and desktops. This uptick was predominantly fuelled by the widespread adoption of remote work and online learning. As offices and educational institutions shuttered, individuals turned to personal computers for professional responsibilities, virtual meetings, and remote classes. Despite the pandemic causing disruptions in the manufacturing sector, resulting in supply chain difficulties and production delays, the market witnessed the emergence of numerous new laptop and desktop companies. Several factors contributed to this growth, with e-commerce platforms playing a pivotal role.

E-commerce platforms like Amazon, Newegg, and others emerged as the primary shopping hubs for consumers seeking to buy laptops and desktops. These platforms offered a convenient and secure shopping experience, which was crucial at a time when physical stores were either closed or operating at limited capacity. One of the primary advantages of e-commerce platforms is the availability of product ratings and reviews. Consumers could readily compare different models, brands, and specifications based on user feedback and expert reviews. This level of transparency fostered trust and guided purchasing decisions, facilitating newer companies in gaining visibility and credibility in the market. Furthermore, the rise of e-commerce encouraged heightened competition, driving innovations and enhancements in product offerings. Established companies had to elevate their offerings to retain their market share, while new players brought fresh ideas and competitive pricing to attract customers. The pandemic also accelerated the trend of digital transformation across various sectors, further amplifying the demand for reliable and efficient computing devices. Businesses invested in robust IT infrastructure to support remote work, while educational institutions upgraded their systems to enrich online learning experiences. In essence, the COVID-19 pandemic created a distinctive environment that significantly boosted the demand for laptops and desktops. Despite challenges in the manufacturing sector, the proliferation of e-commerce platforms and the necessity for digital transformation gave rise to several new companies in the laptop and desktop market. E-commerce platforms, with their focus on ratings and reviews, played a vital role in aiding consumers in making well-informed decisions, thereby propelling the industry's evolution during this timeframe.

2.Literature review:

In last few decades many efforts had been made to represent the manufacturing facility into a mathematical model. These models are of different types depending upon the type of production facility. One of them is time-based model. Time is the main parameter in this model. The main objective of this type of model is reduction of time required to produce final product. Other types of models are sequence-based model. The main objective of these types of models is to determine the optimal and feasible processing sequence. The hybrid type of problem can also be formulated by combination of these two models. Some of the successful attempts of mathematical formulation and optimization are listed here. B. Naderi and A. Azab (2014) [1] formulate the operation-position based model; Operation-sequence based model, and heuristic models for Distributed job shop environment. They also developed the Evolutionary algorithm to solve these models. Xinyu Li, Liang Gao (2010) [2] formulated a mathematical model of integrated process planning and scheduling. They have developed an evolutionary algorithm-based method for integration and optimization. They also compared feasibility and performance of their proposed method with some previous works. J. Behnamiana (2015) [3] solved the mixed integer linear programming by the CPLEX solver. Their problem was for small size instances scheduling. And they also compared their obtained results by heuristic method with two genetic algorithms in the large size instances. Xiao-Ning Shen, Xin Yao (2015) [4] constructed a mathematical model for the multi objective dynamic flexible job shop scheduling problem. Rogers EM, Shoemaker FF (1971) [5] studied Communication Innovations a Cross-Cultural Approach free press, New York. Bass FM (1969) [6] explain A new product growth Model for Consumer Durables Manage. Fisher J.C. Pry RH. (1971) [7] describes a simple substitution Model for technology change. Technol. Forecast social change. Kapoor JN (1992) [8] explain Fascination world of Mathematical sciences volume XI, Mathematical Sciences Trust Society. Srivastava, R.C. and Gupta, U. K. (2017) [9] constructed a mathematical modelling of technological innovation diffusion pro-ceding of ISMAMS. Bhargava, S. CA (1995) [10] generalized

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3.Bass model:

The Bass diffusion model is one of the most thoroughly researched models in market forecasting. Published in 1969, the model has proven to be versatile in representing the different patterns of adoption of products from "sleepers", where the sales pick up is gradual, to the "blockbusters". It works well for a very wide range of categories and application fields within sectors like consumer durables, computers and technology products, medicine and medical services, agricultural innovations and services, prestige personal care, movies, books and so on. The underlying assumption is that adoption by potential customers is triggered by two types of behaviour: innovation and imitation. "Innovation" is driven via influences such as advertising that are not dependent on the decisions of others in the social system. Its impact is more pronounced during the early stages of the product life cycle. "Imitation" is the influence of prior adopters through positive word-of-mouth. The Bass model was originated by marketing professor Frank Bass. It is used to predict new product diffusion patterns. It is based on a mathematical model to predict new product adoption patterns adopted in a market. The model assumes that there are two main kinds of forces determining the diffusion pattern. The Bass Model is especially useful for forecasting the adoption of recent products, estimating marketplace functionality, and knowing the effect of marketing efforts on the adoption manner. It is primarily based on the concept that there are forms of adapters:

