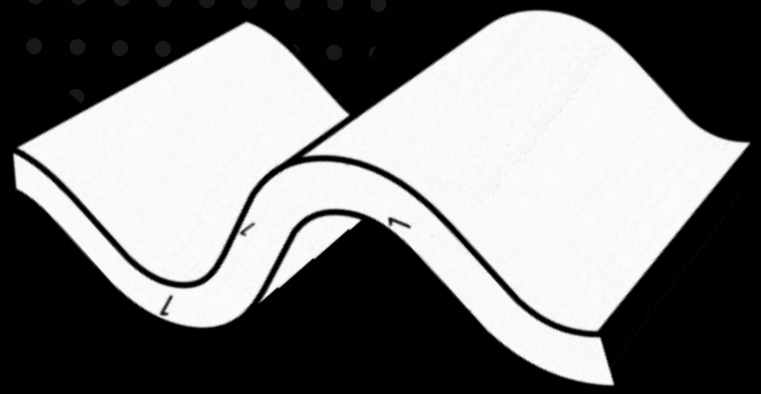
FINANCE AND ANALYTICS CLUB

Advanced Financial Modelling Using Python

WHAT IS IT?



1. To analyze, process data efficiently, and present it.

2. To identify the trends and patterns graphically and mathematically using python libraries

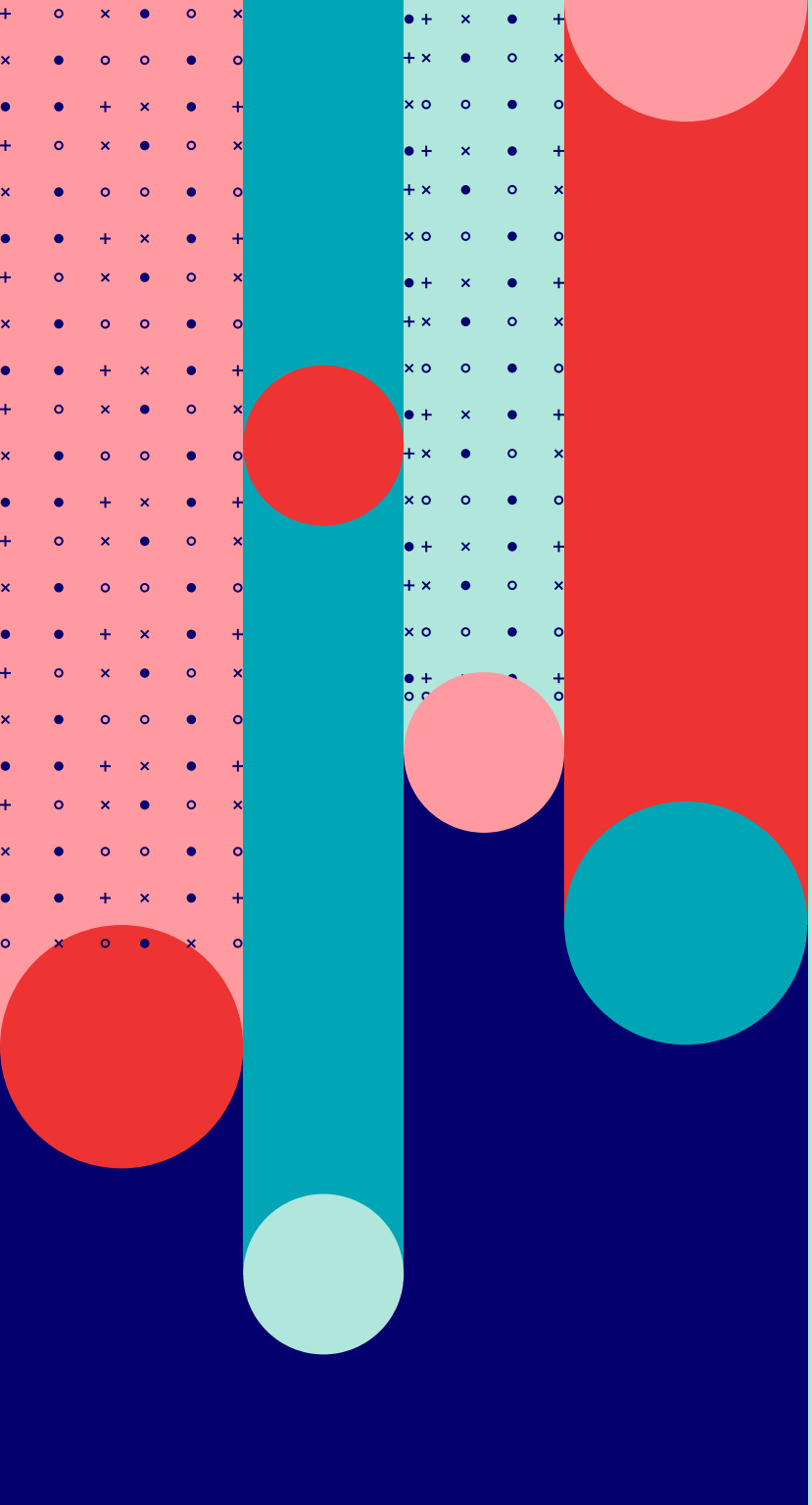
3. To predict and make data-driven business decisions.

ANALYSIS

The process of studying the data to find out the answers to how and why things happened in the past.

ANALYTICS

In data analytics, reading the data set or the outcome of the data analysis and processing them to find out the events that are likely to occur in future.



Python

1. Python is high-level, object oriented programming language that has simple syntax as compared to other programming languages.

2. With python, we can simplify the main tasks of financial modeling such as data gathering, advanced mathematical calculations, and the visualization of results.

BASIC PYTHON

CONDITIONALS

1) if-statements,
2) if-else statements,
3) Nested if-else statements.

LOOPS

1) while loop,
2) for loop,
3) Nested loops

DATA TYPES

1) Numbers,
2)Strings,
3) Lists and Tuples,
4)Dictoniory

FUNCTIONS

>defining a function,
>Calling a function..

NUMPY

Python's library

- NumPy array is simply a grid containsvalues of same type.
- 1D arrays are known as Vectors. and Multi-dimensionalarrays are known as Matrices.
- Creating NumPy arrays
  > using array()
  > using fromiter(),
  > using arange(),
  >using linspace().
- Working with NumPy arrays:
  > Array Indexing,
  > Array Slices,
  > Joining,
  > Spliting.

