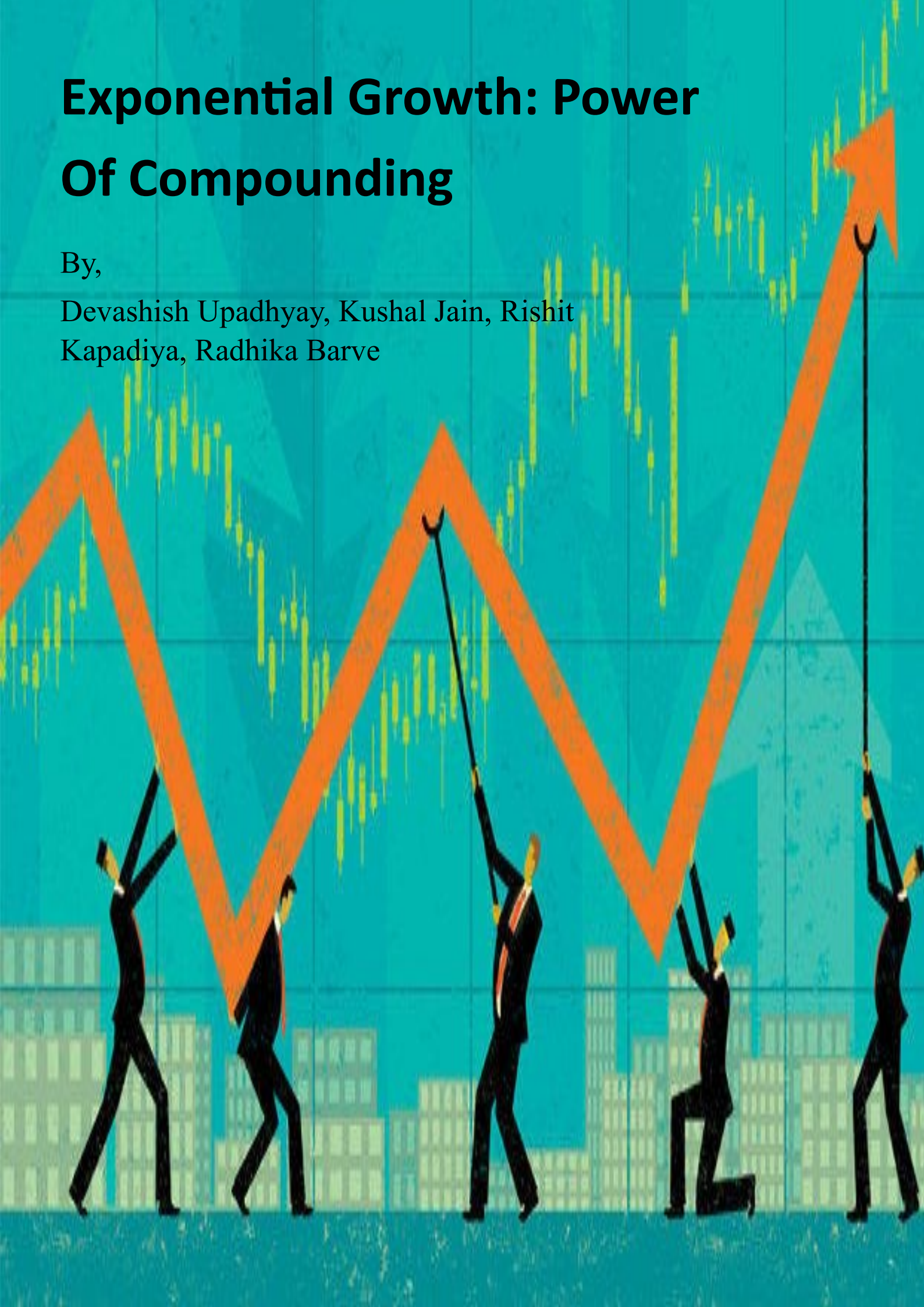
Exponential Growth: Power Of Compounding

By,

Devashish Upadhyay, Kushal Jain, Rishit Kapadiya, Radhika Barve



Acknowledgement

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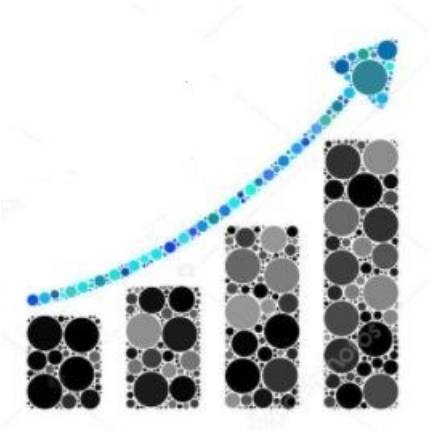
From,

Devashish Upadhyay, Kushal Jain, Radhika Barve and Rishit Kapadiya

S.P JAIN SCHOOL OF GLOBAL MANAGEMENT

(Bachelor's of Data Science)



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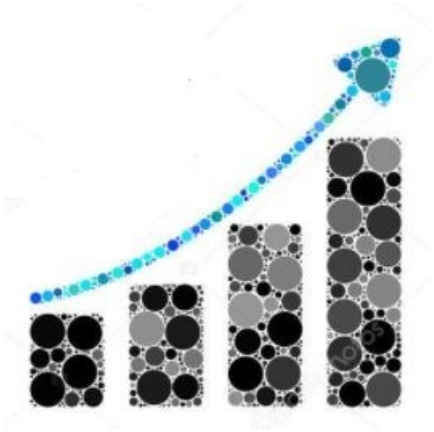


Introduction

Exponential function is an important mathematical function, where the independent variable is the exponent in the function and dependent variable is the output of the function. We have used the exponential function in the financial sector to explain the importance of compounding.