Implementation of BASS Model:

Businesses and researchers can use the Bass Diffusion Model as a useful tool to predict and assess how new technologies and products will be adopted. It is possible to obtain important insights about how and when a product is likely to be adopted by a target market by using this mathematical model. In order to forecast future adoption

trends, the parameters of the model are often fitted to historical adoption data throughout implementation. This method is commonly used in marketing and strategic decision-making to support efficient resource allocation and product launch plans. The innovation spread by words of mouth but they can also spread by external publicity by L.V. newspaper etc. This influence does not depend on the number of adopters but is directly proportional to the number of non-adopters.

Thus, model is modified as

$$\frac{dn}{dt} = p\big(N - n(t)\big)qn(t)\big(N - n(t)\big)$$

Where p is the external influence and q is the internal influence

$$\frac{df}{dt} = p\big(1 - f(t)\big) + qf(t)\big(1 - f(t)\big) = (p + qf)(1 - f)$$

$$f(t) = \frac{\left(1-e^{-(p+q)t}\right)}{\left(1+\frac{q}{p}e^{-(p+q)t}\right)}$$

Here $\frac{df}{dt} \geq 0$ so that f(t) is always increases.

$$\frac{d^2f}{dt^2} = (-p - qf)\frac{df}{dt} + q(1 - f)\frac{df}{dt}$$

$$\frac{d^2f}{dt^2} = 0 \quad \text{when } f(t) = \frac{1}{2} - \frac{p}{2q}$$

In this case the point of inflexion occurs before half the final population size is reached. This moiled is called Bass model. This is not sufficiently flexible since it cannot represent that situation in which the point of inflexion occurs after half the population size is reached.

4.Proposed Mathematical model:

Social media has become an important platform for marketing and product promotion. With the advancement of technology and the internet, social media has been shown to play a vital role in influencing customer behavior in adopting new products. The boom in social media has significantly changed traditional business and marketing strategies. It has been proven that advertisements on social media platforms have the greatest impact on new product awareness. They are a good source of information for customers to know about any new product. Moreover, social media provides a platform to connect with other customers of the same product and make reviews and recommendations. Social media has become a trusted source for the adoption of various products. Based on these aspects, we modeled this scenario to study how social media advertising affects customer adoption of new products.

In 1969 Frank Bass published has paper on new product growth model for consumer durables but at that time there are only two parameters requires mouth publicity and advertisement but now a days the rating of product on the appear also impact the growth of product so we introduce the model for predict the growth of item which in due to mouth publicity (p) , advertisement (q) and rating on app (r) .

Let say that External influence (p)=mouth publicity

Internal influence (q) = advertisement

Review rating (r)= rating on app

$$\frac{dn}{dt} = p\big(N - n(t)\big) + \frac{q}{N}n(t)\big(N - n(t)\big) + r\frac{n(t)}{N}\left[N - \frac{n(t)}{N}\big(N - n(t)\big)\right]$$

Where p is External influence and q is Internal influence and r is Review rating.

the function n(t) and $\frac{dn}{dt}$ strongly depend on the coefficients p and N.

$$n(t) = n(t, p, q, r, N)$$

$$n(t) = n(t,p,q,r,N) = \frac{N\left(1-e^{-(p+q+r)t}\right)}{1+\frac{q}{p}e^{-(p+q+r)t}+\frac{r}{p}e^{-(p+q+r)t}} \quad , \; t \geq 0$$

$$\lim_{t\to\infty} n(t,p,q,r,N) = N$$

$$f(t) = \frac{(p+q+r)^2}{p}\frac{e^{-(p+q+r)t}}{\left(1+\frac{q}{p}e^{-(p+q+r)t}+\frac{r}{p}e^{-(p+q+r)t}\right)^2}$$

$$\frac{df}{dt} = \frac{(p+q+r)^3}{p}\frac{e^{-(p+q+r)t}\left(1-\frac{q}{p}e^{-(p+q+r)t}-\frac{r}{p}e^{-(p+q+r)t}\right)}{\left(1+\frac{q}{p}e^{-(p+q+r)t}+\frac{r}{p}e^{-(p+q+r)t}\right)^3}$$