PANDAS

EFFICIENT HANDLING OF LARGE DATASETS

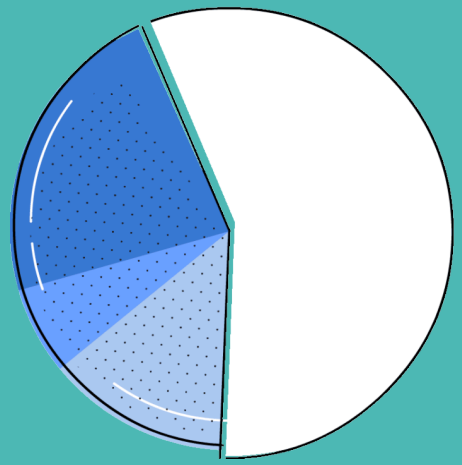
DATA ANALYSIS AND STATISTICS

MISSING DATA HANDLING

DATA EXPORTING AND REPORTING

WHAT FUNCTIONS DOES IT CONTAIN?

Input functions	Data Manipulation	Data Extraction	Data Visualization	Data Exporting
pd.read_csv()	df.sort_values('column_name')	df.loc[]	df.plot(x='x_column', y='y_column')	df.to_csv('filename.csv', index=False)
pd.read_excel()	df.head()	df.loc[df['column_name'] == value]	df['column_name'].plot.pie()	df.to_excel('filename.xlsx', index=False)
pd.read_sql()	df.fillna()	df['column_name'].unique()	df.plot.bar(x='x_column', y='y_column')	df.to_html('filename.html', index=False)
	df.join()	df.select_dtypes(include=['int', 'float'])	df.plot(x='x_column', y='y_column', kind='scatter')	



Assigment 1

Problem 1

Related to python libraries numpy and matplotlib.

problem 2

Come up with any one example of how Financial Modelling can be used in IITK.

PROCESS OF DATA MODELLING

Specify Data requirments

1

Process the data

3

Interpretation

5

2

Collect data

4

Analyse the data

WHY EXCEL?

- EXCEL IS A VERSATILE TOOL FOR FINANCIAL MODELING.
- MAKES IT EASY TO PERFORM COMPLEX CALCULATIONS, CONDUCT ANALYSIS, AND PRESENT RESULTS.
- WIDELY USED IN FINANCIAL MODELING DUE TO ITS VERSATILITY, COMPUTATIONAL CAPABILITIES, AND USER-FRIENDLY INTERFACE.
- MAKES IT EASY TO CREATE VALUATION MODELS USING FINANCIAL STATEMENTS.

EXCEL IN FINANCE

ORGANISING DATA

- Excel allows financial analysts to organize and structure large amounts of data efficiently.
- Provides features like spreadsheets, tables, and filters to manage and manipulate data.

DATA ANALYSIS

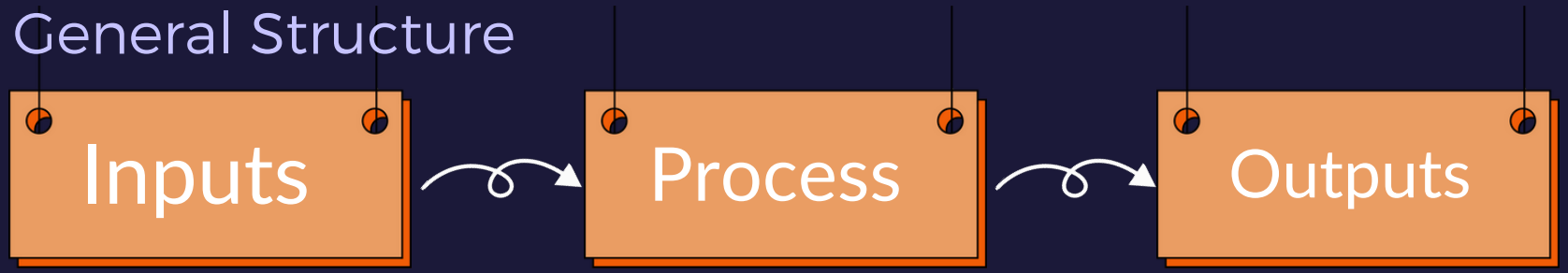
- Excel offers a wide range of tools for data analysis, such as pivot tables, charts, and regression analysis.
- Analysts can use these features to summarize data, identify trends, perform statistical analysis, and visualize financial information effectively.

FINANCIAL STATEMENTS

- Enables the creation of detailed financial statements, including income statements, balance sheets, and cash flow statements.
- Provides a comprehensive view of financial performance, enabling analysts to make informed decisions.