Equation

$Y = I.e^{rt}$

I = Initial value of the curve (INR)

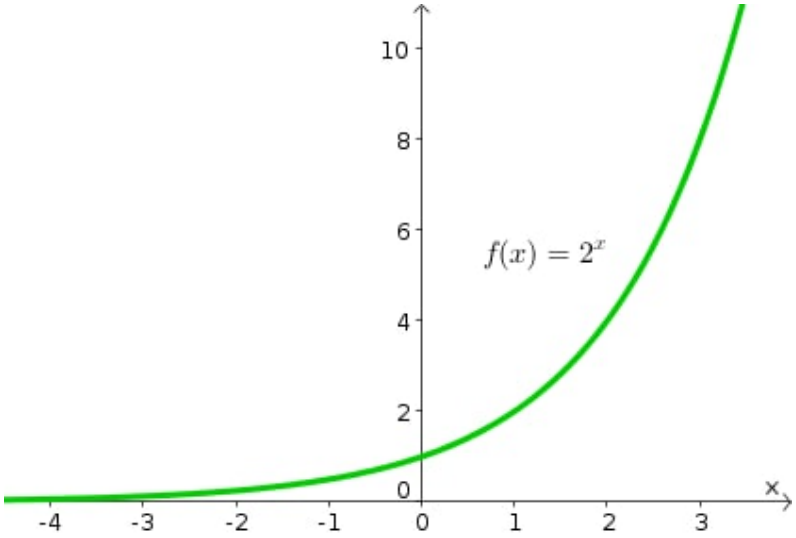
r = Rate of Growth (Percentage %)

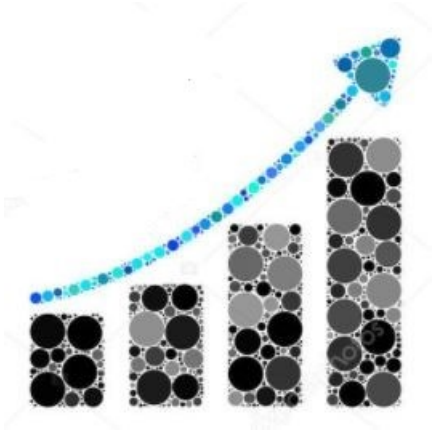
t = Time (in months)

An exponential function can be used in 2 ways:

Exponential Growth

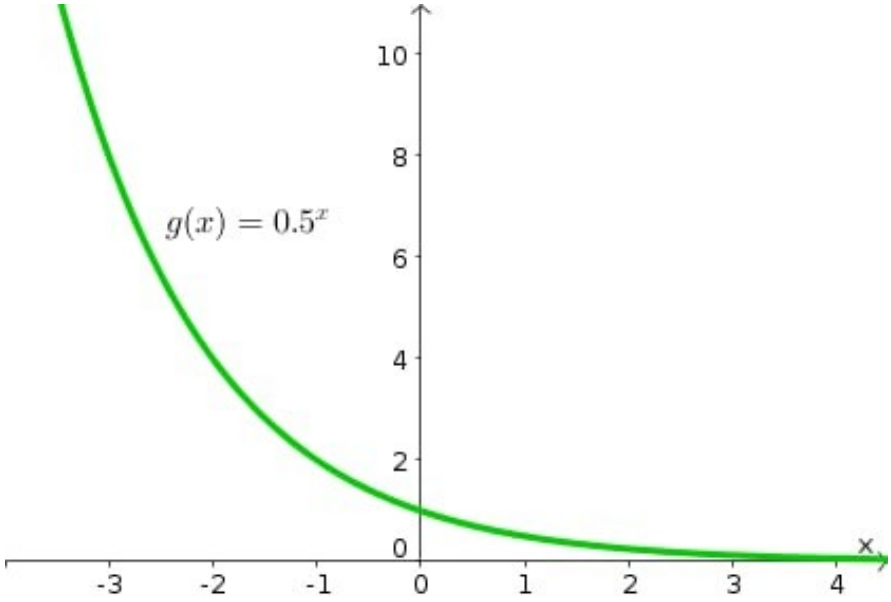
Exponential Growth is a soaring pattern observed in a dataset with respect to time, creating a curve with an exponential function upwards. (r > 1)





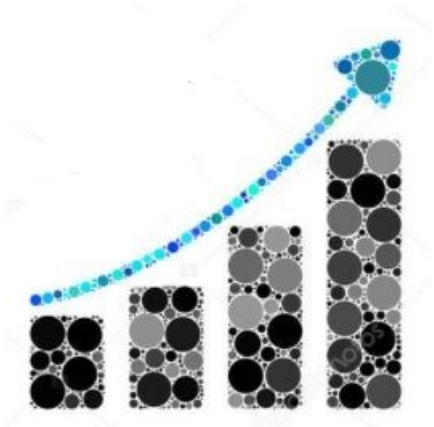
Exponential Decay

Exponential Decay is a pattern of decline observed in a dataset with respect to time, creating a curve with an exponential function downwards. (0 < r < 1)



Understanding Exponential Growth

Compound returns cause the exponential growth in finance, making power of compounding one of the most powerful forces in this field. Investors with small initial investments can make large sums of money in long-term. Common examples of exponential growth are savings account with fixed compound interest, equities with strong fundamentals and more. For example an investor invests a sum of $1000



Key to Exponential Growth : Compounding

Compounding is the most underrated multi-bagger in the financial sector.

An interest on a loan or a deposit, based on the initial principal and the stockpiled interest from previous periods is called compound interest.

Difference Between Compounding and continuous compounding

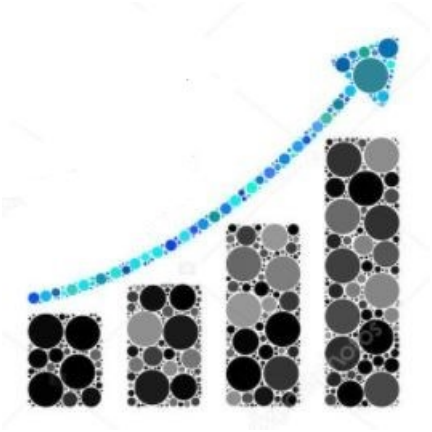
The difference between compounding and continuous compounding is in compounding the interest is applied in a span of time, whereas in continuous compounding the interest is applied at every moment Difference between compounding and continuous compounding.