$$\frac{df}{dt} = 0$$

$$e^{-(p+q+r)\left(1+\frac{q}{p}e^{-(p+q+r)t}+\frac{r}{p}e^{-(p+q+r)t}\right)} = 0$$

$$(q+r)e^{-(p+q+r)t} = \mathrm{p}$$

$$e^{-(p+q+r)t} = \frac{p}{(q+r)}$$

$$t = \frac{1}{(p+q+r)}\ln\left(\frac{q+r}{p}\right)$$

$$t = t^* = \frac{1}{(p+q+r)}\ln\left(\frac{q+r}{p}\right)$$

$$f(t^*) = \frac{(p+q+r)^2}{p}.\frac{\frac{p}{(q+r)}}{\left[1+\frac{qp}{p(q+r)}+\frac{rp}{p(q+r)}\right]^2}$$

$$= (p+q+r)^2.\frac{\frac{1}{(q+r)}}{\left[\frac{q+r+q+r}{q+r}\right]^2}$$

$$f(t^*) = \frac{(p+q+r)^2}{4(q+r)}$$

$$\frac{d^2f}{dt^2} = \frac{(p+q+r)^3}{p}\frac{d}{dt}\left[\frac{e^{-(p+q+r)t}\left(1-\frac{q}{p}e^{-(p+q+r)t}-\frac{r}{p}e^{-(p+q+r)t}\right)}{\left(1+\frac{q}{p}e^{-(p+q+r)t}+\frac{r}{p}e^{-(p+q+r)t}\right)^3}\right]$$

Where $\alpha(t) = e^{-(p+q+r)t}$

$$\frac{d^2f}{dt^2} = \frac{(p+q+r)^3}{p}\frac{d}{dt}\left[\frac{\alpha(t)\left(1-\frac{q}{p}\alpha(t)-\frac{r}{p}\alpha(t)\right)}{\left(1+\frac{q}{p}\alpha(t)+\frac{r}{p}\alpha(t)\right)^3}\right]$$

$$= p(p+q+r)^3\frac{d}{dt}\left[\frac{\alpha(t)\{p-q\alpha(t)-r\alpha(t)\}}{\{p+q\alpha(t)+r\alpha(t)\}^3}\right]$$

$$\frac{d^2f}{dt^2} = p(p+q+r)^3\left[\frac{\{(q+r)\alpha(t)\}^2 - 4p(q+r)\alpha(t) + p^2\}}{\left((q+r)\alpha(t)+p\right)^4}\right]$$

Since

$$\frac{d^2f}{dt^2} = 0$$

$$(q+r)\alpha(t)\}^2 - 4p(q+r)\alpha(t) + p^2 = 0$$

Which is quadratic equation in α(t)

$\alpha(t) = \frac{p}{(q+r)}[2 \pm \sqrt{3}\,]$

$$e^{-(p+q+r)t} = \frac{p}{(q+r)}\left[2 \pm \sqrt{3}\right]$$

$$t = \frac{1}{(p+q+r)}\ln\left[\frac{r+q}{p\left(2 \pm \sqrt{3}\,\right)}\right]$$

$$t = t^{**} = \frac{\ln\left(\frac{q+r}{p}\right) - \ln\left(2 \pm \sqrt{3}\right)}{(p+q+r)}$$

$$t^{**} = t^{*} - \frac{\ln\left(2 \pm \sqrt{3}\right)}{(p+q+r)}$$

From here with the help of α(t) we can predict the future progress of item whether it increases or decreases as there are point of inflection at α(t) we can say that after a certain time the growth of item is flatter and new items should be introduced by making sufficient change in technology of progress items so that the growth of industry must to be fluence.

While purchasing the Laptop or PC there are two major factors are affected to purchase their product –

(i) Its durability

(ii) Its speed for these factors we are depends on those main parameters of advertisement of their product by mouth publicity by advertisement through social media and electronic media and third is rating on apply their product but in earlier there are only two factors influence the growth of market (Laptop) mouth publicity and advertisement (through electronic media, social media) but in current situation media rating in key factor for the effect of growth of item.

The Growth of Laptops in the Electronics Industry: An Analysis of Influencing Factors

Laptops have become important gadgets in today's world, being significant for both individual and professional needs. The creation of a highly dynamic electronic industry has seen a rising demand for laptops that has been influenced by technology advancements, remote work trends and need for portable computing solutions. Among the other electronics, laptops have been placed on higher side with the global market expanding more particularly in India. This essay explores the parameters influencing laptop purchases, emphasizing the roles of mouth publicity, advertisement, and e-commerce website ratings.

