Capital Asset Pricing Model

A portfolio is a basket of financial investments that can carry stocks, bonds, cash, cash equivalents, etc. An efficient portfolio is one that is well diversified and fairly compensates you for risk. Diversification is a technique which helps to minimize risk and maximize returns by allocating investments in different areas that would react differently in same circumstance. No matter how much we diversify there's a part of risk that will always exist. Capital Asset Pricing model (CAPM) is built on the idea of diversification which was developed by William Sharpe. CAPM says the total risk of a financial asset is made up of a diversifiable (unsystematic) and non-diversifiable(systematic) risk, the former is correlated with the general market moves but the latter is not. CAPM helps to calculate risk and return of an investment that an investor should expect.

CAPM describes the relationship between risk and expected return.

The formula is

$$r_{i,t} - r_{f,t} = \alpha_i + \beta_i(r_{m,t} - r_{f,t}) + e_{i,t}$$

Where,

$r_{i,t}$ = observed return for asset i for time t

$r_{f,t}$ = observed return on risk-free rate for time t

$r_{m,t}$ = expected return for the market portfolio for time t

$e_{i,t}$ = error term for time t

The objective is to do regression analysis and find the variability of stocks with market returns. Beta helps to measure the volatility of stock returns with respect to the overall market volatility. Here, the benchmark which is chosen is S&P BSE 500.

A stock of beta:

0 indicates no correlation with the benchmark.

1 indicates the expected return on a security is equal to the benchmark.

-1 indicates security has a perfect negative correlation with the benchmark.

More than 1 indicates a stock that's more volatile than its benchmark.

Less than 1 is less volatile than the benchmark.

Assigned companies:

1. Dhanlaxmi Bank Ltd
2. Vidhi Specialty Food Ingredients Ltd

3. Indian Metals & Ferro Alloys Ltd.
4. Gujarat Pipavav Port Ltd
5. Century Plyboards India Ltd
6. Tanla Solutions Ltd

Process of data analysis

(I)Data Preparation:

1. Get the data :

- The data is taken from Yahoo! Finance, it has monthly stock price data for each of the six assigned companies and S&P BSE 500 for the period of 30 months from April 1, 2018 to September 30, 2020
- The data for monthly yields on Government of India 10-Year Bonds for the period of 30 months from April 1, 2018 to September 30, 2020 is taken from Investing.com.

2. Key variables :

- Log return for a time period is the sum of the log returns of partitions of the time period.
- The S&P BSE 500 data is used as a proxy for the market returns
- Monthly yields on GOI bonds is used as a proxy for risk free rate of return
- Excess returns are the return earned by a stock (or portfolio of stocks) and the risk free rate.
- Equity risk premium refers to an excess return that investing in the stock market provides over a risk-free rate.

3. Import the required libraries

4. Load the data into a pandas DataFrame

5. Preprocess the data

- Extract only the columns that is required for the analysis.
- Detect and treat the null values
- Calculate log returns, equity risk premium and excess returns.
  - Log returns : $R_t = \ln(P_t / P_{t-1})$
  - Equity risk premium = Expected return of the market - Risk free rate of return
  - Excess returns = Return on Asset - Risk free rate of return

(II)Data Analysis:

- Summarize the data
- Scatterplot

- Regression summary
- Characteristic line

Results of data analysis

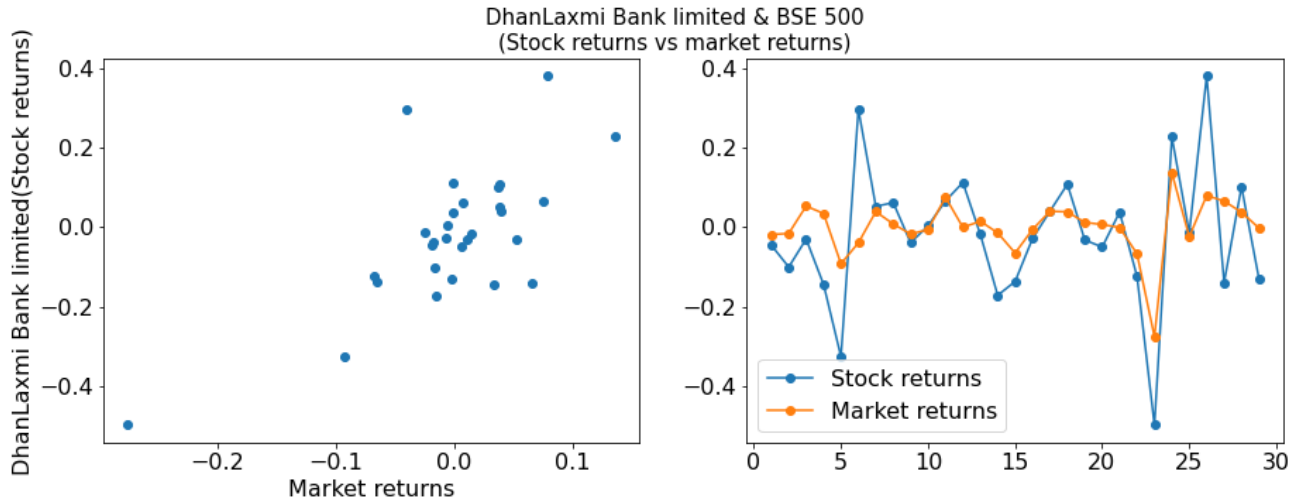
Descriptive statistics of returns of the assigned companies and that of the market index:

	Market returns	Dhanlaxmi Bank Ltd	Vidhi Specialty Food Ingredients Ltd	Indian Metals & Ferro Alloys Ltd	Gujarat Pipavav Port Ltd	Century Plyboards India Ltd	Tanla Solutions Ltd
count	29.000000	29.000000	29.000000	29.000000	29.000000	29.000000	29.000000
mean	-0.000454	-0.018935	0.008189	-0.023375	-0.014738	-0.023145	0.071586
std	0.071257	0.170812	0.154362	0.174204	0.111790	0.135418	0.236534
min	-0.276126	-0.498325	-0.347211	-0.617481	-0.250400	-0.323372	-0.460672
25%	-0.017713	-0.124053	-0.075134	-0.083382	-0.072330	-0.105023	-0.059033
50%	-0.000707	-0.029093	0.024865	0.013013	-0.011936	-0.004383	0.020604
75%	0.038227	0.061369	0.074108	0.073411	0.050000	0.071445	0.240335
max	0.136469	0.380018	0.360042	0.309023	0.221168	0.218892	0.657326

	Skewness	Kurtosis
Market returns	-1.927022	7.550978
Dhanlaxmi Bank Ltd	-0.258781	2.007143
Vidhi Specialty Food Ingredients Ltd	0.159274	0.954903
Indian Metals & Ferro Alloys Ltd	-1.384029	4.014130
Gujarat Pipavav Port Ltd	-0.019352	0.095995
Century Plyboards India Ltd	-0.386621	-0.316881
Tanla Solutions Ltd	0.369778	0.593472

Plots and summaries :