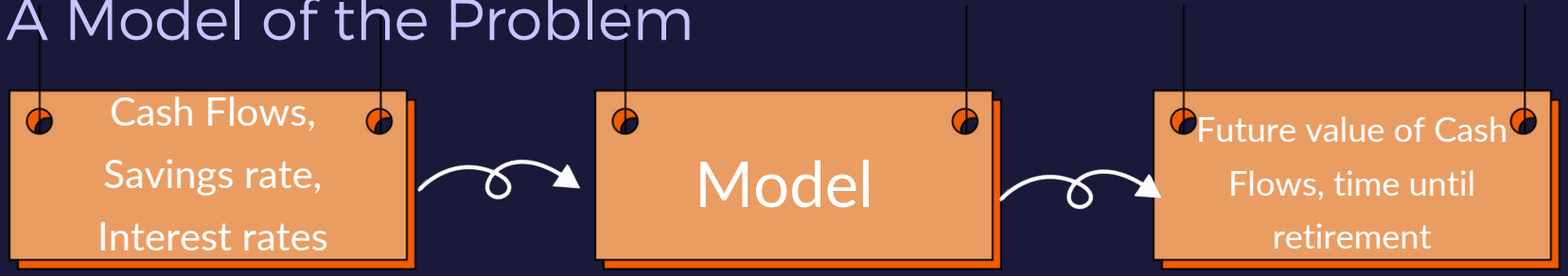
SIMPLE RETIREMENT MODEL

General Structure

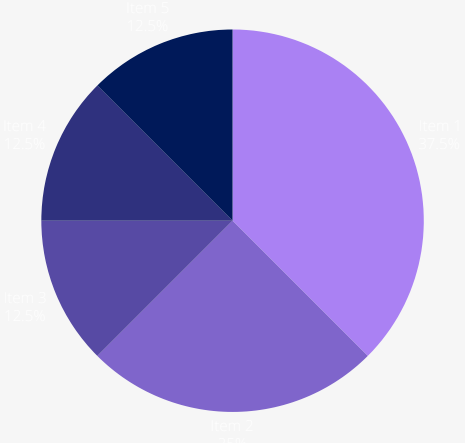


Real-World Problem

A Model of the Problem



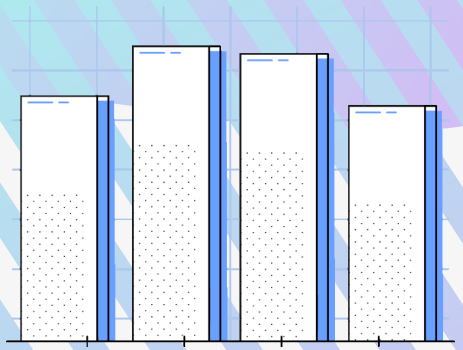
Let's approach this by building a simple model in Excel.
EXAMPLE: David is saving for retirement. He earns $60,000 per year and is able to save 25% of that. If he invests his savings, earning 5% per year, and he needs $1,500,000 to retire, how soon can he retire?



INPUTS			
Salary	**$60,000**		
Savings Rate	**25%**		
Desired Cash	**$1,500,000**		
OUTPUTS			
Annual Cash Saved	**$15,000**		
Investment Rates	**4%**	**5%**	**6%**
Years to Retirement	**41.0**	**36.7**	**33.4**

We've got a few assumptions built into the model.

- The salary is constant over time.
- Investment returns are constant over time.
- The amount needed in retirement does not depend on market conditions or life situations.



DYNAMIC SALARY RETIREMENT MODEL

Assumptions can be relaxed to create a more realistic model.

New assumption: The salary grows at a constant rate for the cost of living raises, and every number of years the salary grows at an additional rate for a promotion.

$$S_t = S_o(1+r_l)^t(1+r_p)^p$$

S_t: Salary at year t

S_o: Starting wealth

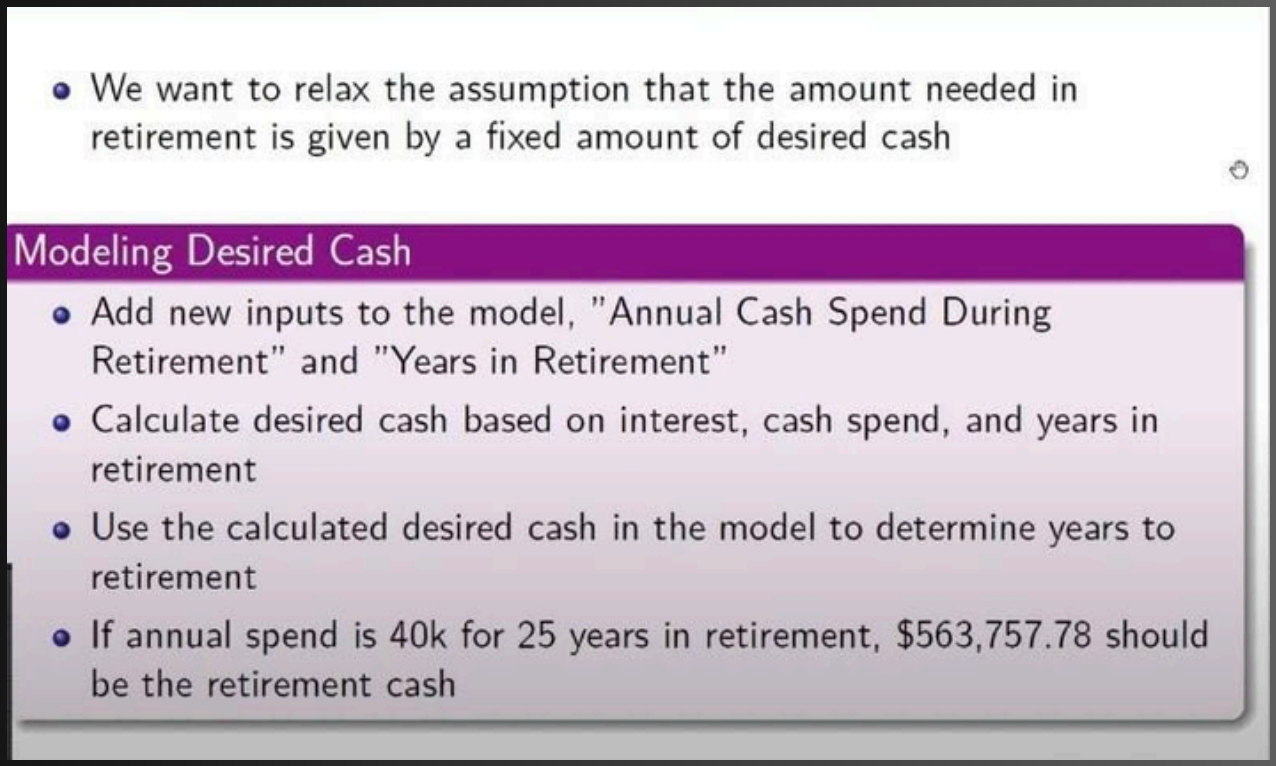
r_l: Return for cost of living

r_p: Return for promotion

t: Number of years

p: Number of promotions

Dynamic Salary Retirement Model



If annual spend is 40k for 25 years in retirement, $563,757.78 should be the retirement cash and there should be 18 years to retirement.