To explain compounding better we will compare three investors-

Rishit invests INR 50,000 per month from the Age of 26 to 35. A total investment of INR 6,00,000 per year and INR 60,00,000 in 10 years. Rishit gets a return of 10% per annum.

Radhika also starts investing INR 50,000 per month from the age of 34 to 60. A total investment of INR 6,00,000 per year and INR 1,62,00,000 in 27 years. Radhika also gets a return of 10% annually.

Rishit invested a total sum of INR 60,00,000 whereas Radhika invested a total sum of INR 1,62,00,000; Rishit invested money for 10 years, Radhika invested for 27 years. During the maturity, it seems obvious Radhika will have a better return. To find out we created programs in python to give us the exact value after every year and plot graphs, and the results were surprising.



Code

```
import pandas
compound=600000
p = 600000
y = 11
rate = 1.1
growth=[]
time=[]

for i in range(36):
    if i < y:
        growth.append(int(compound))
        time.append(i)
        compound = p + (compound*rate)
    else:
        growth.append(int(compound))
        time.append(i)
        compound = compound*(rate)

print(time, growth)
```

Code for Rishit's Investment

```
import pandas as pd

compound=600000
p = 600000
rate = 1.1
growth=[]
time=[]

for i in range(28):
    growth.append(int(compound))
    time.append(i)
    compound = p + (compound*rate)

print(time, growth)
```

Code for Radhika's Investment

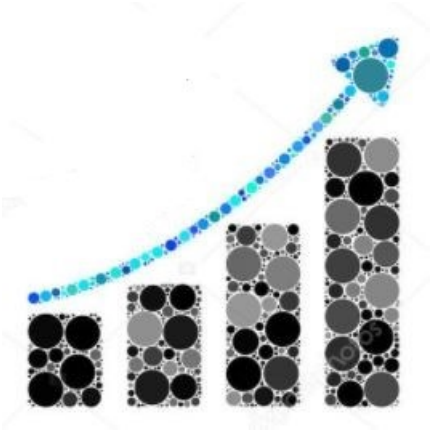
Where,

p is the constant principal amount of INR 6,00,000 invested every year.

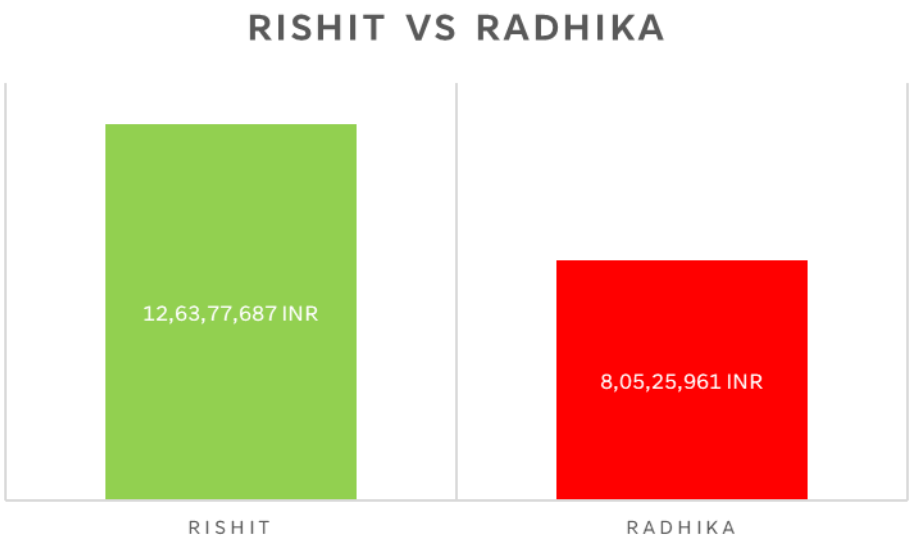
r is the interest compounded annually

compound is the variable which carries operations

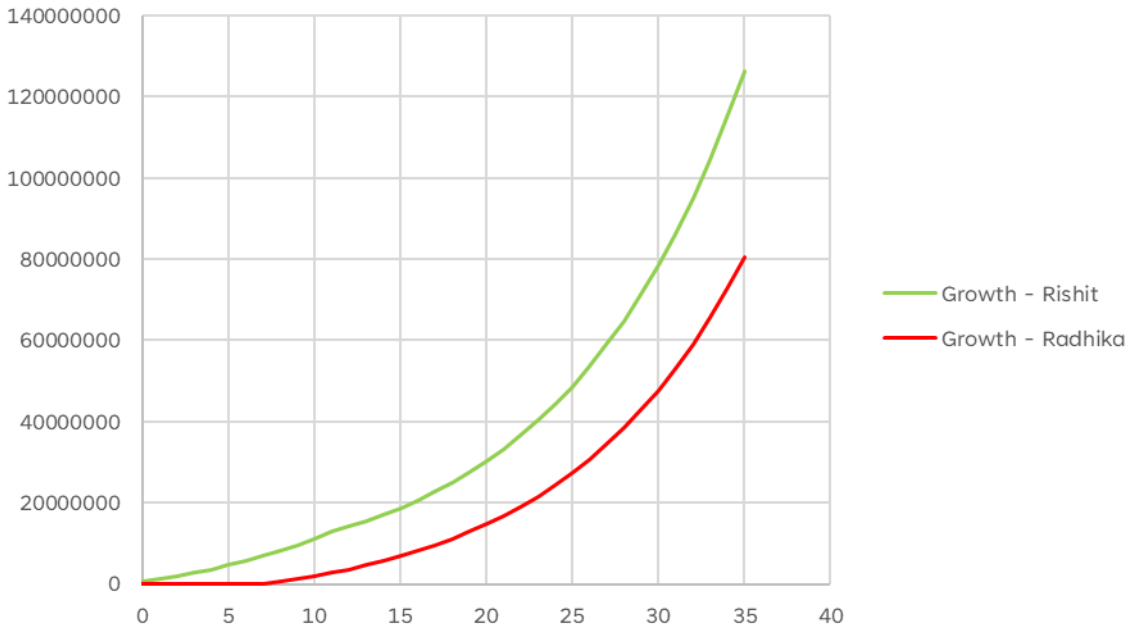
y is the time period in years



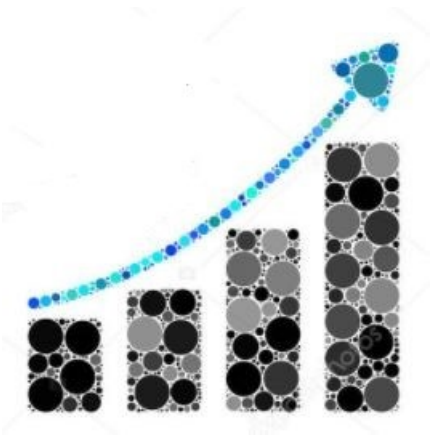
After maturity we observe,



At 61 Rishit gets a return of INR 12,63,77,687 but Radhika only INR 8,05,25,961.