1. Dhanlaxmi Bank Ltd



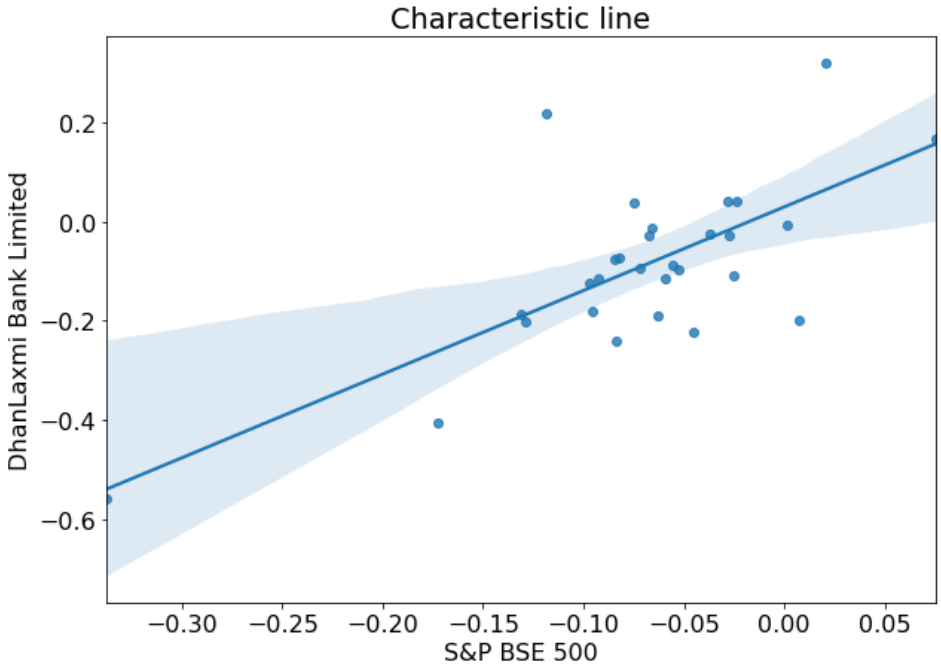
OLS Regression Results

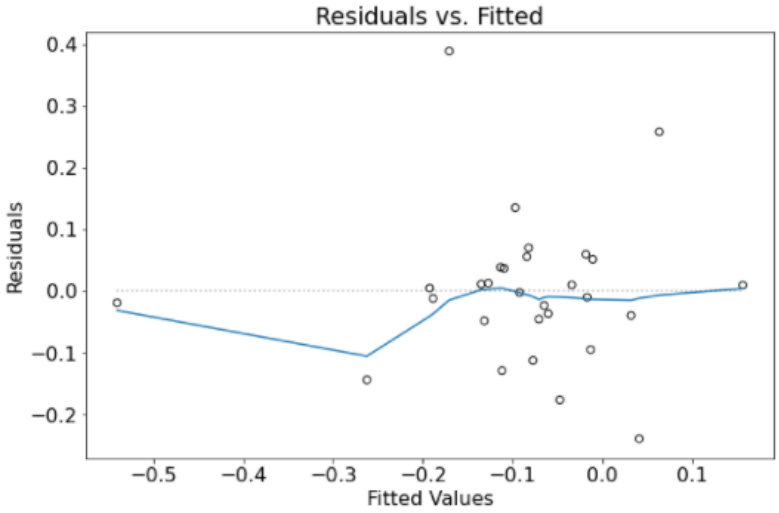
Dep. Variable:	y(t)	R-squared:	0.502
Model:	OLS	Adj. R-squared:	0.483
Method:	Least Squares	F-statistic:	27.18
Date:	Wed, 28 Oct 2020	Prob (F-statistic):	1.72e-05
Time:	15:19:32	Log-Likelihood:	20.636
No. Observations:	29	AIC:	-37.27
Df Residuals:	27	BIC:	-34.54
Df Model:	1		
Covariance Type:	nonrobust		

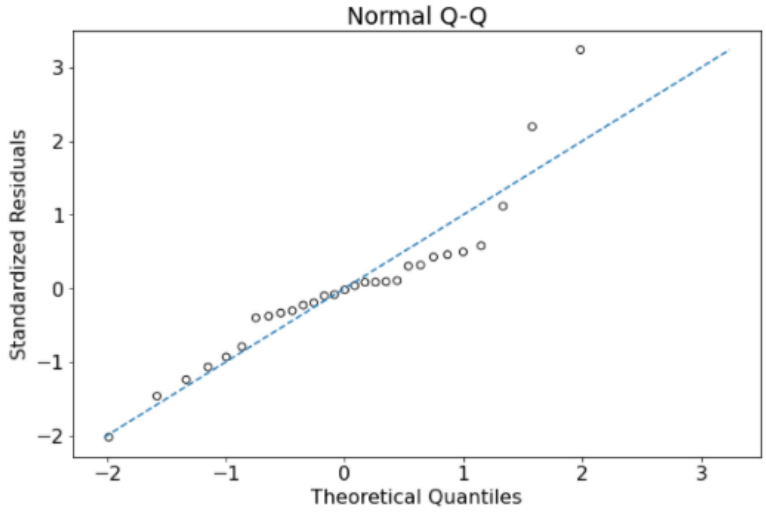
	coef	std err	t	P>|t|	[0.025	0.975]
const	0.0294	0.032	0.915	0.368	-0.036	0.095
x(t)	1.6878	0.324	5.214	0.000	1.024	2.352

Omnibus:	12.602	Durbin-Watson:	2.371
Prob(Omnibus):	0.002	Jarque-Bera (JB):	14.238
Skew:	1.071	Prob(JB):	0.000810
Kurtosis:	5.682	Cond. No.	14.2

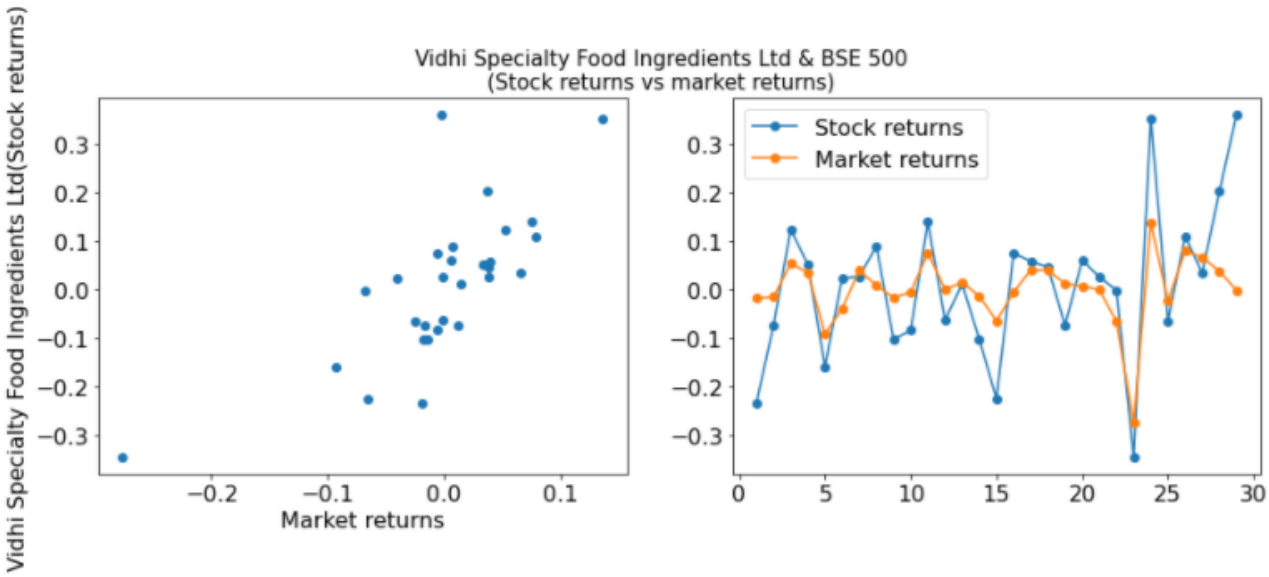
Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.