OUTPUTS :

Martha has 61.1 years to retirement if she earns a 4% return and saves 10%

Martha has 29.0 years to retirement if she earns a 5% return and saves 40%

Martha has 41.0 years to retirement if she earns a 4% return and saves 25%

Martha has 47.6 years to retirement if she earns a 6% return and saves 10%

Martha has 31.9 years to retirement if she earns a 4% return and saves 40%

Martha has 33.4 years to retirement if she earns a 6% return and saves 25%

Martha has 53.3 years to retirement if she earns a 5% return and saves 10%

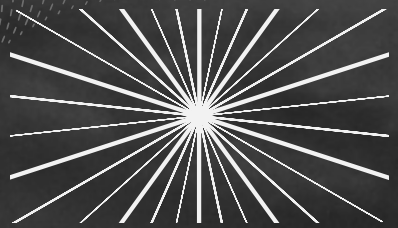
Martha has 26.7 years to retirement if she earns a 6% return and saves 40%

Martha has 36.7years to retirement if she earns a 5% return and saves 25%

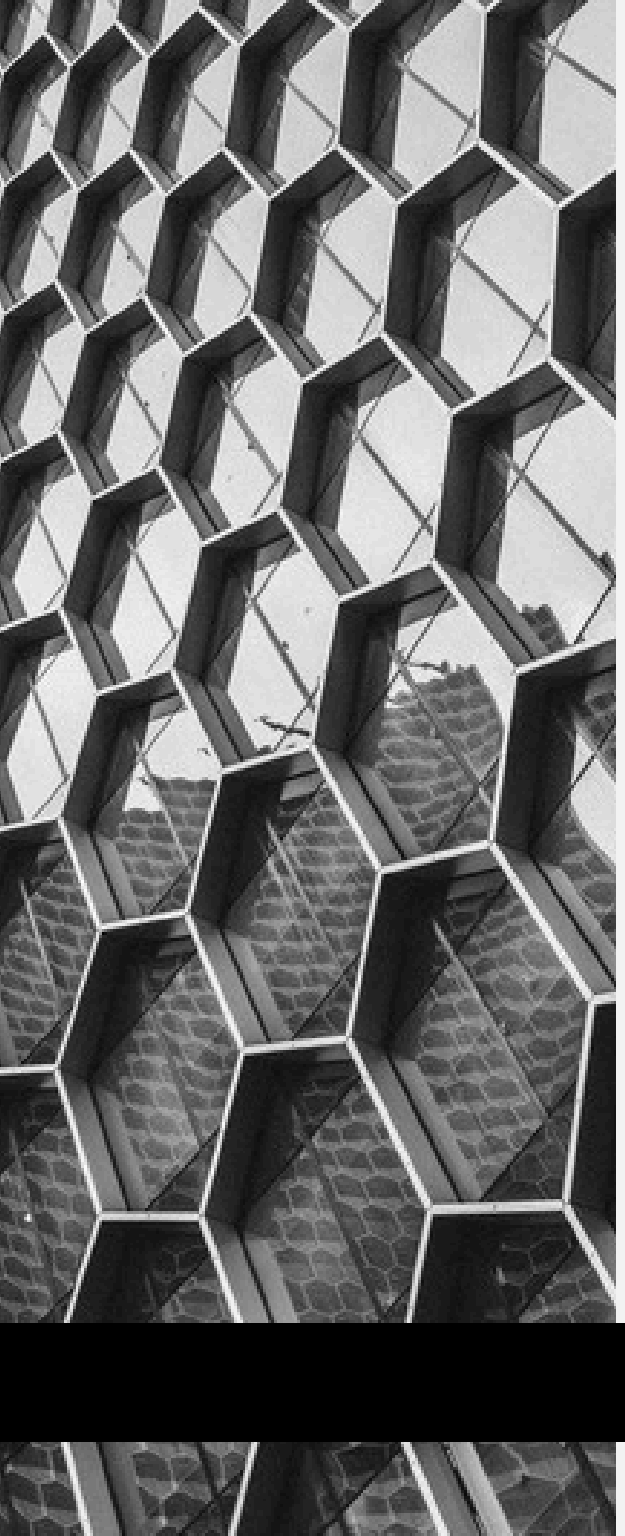
PARAMETER EXPLORATION IN FINANCIAL MODELING

Parameter exploration in financial modeling involves analyzing the effects of different parameter values on model outputs. By systematically varying parameters, we gain insights into their impact, uncover relationships, and enhance the accuracy of predictions. This exploration process improves decision-making and ensures more reliable and robust financial models

METHODS OF PARAMETER EXPLORATION

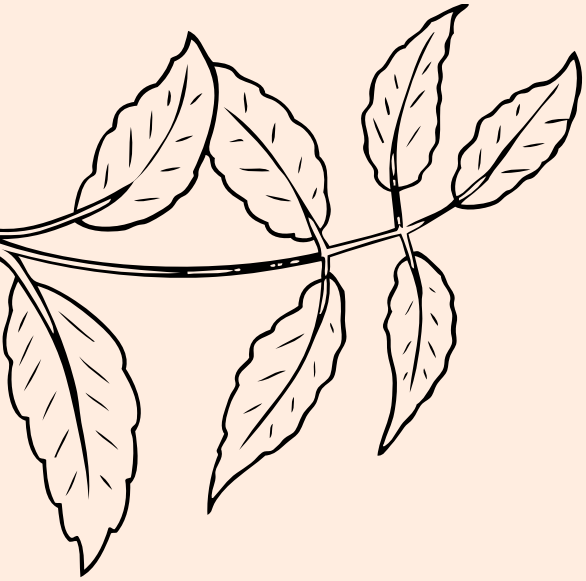


- Sensitivity Analysis
- Monte Carlo Simulation
- Scenario Analysis



Sensitivity Analysis

The process of sensitivity analysis involves systematically varying individual parameters within a financial model to assess their impact on the outputs. First, key parameters are identified. Then, a range of values is defined for each parameter. The model is run multiple times, with each run exploring a specific parameter value while keeping other factors constant. The resulting output changes are observed and analyzed, often using graphs or charts. The analysis helps identify which parameters have the most significant impact on the outputs and understand the nature of their relationships. This information enables informed decision-making, risk assessment, and optimization of financial models by focusing on the critical parameters that drive the outcomes.



Visualization

Why Visualize?