This shows the power of compounding



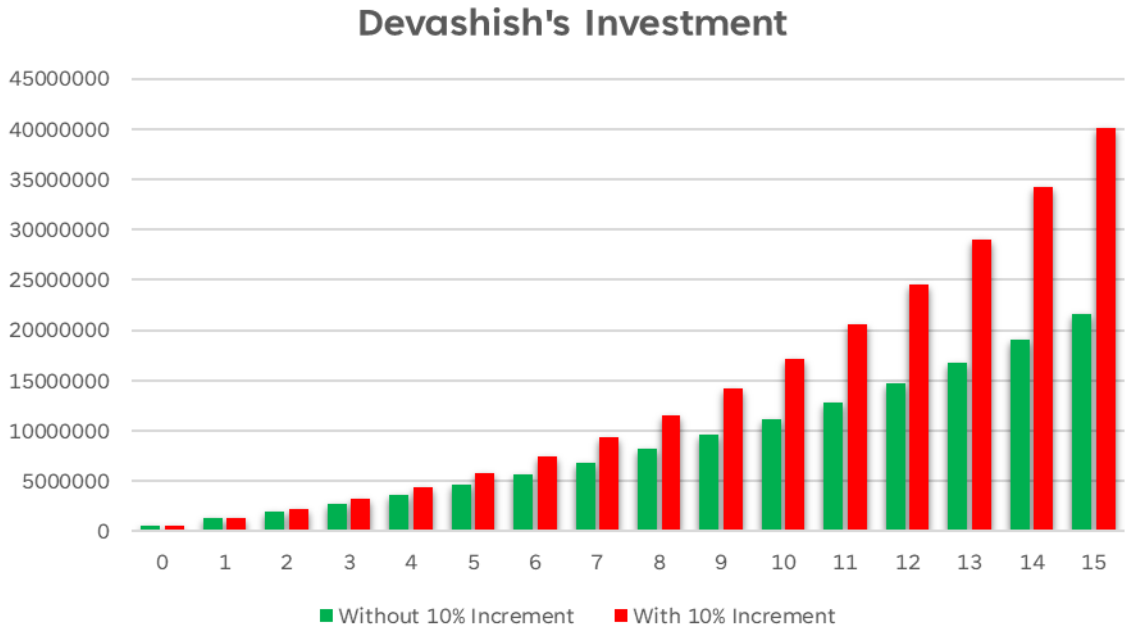
Devashish invests INR 50000 per month, INR 6,00,000 a year but every year he increases his principal amount per month by 10%.

Year 1: 50,000 per month (INR 6,00,000 a year)

Year 2: 55,000 per month (INR 6,60,000 a year)

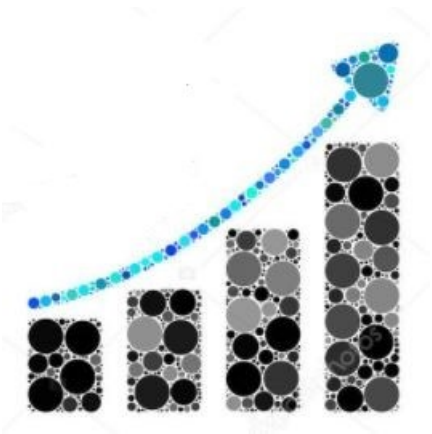
Year 3: 60,500 per month (INR 7,26,000 a year)…

The investment is compared to another investment without 10% increment every year. Returns after 15 years are observed in the graph.



It is observed in the graph that just an increment of 10% every year can give us twice as much returns at the end of 15 years.

Through various investment examples and data analysis we will observe exponential growth in real life.



Analysing Stock Prices Using Exponential Curve

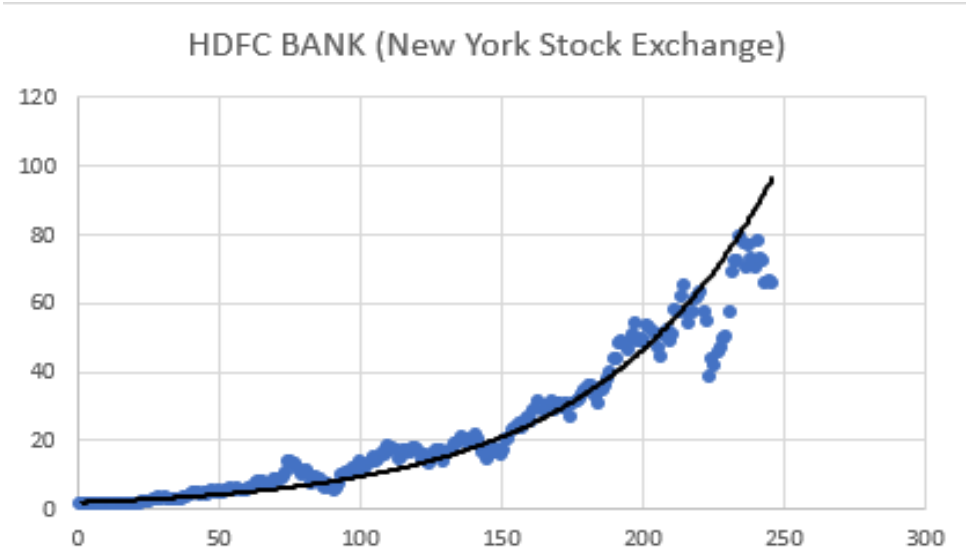
1) HDFC BANK (Listed on New York Stock Exchange)

HDFC Bank Limited offers a variety of banking and financial services to individuals and businesses in India, Bahrain, Hong Kong, and Dubai. It operates in treasury, retail banking, wholesale banking, other banking, and unallocated segments. The company accepts savings, payroll, checks, local, public retirement funds, pensions and demat accounts. Fixed and time deposits, lockers for lockers. The same applies to offshore accounts and deposits, overdrafts, and sweep-in facilities.