Growth Through Mouth Publicity

Word-of-mouth marketing remains one of the most powerful promoters today (Mouth). Word-of-mouth marketing is considered as positive reviews from friends or family while considering to buy a laptop. Positive experiences shared by trusted sources can significantly impact a potential buyer's choice. In India where community ties are strong word-of-mouth publicity makes an even greater difference. Brand reputation is developed through satisfied customers who share their experiences leading to increased sales without necessarily advertising.

Influence of Advertisement

Advertisements play a crucial role in increasing product awareness and sales. In the highly competitive laptop market, manufacturers invest significantly in advertising to showcase their products' unique features, specifications, and benefits. These ads are strategically placed on various media platforms like television, print, and digital media to reach a wide audience.

In India the increasing internet penetration and smartphone usage have shifted towards digital advertising. Social media platforms, YouTube, and search engines have become key channels to reach potential laptop buyers. Advertisements not only inform consumers about new models and features but also create brand recall, influencing their purchase decisions.

Impact E-Commerce Website Ratings

The growth of e-commerce has empowered consumers with a wealth of information. Ratings and reviews on e-commerce platforms now play a crucial role in the purchasing process. Websites like Amazon, Flipkart, and others allow users to leave detailed reviews and rate their purchases, offering valuable insights to prospective buyers. High ratings and positive reviews can significantly enhance a laptop's market performance. Prospective buyers often rely on these reviews to assess the reliability, performance, and value for money of different laptop models. A laptop with consistently high ratings is more likely to attract buyers, while negative reviews can deter potential customers. In India, where e-commerce is rapidly growing, the influence of online ratings is undeniable. Consumers increasingly depend on these ratings to make informed decisions, making it essential for manufacturers to maintain high product standards and customer satisfaction.

5. Application of Model:

Case 1. If we choose p is less than q then we cannot discuss anything from our model

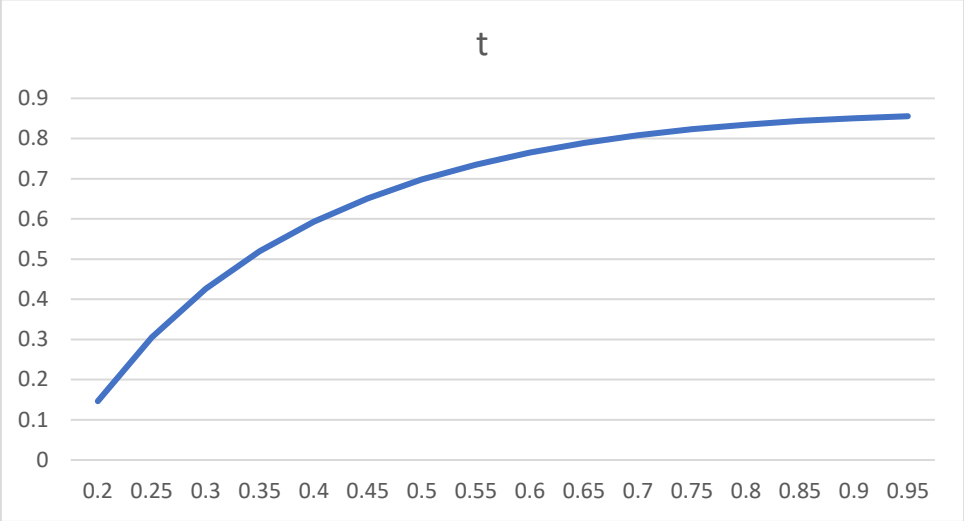
Case 2. we choose p is greater than q

a. If we take p=0.8, q=0.05 , $r \in (0\ 1)$

r	**t**
0.2	0.14629
0.25	0.3054
0.30	0.426165
0.35	0.51963
0.40	0.59312
0.45	0.65135
0.50	0.69782
0.55	0.73505
0.60	0.76491
0.65	0.788819
0.70	0.80789
0.75	0.822975
0.80	0.83477
0.85	0.843848
0.90	0.85063