Characteristic line
DhanLaxmi Bank Limited
S&P BSE 500
0.2
0.0
−0.2
−0.4
−0.6
−0.30
−0.25
−0.20
−0.15
−0.10
−0.05
0.00
0.05


Residuals vs. Fitted
Residuals
Fitted Values
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.5
−0.4
−0.3
−0.2
−0.1
0.0
0.1


Normal Q-Q
Standardized Residuals
Theoretical Quantiles
3
2
1
0
−1
−2
−2
−1
0
1
2
3

2. Vidhi Specialty Food Ingredients Ltd



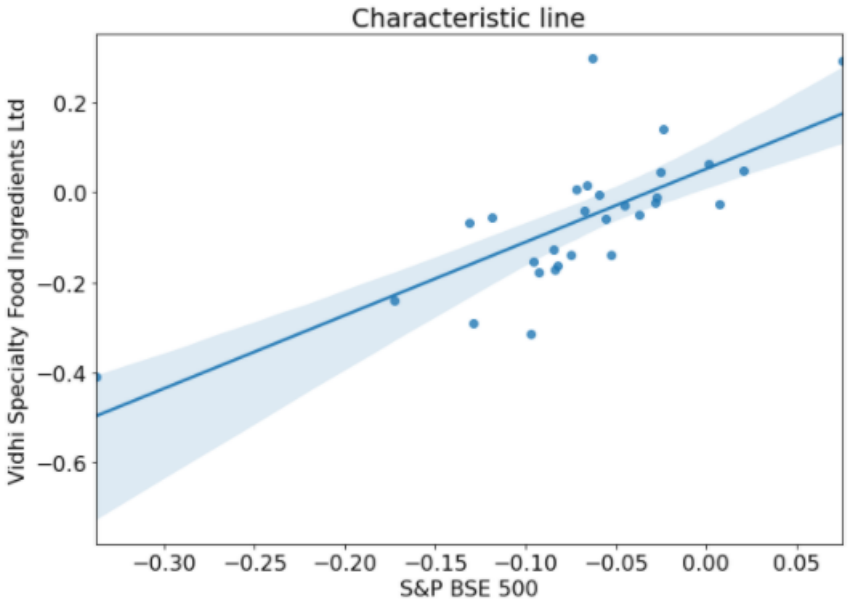
OLS Regression Results

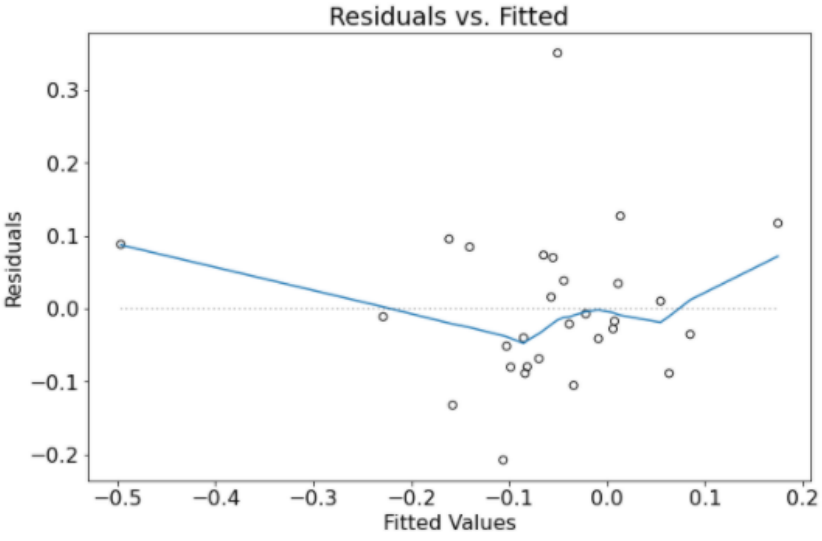
Dep. Variable:	y(t)	R-squared:	0.558
Model:	OLS	Adj. R-squared:	0.541
Method:	Least Squares	F-statistic:	34.07
Date:	Wed, 28 Oct 2020	Prob (F-statistic):	3.26e-06
Time:	15:35:38	Log-Likelihood:	24.997
No. Observations:	29	AIC:	-45.99
Df Residuals:	27	BIC:	-43.26
Df Model:	1		
Covariance Type:	nonrobust		