The bank also offer personal loans, mortgages, car loans, motorcycle loans, business loans, education loans, gold loans, consumer loans and local loans. Loans for real estate, stocks, loans, and assets.

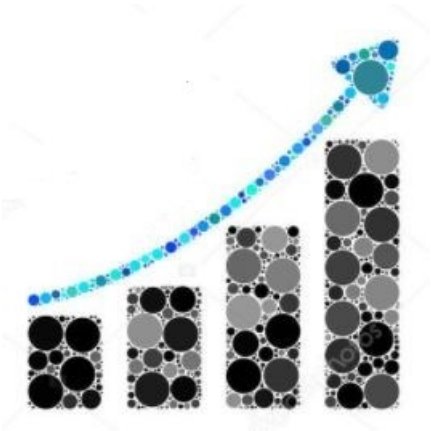
The company also offers credit, debit, prepaid and currency cards. Payment and collection, export, import, remittance, bank guarantee, letter of credit, trade, insurance, dealer, and cash management services. The same is true for insurance and investment products. In addition, we offer short-term lending, invoice discounts, structured finance, export credit, loan syndication, and document collection services

Fitting an exponential curve



Price on 1st August 2002 is USD 1.55

Price on 1st December 2021 is USD 65.88



Derivation of the Formula:

$$\frac{dy}{dt} \propto y$$

$$\frac{dy}{dt} = yr$$

$$r = constant\ of\ proportionality\ (Rate\ of\ Growth)$$

$$\int \frac{dy}{y} = \int r\,dt \quad (Integrating\ Both\ Sides)$$

$$\ln(y) = rt + C$$

$$e^{rt+C} = y$$

$$y = e^{rt}.e^{C}$$

$$y = I\,.e^{rt} \quad (I = e^{C})$$

y = value at a given time[t] (INR)

I = Initial value of the curve (INR)

r = Rate of Growth (Percentage %)

t = Time (in months)

Using Excel we fitted an exponential curve on the dataset such as,

$y = 1.9337e^{0.0159x}$

$R^2 = 0.9391$

Accuracy

Random Point 1 (62,6.105)

$y_1 = 1.9337e^{0.0159*62}$ ——————————(1)

$y_1 = 5.18222$

$y = 6.105$

Random Point 2 (154,22.515)

$y_2 = 1.9337e^{0.0159*154}$ ——————————-(2)

$y_2 = 22.377$

$y = 22.515$

Therefore, the exponential curve fits to the dataset.

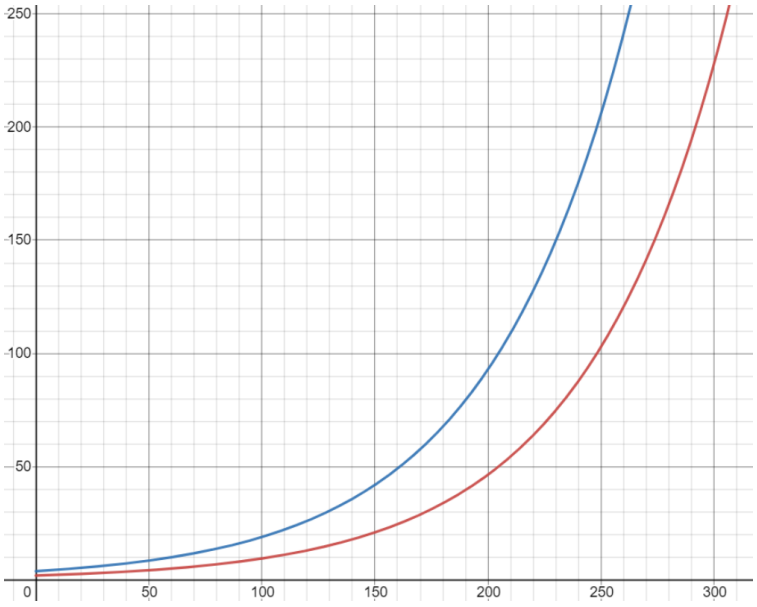
Changing the initial value

In the graph below the red line indicates the exponential curve of original initial value and blue line indicates the exponential curve of new initial value. With the change in initial value we can see that the curve is getting steeper which indicates price is getting compounded in less amount of time.

$$y = 1.9337e^{0.0159x}$$

$$y = (1.9337*2)e^{0.0159x}$$

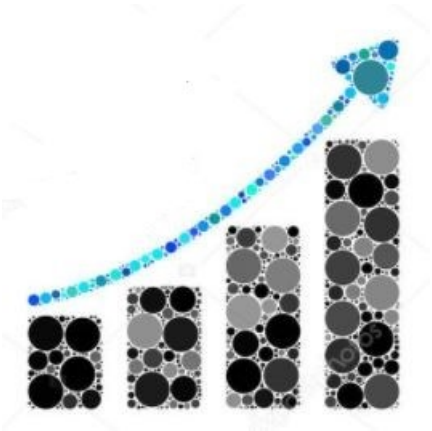
(Equation of the price of 2 stocks)



Predictions:

According to the equation ($y = 1.9337e^{0.0159x}$), the short term (6 months) predictions will be 106.2 USD and Long term (2 year) predictions will be 146.519 USD.