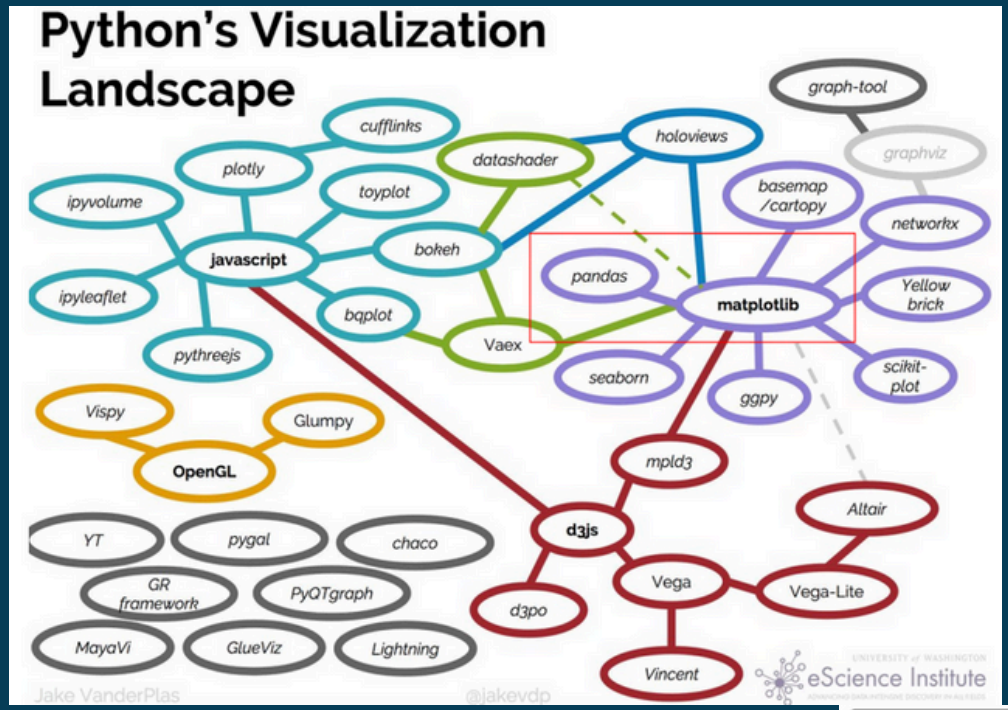
It makes the complex results easily interpretable. Visual representations make it easier to identify patterns, trends, and outliers.

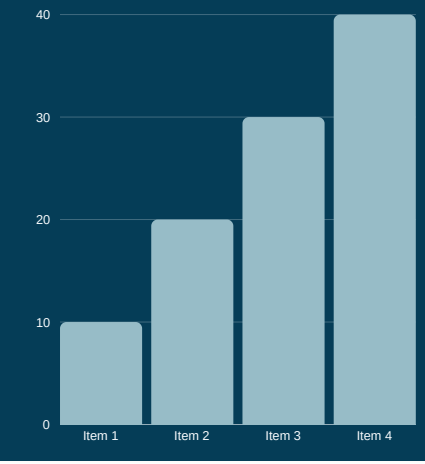
Benefits

.1. Clarity
2. Insights
3.Decision-making
4.Communication

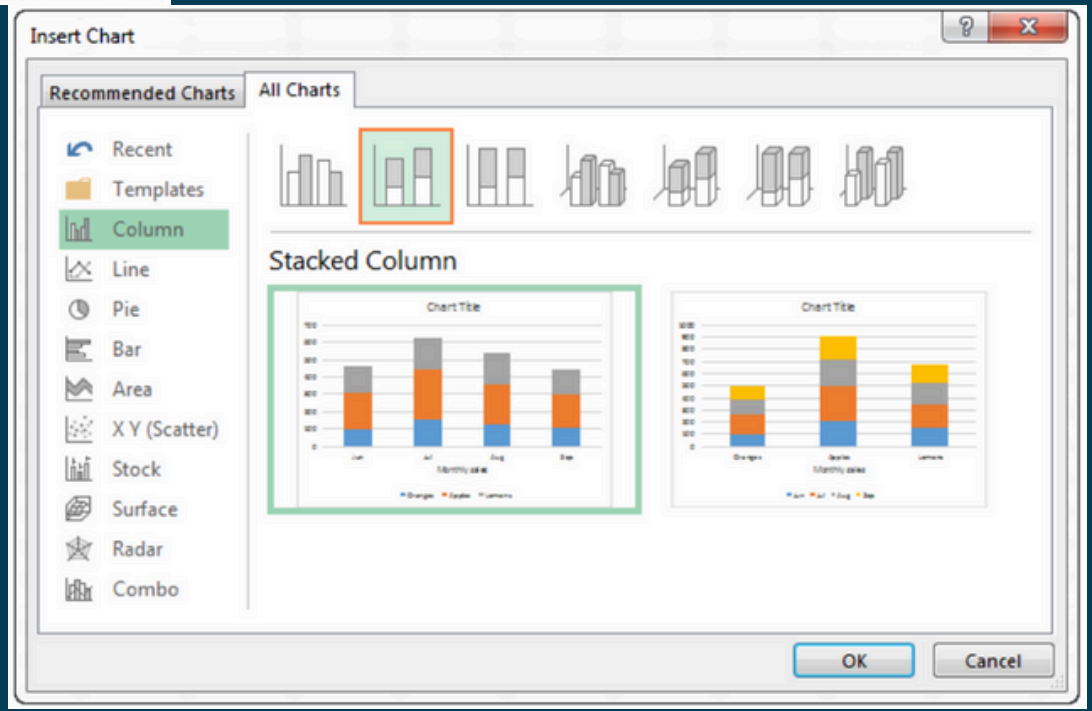
Types of visualization

- .Line charts
- Bar charts
- Pie charts
- Scatter plots
- Heat maps
- Treemaps
- Sankey diagrams