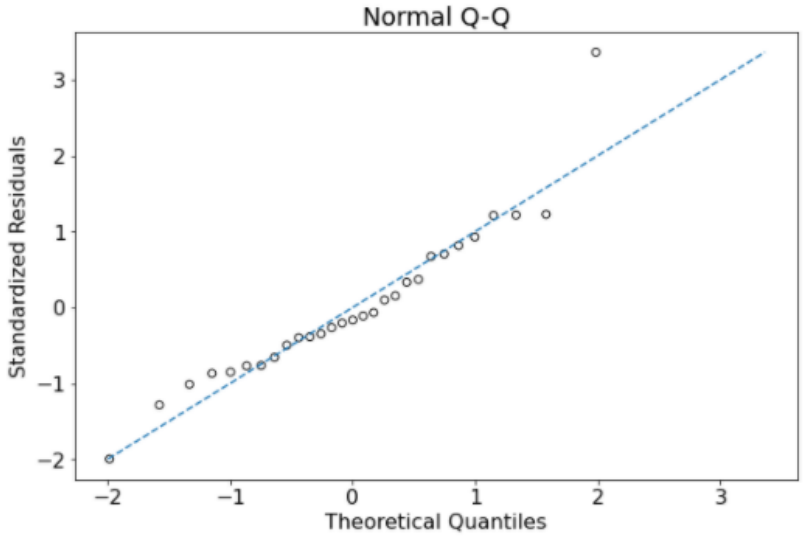
	coef	std err	t	P>|t|	[0.025	0.975]
const	0.0522	0.028	1.890	0.070	-0.004	0.109
x(t)	1.6257	0.279	5.837	0.000	1.054	2.197

Omnibus:	13.023	Durbin-Watson:	1.071
Prob(Omnibus):	0.001	Jarque-Bera (JB):	15.009
Skew:	1.099	Prob(JB):	0.000551
Kurtosis:	5.756	Cond. No.	14.2

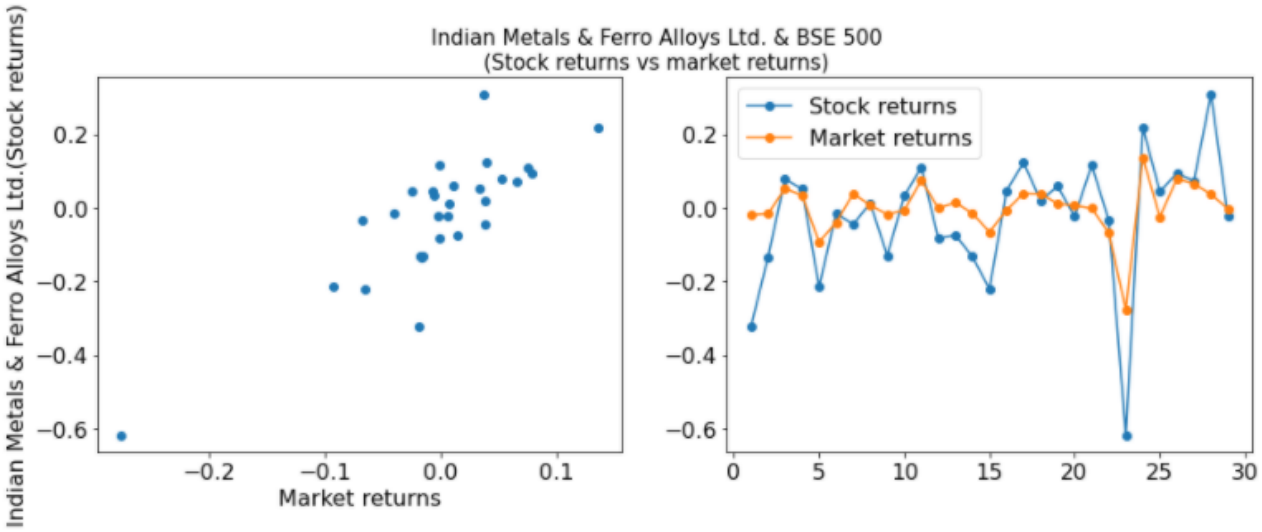
Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.


Characteristic line
Vidhi Specialty Food Ingredients Ltd
S&P BSE 500
0.2
0.0
−0.2
−0.4
−0.6
−0.30
−0.25
−0.20
−0.15
−0.10
−0.05
0.00
0.05


Residuals vs. Fitted
Residuals
Fitted Values
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.5
−0.4
−0.3
−0.2
−0.1
0.0
0.1
0.2


Normal Q-Q
Standardized Residuals
Theoretical Quantiles
3
2
1
0
−1
−2
−2
−1
0
1
2
3