Time	Value
Short-Term (6 Months)	106.2 USD
Long-Term (24 Months)	146.519 USD



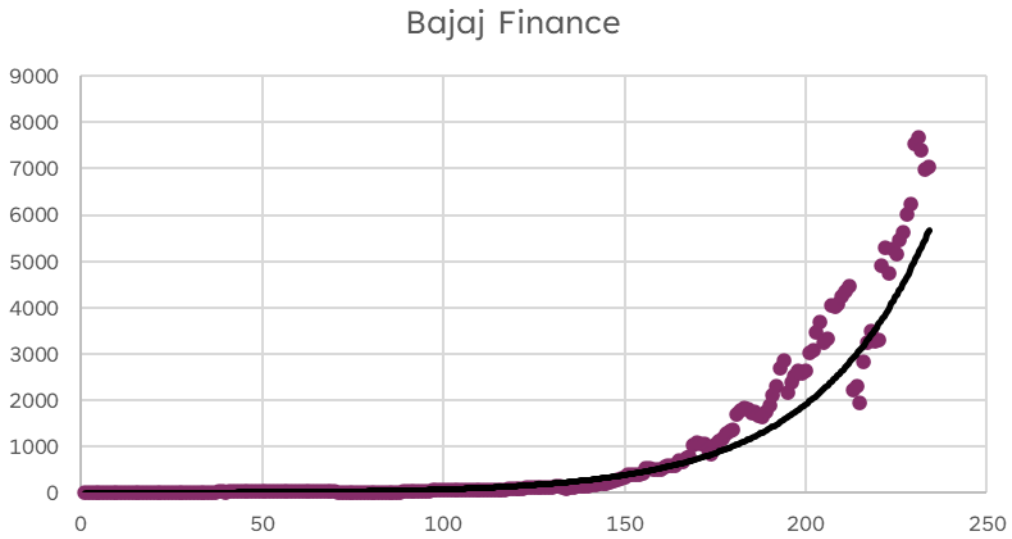
2.) Bajaj Finance Limited (Listed on National Stock Exchange)

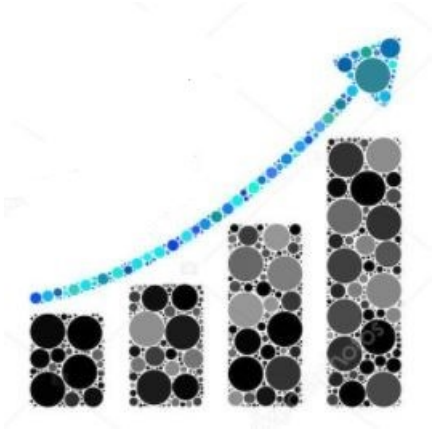
Bajaj Finance Limited, a subsidiary of Bajaj Finserv is a Public Company which comes under Financial Services Industry. The Founder of this Company is Rahul Bajaj. The Company has its headquarters located in Maharashtra, India. The Company provides services such as Lending, Fixed Deposits, Mutual Funds, etc. Current year revenue and net income of the Company are INR 26668 crore and INR 4419 crore respectively. In India, Bajaj Finance Limited is a non-banking financial organisation.

Consumer durables, lifestyle, lifecare, digital product, two and three wheeler, developer, used car, medical equipment, vendor, ; extended warranty, e-commerce, and lease rental discounting services; financial fitness reports; EMI cards, and co-branded credit cards and wallets; and investment services, including systematic deposit plans, fixed and term deposits, mutual funds and many more.

The company was previously known as Bajaj Auto Finance Limited, but in September 2010, it changed its name to Bajaj Finance Limited.

<u>Fitting exponential curve</u>





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$$y = e^{rt}.e^{C}$$

$$y = I\,.e^{rt} \quad (I = e^{C})$$

y = value at a given time[t] (INR)

I = Initial value of the curve (INR)

r = Rate of Growth (Percentage %)

t = Time (in months)

Using Excel we fitted an exponential curve on the dataset such as,

$y = 3.2526e^{0.0319x}$

$R^2 = 0.9567$

Accuracy

Random Point 1 (151,405.054)

$y_1 = 3.2526e^{0.0319*151}$ ——————————(1)

$y_1 = 401.96084$

y = 405.054

Random Point 2 (217,3215.3000)

$y_2 = 3.2526e^{0.0319*217}$ ——————————-(2)

$y_2 = 3300.2538$

y = 3215.3000

Therefore, the exponential curve fits to the dataset.

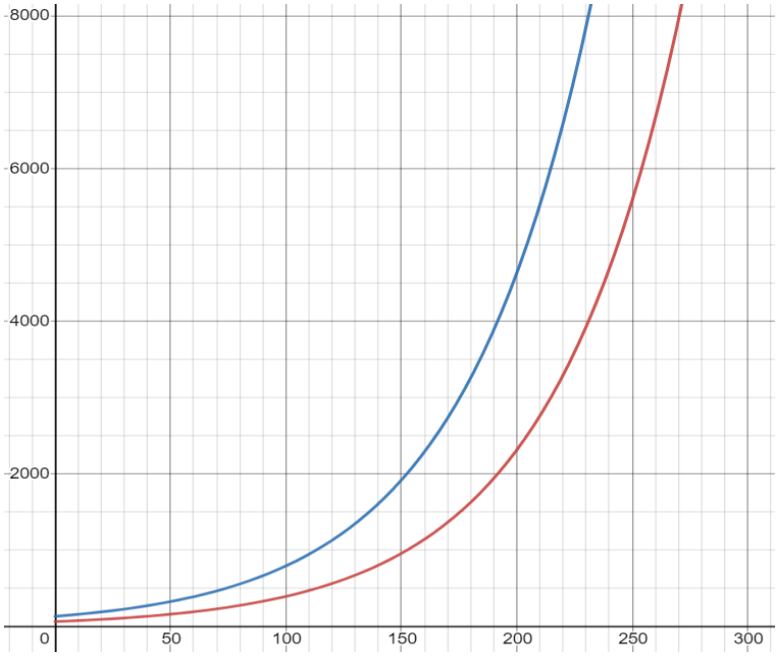
Changing the initial value

In the graph below the red line indicates the exponential curve of original initial value and blue line indicates the exponential curve of new initial value. With the change in initial value we can see that the curve is getting steeper which indicates price is getting compounded in less amount of time.

$$y = 3.2526e^{0.0319x}$$

$$y = (3.2526*2)e^{0.0319x}$$

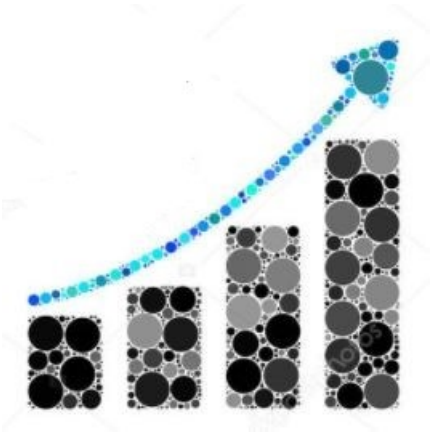
(Equation of the price of 2 stocks)



Predictions:

According to the equation, the short term (6 months) predictions will be 6873.678 INR and Long term (2 year) predictions will be 12205.655 INR.

