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Introduction :

The Capital asset pricing model describes the relation between systematic risk and the expected return of the asset, particularly stocks. CAPM can be expressed as follows:

$$r_{it} - r_{ft} = \beta_i(r_{mt} - r_{ft}) + \varepsilon_{it}$$

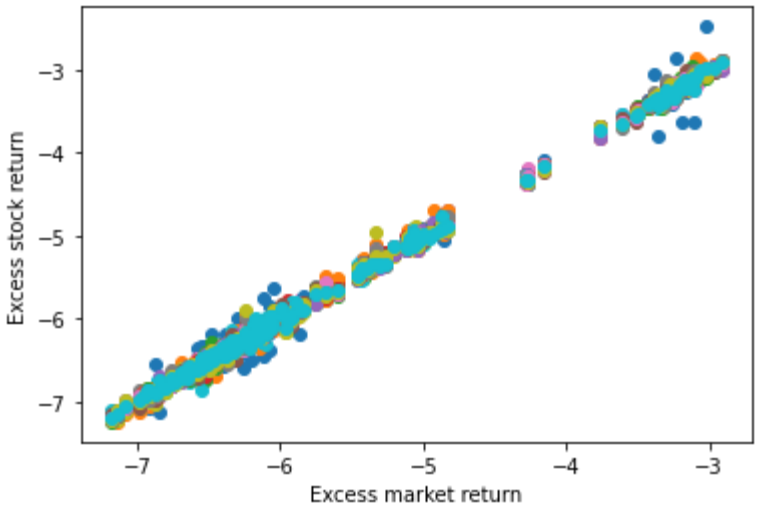
where r_{it} represents the returns on stock i, r_{mt} represents the return on the market portfolio, and r_{ft} is the risk-free rate at time period t, β_i is the beta of stock i and ε_{it} is the random component of the excess returns.

Data Set :

The Data can be found on the following link :
https://docs.google.com/spreadsheets/d/10J09SDxERp61AuWE9JYgnZ_WNVx4YBhHTqibHyaPq3w/edit?usp=sharing

Empirical Results :

- In step 1 we downloaded the data from the Yahoo Finance database on a weekly basis for a period of 5 years between 30 January 2017 to 28 February 2022. We took NIFTY 100 as the Stock market index.
- In step 2 we created the series for each stock and the market index.
- In step 3 we created a series for excess return r_{it} - r_{ft} and a series for market return r_{mt} - r_{ft}
- In step 4 firstly we plotted the Excess stock returns vs the Excess market returns which is shown below



We then calculated the summary statistics for all stocks and the market such as mean, median, mode, variance etc. The correlation matrix, coefficient of skewness, kurtosis were also calculated.

For Example :

For the stocks of company Airtel, the statistics are shown below :

Mean = `-5.356813086847331`

Median = `-6.085555534919876`

Mode = `-7.216205948942595`

Variance = `2.019653461880049`

Coefficient of Skewness = `1.4875736404273863`

The Coefficient of Skewness is positive which indicates that the distribution is positively skewed when compared to the normal distribution.

Kurtosis = `4.129034385983609`

The correlation matrix obtained for the companies is shown below :

```
{'AIRTEL': 0.9912302433832632,
 'ASIAN PAINTS': 0.9976174361622865,
 'BAJAJ': 0.9979838043464544,
 'BRITANIA': 0.997948389314785,
 'Berger Paints': 0.9914669301186224,
 'COLGATE': 0.9950175307994563,
 'DABUR': 0.9903079747797731,
 'GODREJ': 0.9917056243824862,
 'HAVELLS': 0.9941015658325686,
 'HDFC': 0.9948557238345052,
 'HERO': 0.9968831139800879,
 'HINDUSTAN UNILEVER ': 0.9966669471033354,
```

```
 'ICICI': 0.9946969036409385,
 'INFOSYS': 0.9927951547346625,
 'JSW STEEL': 0.9903130377681453,
 'L and T': 0.9953777235607555,
 'MAHINDRA': 0.9922076570813018,
 'MARUTI SUZUKI': 0.9989921482736623,
 'NESTLE INDIA': 0.999633967810472,
 'NIFTY 100': 1.0,
 'ONGC': 0.9804467389463135,
 'Pidilite Industries': 0.9968361825952942,
 'RELIANCE': 0.9965685237239101,
 'SBI': 0.988737386586367,
 'TATA': 0.9952176912620183,
 'TCS': 0.9977796850584266,
 'TVS': 0.9903653229752062,
 'ULTRA TECH CEMENT': 0.9991329899037843,
 'VOLTAS': 0.99416427604424,
 'WHIRLPOOL': 0.9954663006769201,
 'WIPRO': 0.9893351832754799}
```

As we can see the values are closer to 1 indicating a strong relationship between the variance and the covariance.