0.95	0.855501

Table 1



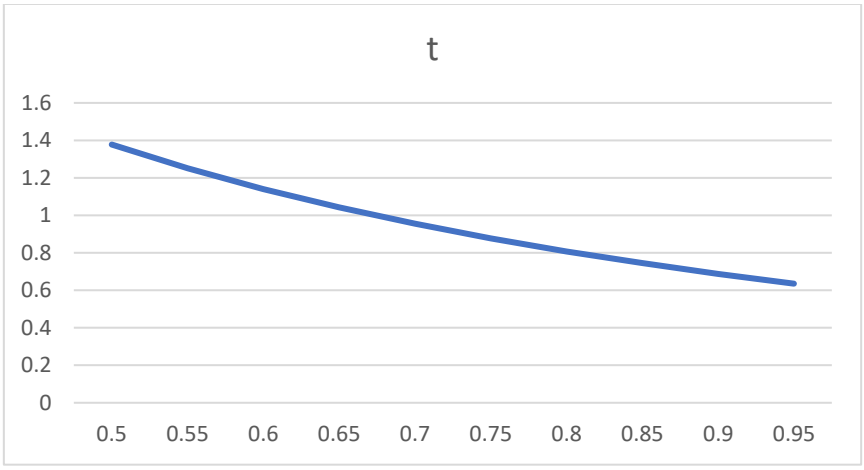
Graph. 1

From this graph we can say that if the rating of the product increases, then the sales of product will increase.

b.If we take q=0.05 and r=0.70 then

p	t
0.50	1.37778
0.55	1.251473
0.60	1.1406693
0.65	1.042757
0.70	0.9556916
0.75	0.87784
0.80	0.8078848
0.85	0.744748
0.90	0.6875384
0.95	0.635512

Table 2



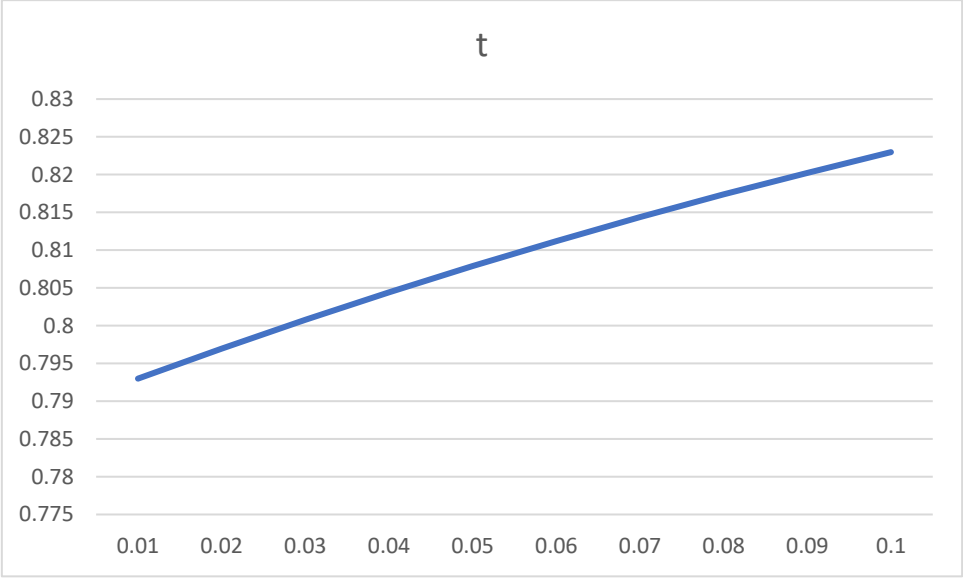
p

Graph 2

c. If we take p=0.8 and r= 0.70 then

q	t
0.01	0.7929889
0.02	0.796973
0.03	0.8007796
0.04	0.8044145
0.05	0.8078848
0.06	0.8111966
0.07	0.8143559
0.08	0.817368
0.09	0.82023976
0.10	0.822975