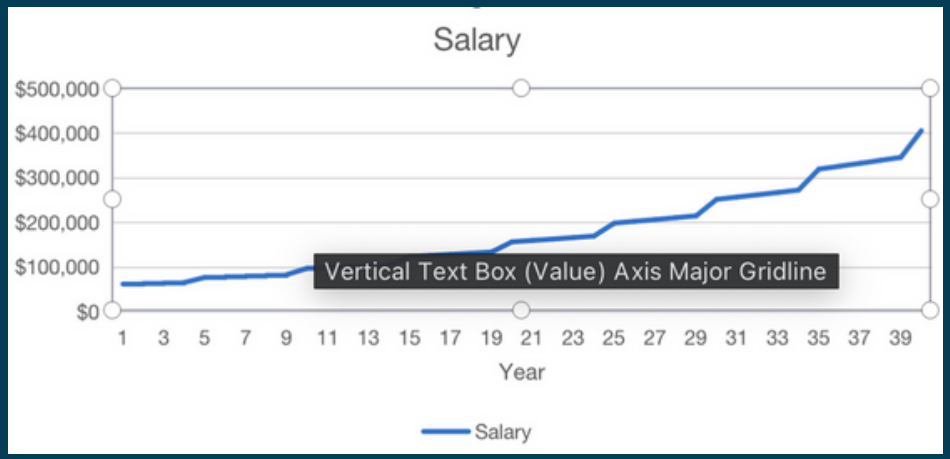


Visualization in Excel

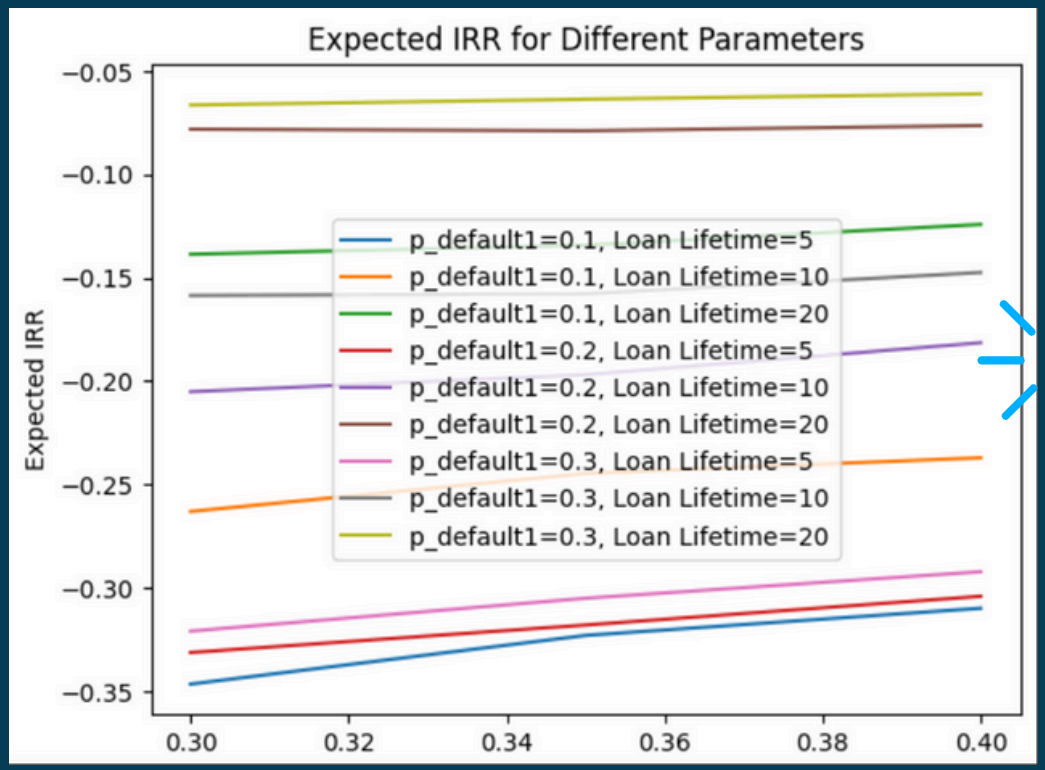


Visualization in Excel

We added visualizations to "Dynamic Salary Retirement model.xlsx" Excel model.



Visualization in Python



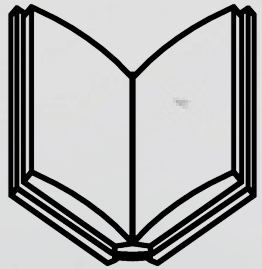
We have created graphs using matplotlib and pandas.

Created "Dynamic Salary Retirement Model" using python.

Monte Carlo Simulation

Monte Carlo simulation is a computational technique used in financial modeling to generate multiple simulations by randomly sampling parameter values. It allows for a comprehensive exploration of possible outcomes by simulating a large number of scenarios. Through repeated iterations, Monte Carlo simulation provides a distribution of results, enabling the assessment of probabilities and risk exposure. This technique is particularly useful when dealing with complex systems and uncertainties. By capturing the variability of inputs, Monte Carlo simulation helps in making more informed decisions, identifying potential risks, and evaluating the robustness of models. It provides valuable insights into the range of possible outcomes, aiding in risk management and strategic planning.

Scenario Analysis



Scenario analysis is a technique used in financial modeling to evaluate the impact of various combinations of parameter values on model outputs. It involves constructing and examining multiple scenarios to understand how changes in parameters affect outcomes. By considering different plausible future conditions, scenario analysis helps assess risks, identify potential opportunities, and make more informed decisions. This approach allows for a comprehensive exploration of the model's behavior under different circumstances and aids in managing uncertainty. Scenario analysis provides valuable insights into the range of possible outcomes, facilitating proactive planning and risk mitigation strategies.