3. Indian Metals & Ferro Alloys Ltd.



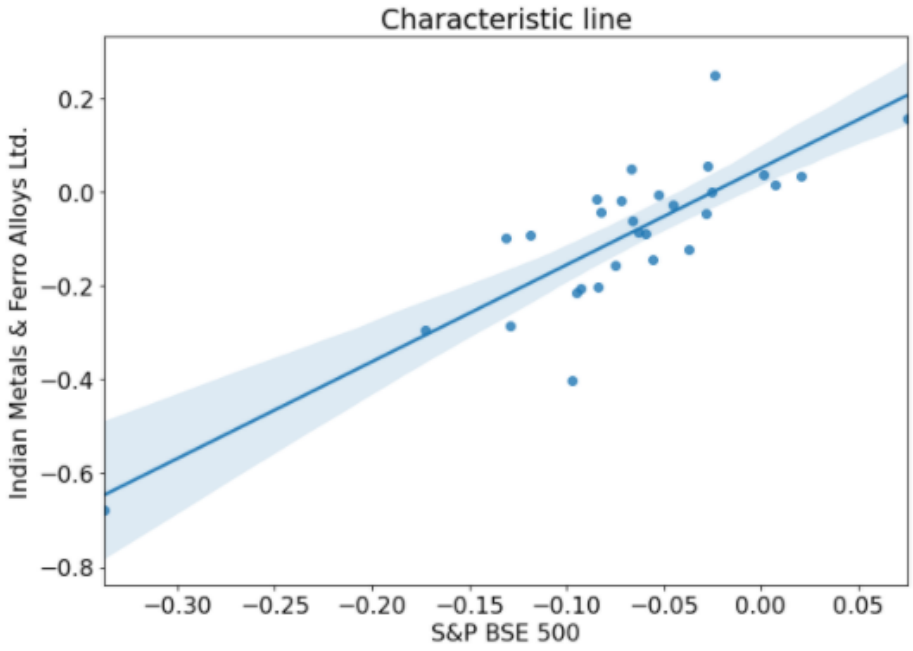
OLS Regression Results

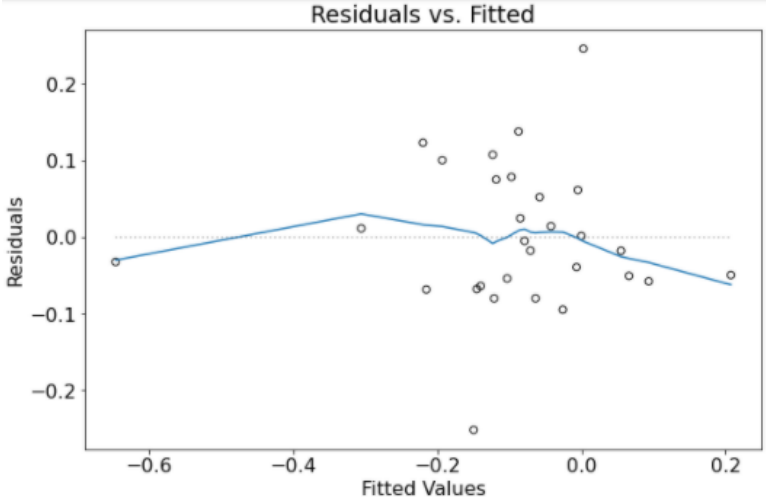
Dep. Variable:	y(t)	R-squared:	0.713
Model:	OLS	Adj. R-squared:	0.703
Method:	Least Squares	F-statistic:	67.18
Date:	Wed, 28 Oct 2020	Prob (F-statistic):	8.41e-09
Time:	15:36:56	Log-Likelihood:	27.875
No. Observations:	29	AIC:	-51.75
Df Residuals:	27	BIC:	-49.02
Df Model:	1		
Covariance Type:	nonrobust		

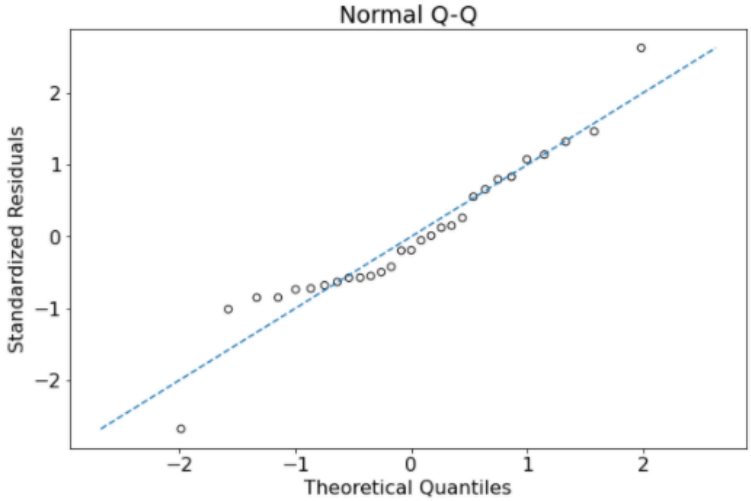
	coef	std err	t	P>|t|	[0.025	0.975]
const	0.0513	0.025	2.053	0.050	1.71e-05	0.103
x(t)	2.0672	0.252	8.196	0.000	1.550	2.585

Omnibus:	2.938	Durbin-Watson:	1.747
Prob(Omnibus):	0.230	Jarque-Bera (JB):	1.708
Skew:	0.149	Prob(JB):	0.426
Kurtosis:	4.151	Cond. No.	14.2