- In step 5 we estimated each stock's β coefficient by running the time series regressions.
  The beta coefficient obtained for each stock is given below which is Indicated in the bracket in front of the Company's name :

```
{'AIRTEL': array([[0.67004511]]),
 'ASIAN PAINTS': array([[0.82595041]]),
 'BAJAJ': array([[0.83879932]]),
 'BRITANIA': array([[0.83589149]]),
 'Berger Paints': array([[0.66996047]]),
 'COLGATE': array([[0.7466192]]),
 'DABUR': array([[0.64958646]]),
 'GODREJ': array([[0.68115632]]),
 'HAVELLS': array([[0.72614044]]),
 'HDFC': array([[0.74499993]]),
 'HERO': array([[0.79614951]]),
 'HINDUSTAN UNILEVER ': array([[0.78874378]]),
 'ICICI': array([[0.74400123]]),
 'INFOSYS': array([[0.75614042]]),
 'JSW STEEL': array([[0.6607527]]),
 'L and T': array([[0.76449837]]),
 'MAHINDRA': array([[0.68887288]]),
```

```
 'MARUTI SUZUKI': array([[0.92585192]]),
 'NESTLE INDIA': array([[1.00267087]]),
 'ONGC': array([[0.52034487]]),
 'Pidilite Industries': array([[0.79787979]]),
 'RELIANCE': array([[0.79662866]]),
 'SBI': array([[0.63400644]]),
 'TATA': array([[0.78659256]]),
 'TCS': array([[0.83854033]]),
 'TVS': array([[0.65928828]]),
 'ULTRA TECH CEMENT': array([[0.90323228]]),
 'VOLTAS': array([[0.73259576]]),
 'WHIRLPOOL': array([[0.76166067]]),
 'WIPRO': array([[0.64269343]])}
```

- In step 6, the value of a stock's β can help us determine whether a stock is defensive or aggressive.
  If β>1, the stock is aggressive with higher risk.
  If β<1, the stock is defensive with lower risk.

  As we can see that all the stocks are defensive as they have β<1 except the stock of company NESTLE INDIA which has aggressive stocks as β>1.
  The R^2 value for each stocks is given below :

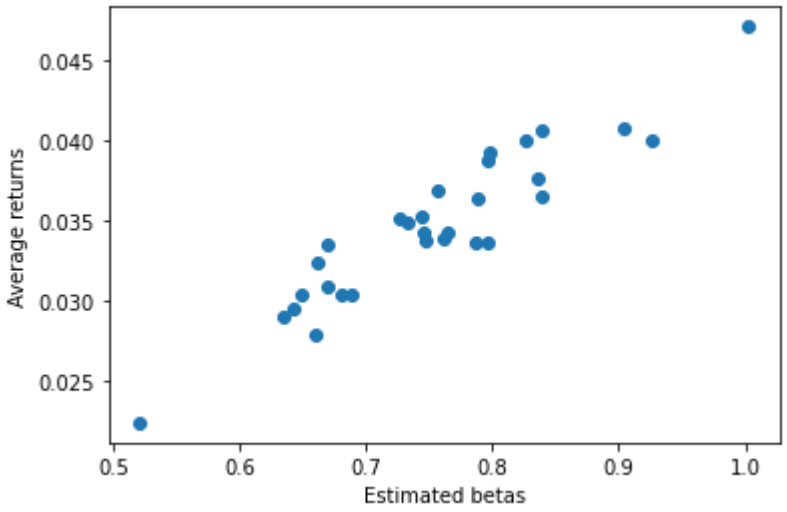
```
{'AIRTEL': 1.4,
 'ASIAN PAINTS': 3.8346354166666665,
 'BAJAJ': 3.92578125,
 'BRITANIA': -5.1875,
 'Berger Paints': 1.0,
 'COLGATE': 1.25,
 'DABUR': 1.2625,
 'GODREJ': 0.8958333333333334,
 'HAVELLS': 0.9609375,
 'HDFC': 0.6666666666666667,
 'HERO': 0.9852941176470589,
 'HINDUSTAN UNILEVER ': 0.9305555555555556,
 'ICICI': 1.775,
 'INFOSYS': -1.265625,
 'JSW STEEL': 0.7916666666666666,
 'L and T': 1.2375,
 'MAHINDRA': 1.1166666666666667,
 'MARUTI SUZUKI': 0.81171875,
 'NESTLE INDIA': 0.6875,
 'ONGC': 1.1666666666666667,
 'Pidilite Industries': 3.0625,
 'RELIANCE': 1.1477272727272727,
```

```
'SBI': 3.125,
'TATA': 3.25,
'TCS': 0.84375,
'TVS': 0.7777777777777778,
'ULTRA TECH CEMENT': 0.7534722222222222,
'VOLTAS': 0.53125,
'WHIRLPOOL': 1.3888888888888888,
'WIPRO': 1.4423076923076923}
```

β^2 = 1 indicates that the model fits the data correctly and values of β^2 other than 1 indicate the deviation of the data.

- In step 7 we obtained the residuals of each of the regressions performed.
- In step 8 we did cross sectional regression, and further calculated the $E(\gamma_1)$, $E(\gamma_2)$ and $E(\gamma_3)$.
- In step 9 we compared the values and got $E(\gamma_1)$ = `0.07154048`
  $E(\gamma_2)$ = `-0.01666933`
  $E(\gamma_3)$ = `0.0038944`

  As $E(\gamma_1) > 0$, there is a positive relationship between return and risk.
- In step 10 we found that our results are supportive of the CAPM model.
- In step 11 we plotted the average returns against the estimated Betas.



Concluding Remarks :

We successfully implemented the Capital Asset Pricing Model, we were able to obtain the betas, we could classify which stocks were defensive and which were aggressive based on beta. We were able to execute all the steps.