Time	Value
Short-Term (6 Months)	6873.678 INR
Long-Term (24 Months)	12205.655 INR



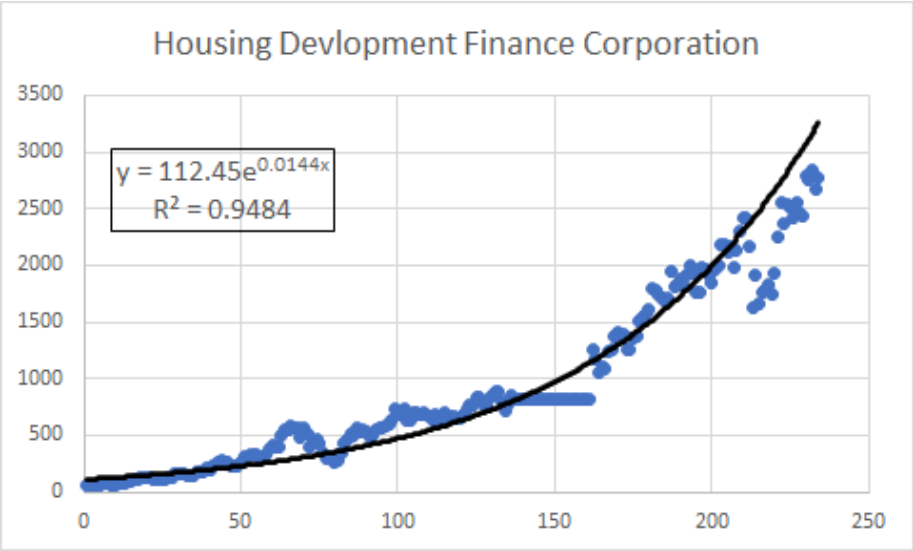
3.) Housing Development Finance Corporation (Listed on National Stock Exchange)

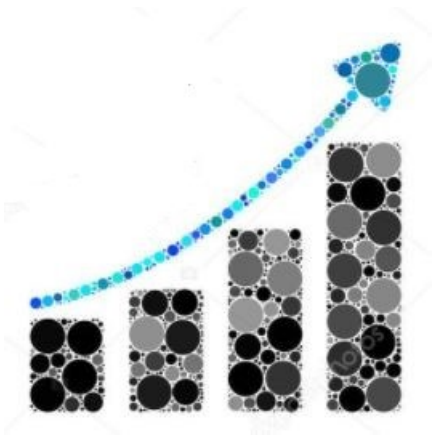
Housing Development Finance Corporation Limited is an Indian housing finance company that serves both individuals and businesses. Loans, Life Insurance, General Insurance, Asset Management, and other segments make up the company's operations.

Fixed deposits, such as monthly income plans, non-cumulative interest plans, annual income plans, and cumulative choices, as well as trust deposits, are accepted by the company. It provides loans for home purchase and construction, home improvement and extension, plot, and top-up loans, loans to agriculturists, planters, horticulturists, and dairy farmers, salaried/self-employed individuals, non-resident Indians, loans against property, and loans for non-residential premises and commercial plots, as well as education loans.

In addition, the company offers cross-selling services, investment advisory services, life insurance products, general insurance products, such as motor, health, travel, crop, home, personal accident, property, marine, aviation, and liability insurance, venture capital funds, asset management services, such as portfolio management, mutual fund, and property investment management, and other financial services.

Fitting Exponential Curve

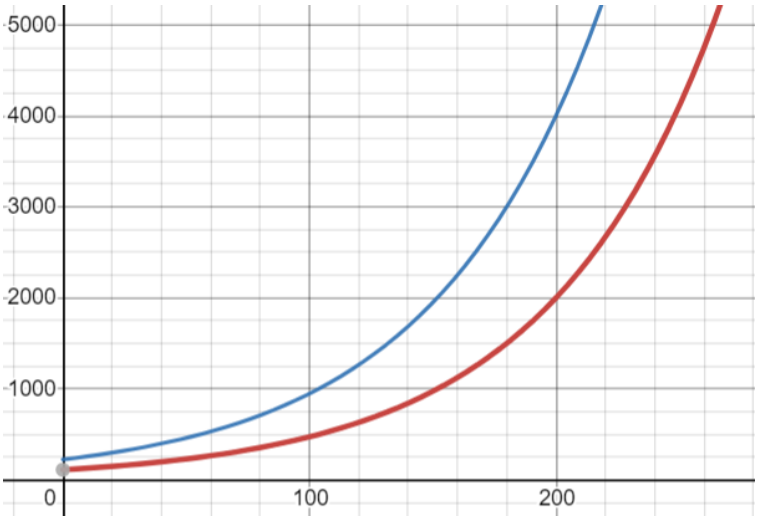




Now changing initial value to two times the current value. In the graph below the red line indicates the exponential curve with original initial value and blue line indicates the exponential curve with new initial value. With the change in initial value we can see that the curve is getting steeper which indicates price is getting compounded in less amount of time.

$$y = 112.45e^{0.0144x}$$

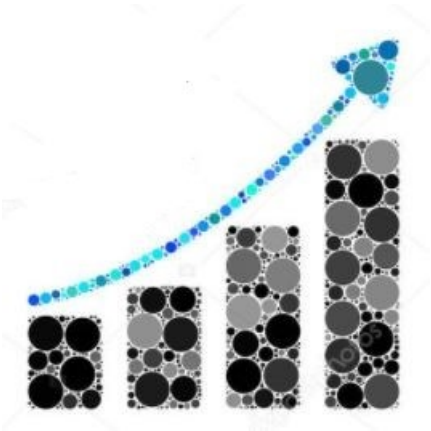
$$y = (112.45*2)e^{0.0144x}$$



Predictions:

According to the equation ($y = 112.45e^{0.0144x}$), the short term (6 months) predictions will be 3563.536 INR and Long term (2 year) predictions will be 4617.962 INR.