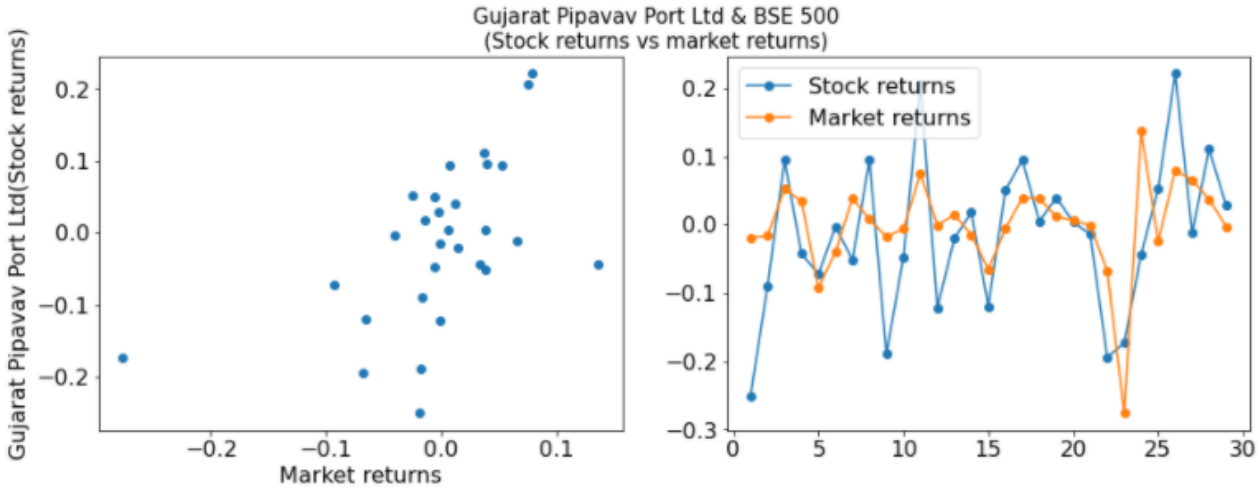
Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.


Characteristic line
Indian Metals & Ferro Alloys Ltd.
S&P BSE 500
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−0.30
−0.25
−0.20
−0.15
−0.10
−0.05
0.00
0.05


Residuals vs. Fitted
Residuals
Fitted Values
0.2
0.1
0.0
−0.1
−0.2
−0.6
−0.4
−0.2
0.0
0.2


Normal Q-Q
Standardized Residuals
Theoretical Quantiles
2
1
0
−1
−2
−2
−1
0
1
2

4. Gujarat Pipavav Port Ltd



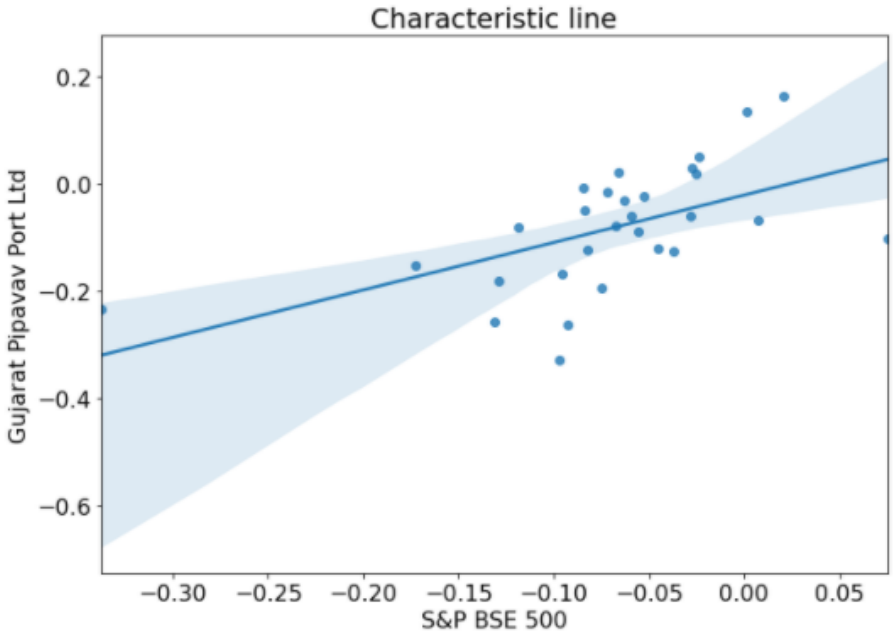
OLS Regression Results

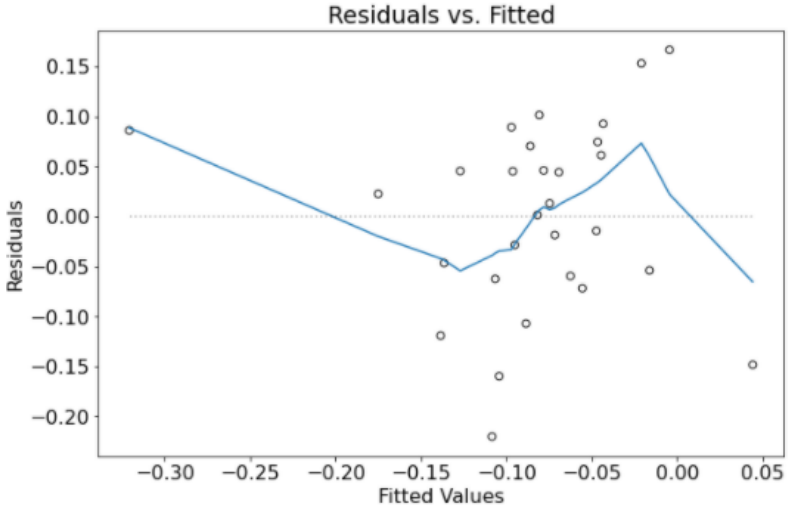
Dep. Variable:	y(t)	R-squared:	0.311
Model:	OLS	Adj. R-squared:	0.286
Method:	Least Squares	F-statistic:	12.21
Date:	Wed, 28 Oct 2020	Prob (F-statistic):	0.00166
Time:	15:38:16	Log-Likelihood:	27.794
No. Observations:	29	AIC:	-51.59
Df Residuals:	27	BIC:	-48.85
Df Model:	1		
Covariance Type:	nonrobust		