Table 3



Graph 3

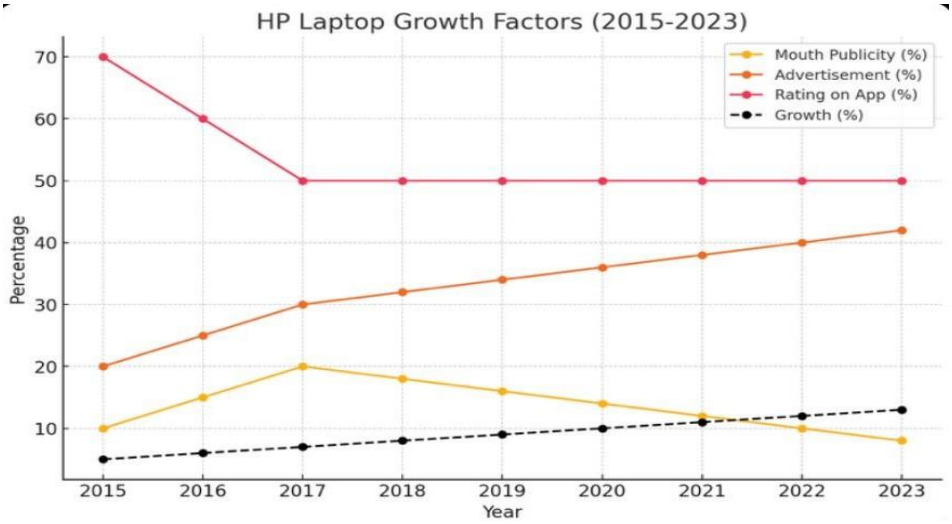
Application on HP laptop growth:

We are creating hp laptop growth influence by mouth publicity, advertisement and rating on the app over the years 2015-2023 would involve specifying values for each factor per year and their contribution to growth, the following data is shown under

Year	p (%)	q (%)	r (%)	Growth (%)
2015	10	20	70	5
2016	15	25	60	6
2017	20	30	50	7
2018	18	32	50	8
2019	16	34	50	9
2020	14	36	50	10
2021	12	38	50	11
2022	10	40	50	12
2023	8	42	50	13

Table 4

In this dataset p starts higher but gradually decrease as other factors become more influential, advertisement steadily increases in influence over the year rating on app remains a consistently strong influence, driving the majority of the growth



Graph 4

An analysis of HP laptops from 2015 to 2023 involves various actions. In this perspective, we gathered historical sales data, market sales for HP laptops during the said duration, word-of-mouth advertising, ad expenditure and ratings on app stores regarding these specific devices. The subsequent step was that we investigate the information through questioning internet media mentions and word-of-mouth marketing reports which were quantified by application budgeting size, advertising reach, frequency and engagement metrics. We also rely on average user ratings from app stores and review websites as part of our analysis. Based on how much each factor affects buying decisions a weightage was assigned to them. As an illustration, ratings were given a lot of attention because they heavily influence customers' trust levels and whether or not to make purchases. Also, the data must be scaled for consistency so that the percentage range of each factor falls into an equal category scale. Later we plotted a trend using a normalized data over time graph. These graphs show how each factor changes its impact over time coupled with growth in terms of correlation between such factors. Our model integrates quantitative analysis with qualitative insights to unravel these drivers behind HP laptop growth.

6. Conclusion:

The growth of laptops in the electronics industry is influenced by various factors, including word-of-mouth publicity, advertisements, and e-commerce website ratings. In India, these elements play a crucial role in shaping consumer preferences and driving sales. Word-of-mouth publicity fosters trust and credibility, advertisements create awareness and brand recall, and e-commerce ratings offer detailed insights for consumers to make informed decisions. Together, these factors contribute to the dynamic and ever-expanding laptop market, ensuring its continuous prominence in the global electronics industry. The Bass model is the most convenient model for market adoption forecasting of a new product/service in the sense of flexibility vs. number of free parameters needed to be determined. Estimation of the parameters when limited time series data are available can be improved by introducing the Bass model with explanatory parameters. Direct inclusion of explanatory parameters in the Bass model is not possible, but solution with an approximate mapping function in combination with reparametrized Bass model makes it achievable. Bass model with explanatory parameters is suitable for the forecasting of new product/service adoption where all model parameters can be assumed by means of analogy with the existing products services. Whenever a company launches a new product on the market, it tries to increase its growth as much as possible. To increase growth, three factors work because, till now, only two factors have worked. Why else would they work? Because the person who buys a product is the factor that increases the growth rate of the other, so the ratio increases, i.e., the word-of-mouth and queue factor, which increase the growth of the product by giving guidelines to it like television, paper, etc. But if we look at today's world, we see that when any person buys a new product, he trusts neither television nor anyone telling him the same. The maximum of trust is based on the feedback of people on it, how beneficial the product is for people, and how much it affects them. So he buys the product by looking at its online rating; similarly, for any product, we look at its current rating. The thing that is most influential in increasing the growth rate is online rating. That's why we added a new parameter to our hypothesis for a new type of model; this parameter depends on p and q. Those who are adopters and those who are non-adopters, that is, those through word of mouth, television, or in the newspaper, The success of a product depends on its customers. If a product is successful in the market, then its customers will like it.

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