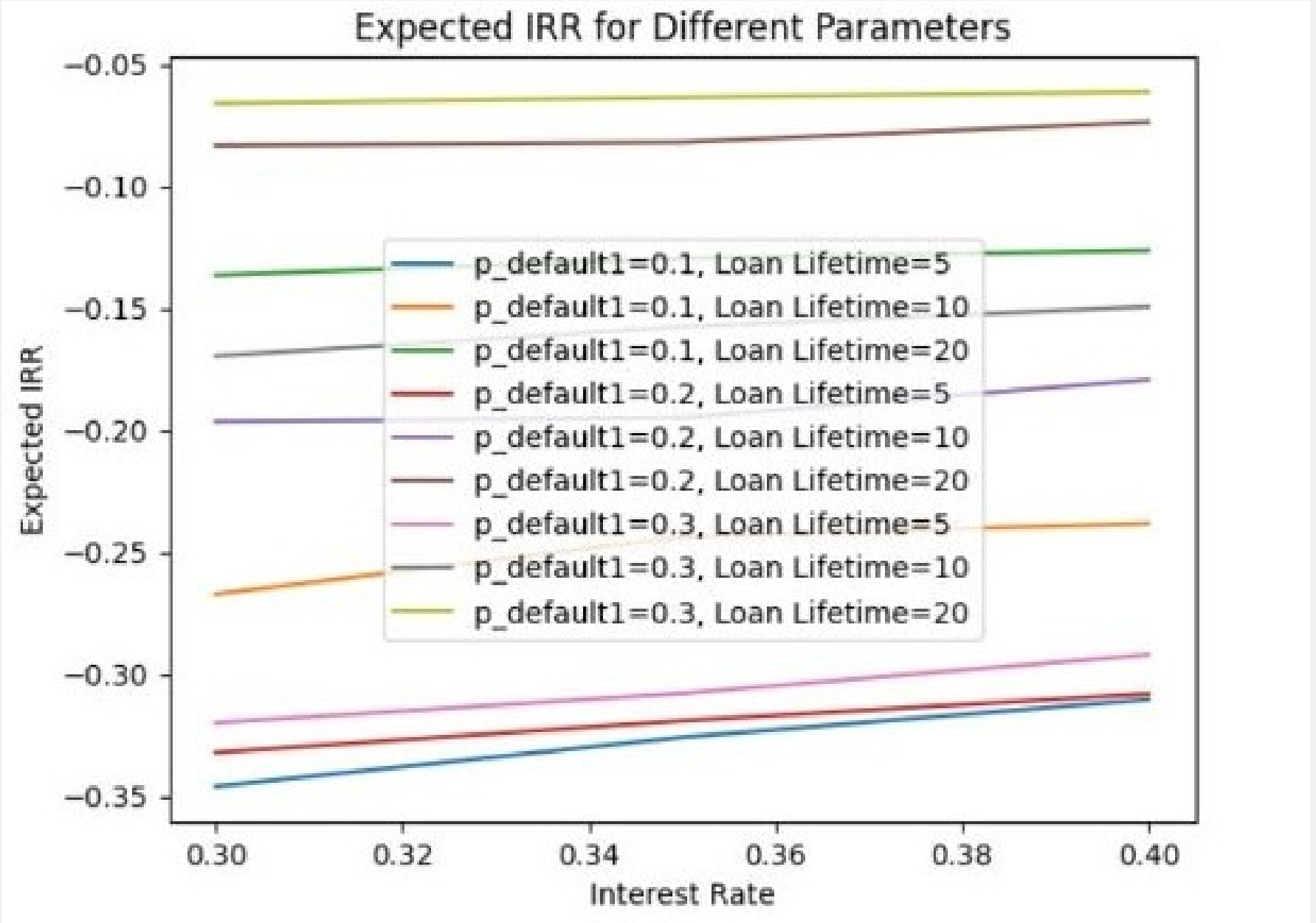
Probabilistic Modelling

Input:

```
!pip install numpy_financial
import numpy as np
import numpy_financial as npf
import matplotlib.pyplot as plt

# Define the initial parameters
interest_rates = np.arange(0.3, 0.41, 0.05) # Interest rates from 30% to 40%
default_probabilities = [0.1, 0.2, 0.3] # Default probabilities p_default1
recovery_rate = 0.5 # Recovery rate after default
loan_lifetimes = [5, 10, 20] # Loan lifetimes

iterations = 1000 # Number of iterations for Monte Carlo simulation

results = {} # Dictionary to store the results

# Simulate the loan process and calculate IRR
for interest_rate in interest_rates:
for default_probability in default_probabilities:
for loan_lifetime in loan_lifetimes:
irr_values = []
for _ in range(iterations):
cash_flows = [0] * (loan_lifetime + 3) # Initialize cash flows
default_year = np.random.geometric(p=default_probability) + 1
```

```
default_year = min(default_year, loan_lifetime + 1) # Cap default year to loan lifetime
cash_flows[default_year] = -1 # Cash flow at default year
cash_flows[default_year + 1] = -1 # Cash flow at year after default
cash_flows[-1] = (1 + interest_rate) * recovery_rate # Cash flow after bankruptcy process
irr = npf.irr(cash_flows)
irr_values.append(irr)
avg_irr = np.mean(irr_values)
results[(interest_rate, default_probability, loan_lifetime)] = avg_irr

# Visualize the results
for default_probability in default_probabilities:
for loan_lifetime in loan_lifetimes:
x_values = interest_rates
y_values = [results[(interest_rate, default_probability, loan_lifetime)] for interest_rate in
interest_rates]
plt.plot(x_values, y_values, label=f"p_default1={default_probability}, Loan
Lifetime={loan_lifetime}")
plt.xlabel("Interest Rate")
plt.ylabel("Expected IRR")
plt.legend()
plt.title("Expected IRR for Different Parameters")
plt.show()
```

OUTPUT:


Expected IRR for Different Parameters
Expected IRR
−0.05
−0.10
−0.15
−0.20
−0.25
−0.30
−0.35
0.30
0.32
0.34
0.36
0.38
0.40
Interest Rate
p_default1=0.1, Loan Lifetime=5
p_default1=0.1, Loan Lifetime=10
p_default1=0.1, Loan Lifetime=20
p_default1=0.2, Loan Lifetime=5
p_default1=0.2, Loan Lifetime=10
p_default1=0.2, Loan Lifetime=20
p_default1=0.3, Loan Lifetime=5
p_default1=0.3, Loan Lifetime=10
p_default1=0.3, Loan Lifetime=20

Discounted Cash Flow

- The Discounted Cash Flow (DCF) valuation of a stock is often considered a capstone finance model as incorporates many different concepts and also the technical skills to implement them.
- It is also generally considered the valuation approach which can be the most accurate, though there are a lot of assumptions which must be made which could influence the results.
- There are two main portions of the DCF model: coming up with the weighted average cost of capital (WACC) and estimating future free cash flows. Each of these portions have smaller tasks involved.
- Eventually, the concept of the model is extremely simple: take the present value of future cash flows to determine the value of the company. The difficult part was figuring out those cash flows and the discount rate.
- We have focused on the cost of capital estimation, and we have dealt with FCF estimation later.
- We have focused on using the Capital Asset Pricing Model (CAPM) to estimate the cost of equity and we have discussed several approaches for estimating the cost and market value of debt depending on the availability of data and amount of time that can be invested into building the model.

DCF works on the concept of Time Value of Money. It estimated the future profits of a company to determine its present value, which will be more than that profit in future.

- Enterprise Value = Dept + Equity
- Additional cash reduces the EV. As liquid cash is not counted in the EV. Only assets that are reproducible contribute in EV.
- Additional cash can be also introduced by Share Dilution, which suddenly increases the total value of the company. But still the assets remain of the same value. So at the time of liquidating the company EV will be of the previous value of company. So AC reduced the EV.