Time	Value
Short-Term (6 Months)	3563.536 INR
Long-Term (24 Months)	4617.962 INR

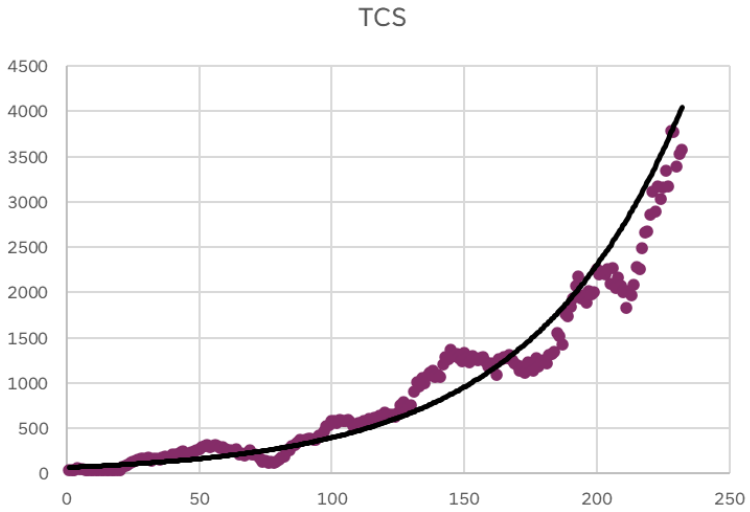


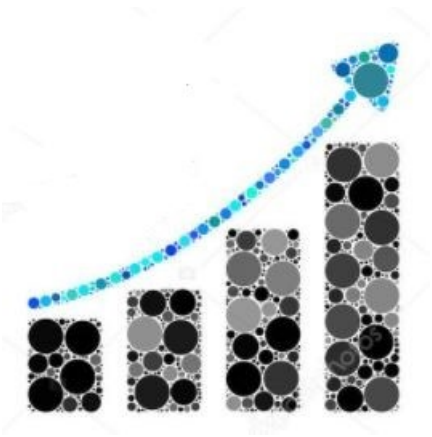
4.) Tata Consultancy Service (Listed on National Stock Exchange)

Information technology (IT) and IT-enabled services are provided by Tata Consultancy Services Limited around the world. Banking, Financial Services, and Insurance, Manufacturing, Retail and Consumer Business, Communication, Media, and Technology, and Others are the company's segments. TCS iON, an assessment platform; TAP, a procurement offering; TCS MasterCraft, a platform to automate and manage IT operations; Quartz, a blockchain solution; and TCS OmniStore, a commerce platform are among the company's offerings.

Customer intelligence and insight solutions, Intelligent Urban Exchange, an integrated software to speed smart city programmes, OPTUMERA, a digital merchandising suite, TCS BaNCS, a finance platform, and Jile, an agile DevOps product are among the company's other offerings. It also offers sophisticated drug development and connected intelligence platforms, as well as ERP on Cloud, an enterprise solution, and HOBS, a subscription-based digital business platform.

<u>Fitting a exponential curve</u>

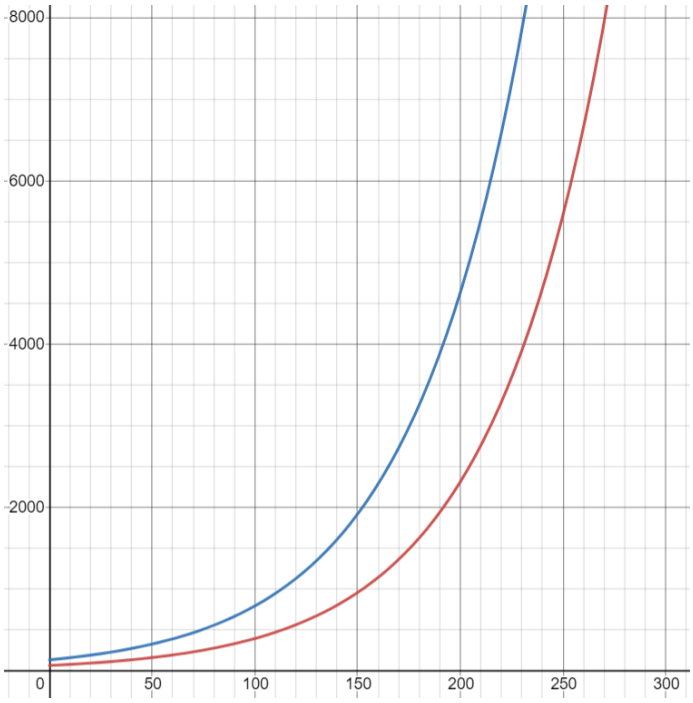




Now changing initial value to two times the current value. In the graph below the red line indicates the exponential curve with original initial value and blue line indicates the exponential curve with new initial value. With the change in initial value we can see that the curve is getting steeper which indicates price is getting compounded in less amount of time.

$$y = 68.585e^{0.0176x}$$

$$y = (68.585*2)e^{0.0176x}$$



Predictions:

According to the equation, the short term (6 months) predictions will be 4522.743 INR and Long term (2 year) predictions will be 6208.495 INR.

Time	Value
Short-Term (6 Months)	4522.743 INR
Long-Term (24 Months)	6208.495 INR

Bibliography

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2. https://yahoofinance.com
3. https://moneycontrol.com
4. https://mannapuramfinance.com/en_us
5. https://desmos.com