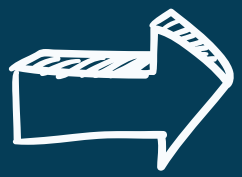
WACC

$$\text{WACC} = \left[\left(\text{Weightage of Equity} \times \text{Cost of Equity}\right) + \left(\text{Weightage of Debt} \times \text{Cost of Debt}\right)\right] \times \left(1 - \text{Tax Rate}\right)$$

Equity Evaluation

$$\bar{r}_a = r_f + \beta_a (r_m - r_f)$$

Final Task



SaaS Startup
Financial
Model

	LTV (1 user)	LTV (company)
Price	$ 12.99	$ 72.74
Users	1.0	5.6
Churn	2.10%	2.10%
Lifetime	47.6	47.6
LT Rev	$ 618.6	$ 3,464
GM %	83%	83%
LTV	$ 518.4	$ 2,875.1
Monthly GM	$ 10.78	$ 60.34
CAC		$ 906 *Customer acquisition cost

over time.

M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16
3,951	4,461	5,036	5,685	6,419	7,247	8,182	9,237	10,429	11,774	12,940	14,221	15
2.10%	2.10%	2.10%	2.10%	2.10%	2.10%	2.10%	2.10%	2.10%	2.10%	2.10%	2.10%	2
(83)	(94)	(106)	(119)	(135)	(152)	(172)	(194)	(219)	(247)	(272)	(299)	
15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	15.00%	12.00%	12.00%	12.00%	12
593	669	755	853	963	1087	1227	1386	1564	1413	1553	1707	
4,461	5,036	5,685	6,419	7,247	8,182	9,237	10,429	11,774	12,940	14,221	15,629	17
5.8	5.9	6.00	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	
769	854	948	1052	1169	1299	1443	1604	1784	1931	2091	2265	
76	85	94	104	117	130	144	161	180	147	160	174	
$ 57,948	$ 65,418	$ 73,848	$ 83,383	$ 94,139	$ 106,284	$ 119,989	$ 135,473	$ 153,044	$ 168,091	$ 184,791	$ 203,021	$ 22
9,851	11,121	12,554	14,175	16,004	18,068	20,398	23,030	26,003	28,575	31,404	34,514	3
$ 48,097	$ 54,297	$ 61,294	$ 69,208	$ 78,135	$ 88,216	$ 99,591	$ 112,442	$ 126,944	$ 139,515	$ 153,387	$ 168,507	$ 18
83%	83%	83%	83%	83%	83%	83%	83%	83%	83%	83%	83%	
$ 35,417	$ 35,417	$ 35,417	$ 42,500	$ 42,500	$ 49,583	$ 49,583	$ 56,667	$ 63,750	$ 63,750	$ 70,833	$ 70,833	$ 7
8,854	8,854	8,854	10,625	10,625	12,396	12,396	14,167	15,938	15,938	17,708	17,708	1
68,070	75,706	83,252	91,589	102,453	113,186	124,655	138,567	154,019	125,047	135,806	146,375	15
8,854	8,854	8,854	10,625	10,625	12,396	12,396	14,167	15,938	15,938	17,708	17,708	1
10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	20,000	20,000	20,000	2

Money Raised		$ 1,250,000									
Cash Balance	$ 500,000	$ 1,670,934	$ 1,595,787	$ 1,516,689	$ 1,432,154	$ 1,347,071	$ 1,250,940	$ 1,152,872	$ 1,043,527	$ 934,087	$ 812,963

Assumptions

Customer Acquisition Cost	$ 906	$ 906	$ 901	$ 896	$ 891	$ 886	$ 881	$ 876	$ 871	$ 866	$ 861
Companies / Employee (EE)	150	155	160	165	170	175	180	185	190	195	200
Total Employees	4	4	4	5	5	5	6	6	7	7	8
Avg Annual Salary	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000	$ 85,000
Benefits, Taxes, Etc	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Consultants as % of Payroll	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Miscellaneous Exp	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000

2. Layout & calculate best metrics to track business performance

Lifetime Value (Company)	$ 2,875	$ 2,875	$ 2,926	$ 2,978	$ 3,029	$ 3,080	$ 3,132	$ 3,183	$ 3,235	$ 3,286	$ 3,337
CAC	$ 906	$ 906	$ 901	$ 896	$ 891	$ 886	$ 881	$ 876	$ 871	$ 866	$ 861
LTV: CAC Ratio	3.17	3.17	3.25	3.32	3.40	3.48	3.56	3.64	3.71	3.80	3.88
Annual Recurring Revenue	$ 483,228	$ 545,580	$ 615,882	$ 695,381	$ 785,012	$ 886,178	$ 1,000,594	$ 1,129,662	$ 1,275,410	$ 1,439,864	$ 1,625,475
Monthly Recurring Revenue	$ 40,269	$ 45,465	$ 51,323	$ 57,948	$ 65,418	$ 73,848	$ 83,383	$ 94,139	$ 106,284	$ 119,989	$ 135,473
Net Burn		$ 79,066	$ 71,147	$ 83,098	$ 84,535	$ 85,083	$ 96,131	$ 98,068	$ 109,345	$ 109,440	$ 121,124
Net New ARR		$ 62,352	$ 70,302	$ 79,499	$ 89,631	$ 101,166	$ 114,416	$ 129,069	$ 145,748	$ 164,453	$ 185,609
Burn Multiple		1.27	1.01	1.05	0.94	0.84	0.84	0.76	0.75	0.67	0.65

*Puts focus on burn as a multiple of new revenue growth.

<1X	Amazing	*Great measure of product market fit.
1-1.5X	Great	https://medium.com/craft-ventures/the-burn-multiple-51a7e43cb200
1.5-2X	Good	
2-3X	Suspect	
>3X	Bad	

3. Opportunities, risks, recommendations

Opportunities
Spend more on marketing - grow faster given that our efficiency is so high, we can tolerate a much higher CAC to accelerate growth.
Try to create usage based feature to increase revenue / user.
Cross sell other products via affiliate partnerships (instead of building them ourselves).
If we slow growth down to 5% we become instantly profitable => powerful level in emergencies.
What changes can we make to our product to reduce churn?
Start enterprise sales team to sell top-down into larger companies and push our average customers / company up more quickly.

Risks
Churn, we have to rebuild our customer base completely from scratch every 3-4 years at a 25% annual churn, we could run out of TAM (addressable market) to sell into.