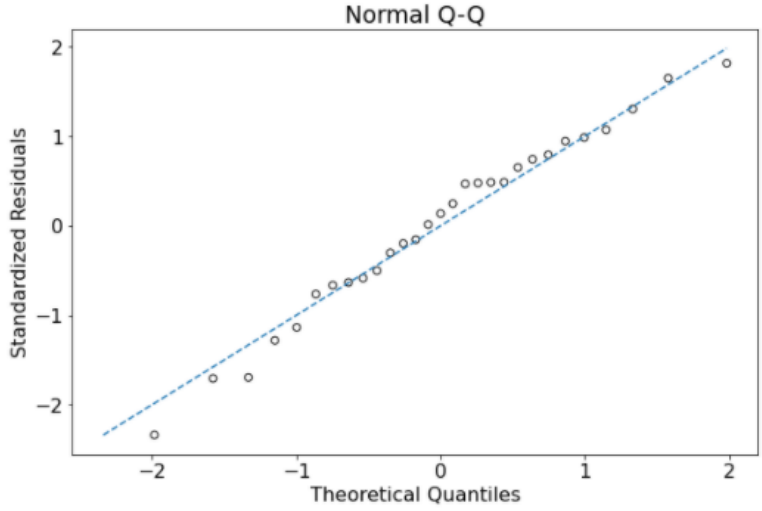
	coef	std err	t	P>|t|	[0.025	0.975]
const	-0.0224	0.025	-0.892	0.380	-0.074	0.029
x(t)	0.8838	0.253	3.494	0.002	0.365	1.403

Omnibus:	1.053	Durbin-Watson:	2.346
Prob(Omnibus):	0.591	Jarque-Bera (JB):	0.973
Skew:	-0.404	Prob(JB):	0.615
Kurtosis:	2.610	Cond. No.	14.2

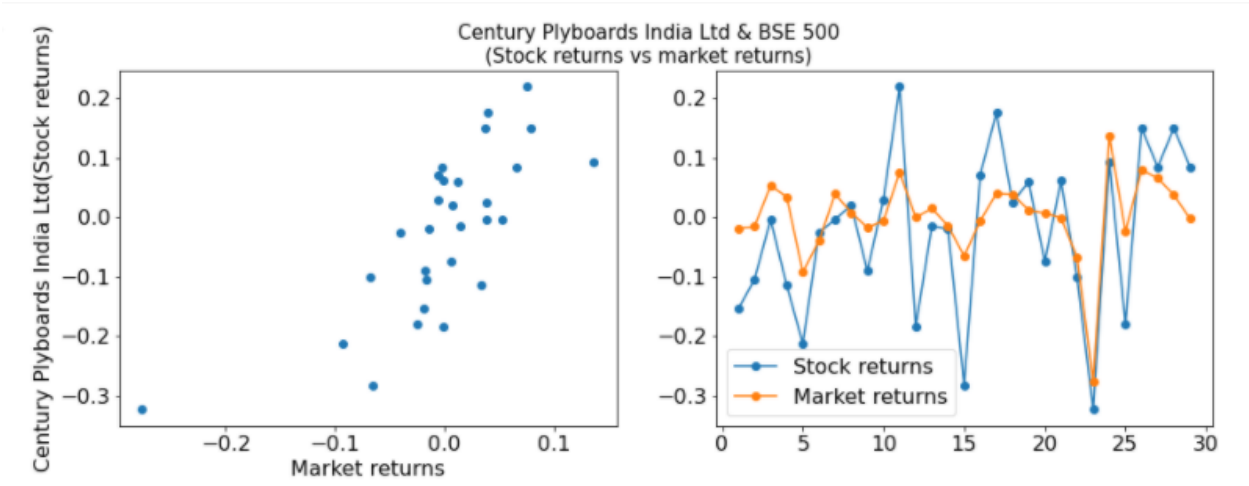
Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.


Characteristic line
Gujarat Pipavav Port Ltd
S&P BSE 500
0.2
0.0
−0.2
−0.4
−0.6
−0.30
−0.25
−0.20
−0.15
−0.10
−0.05
0.00
0.05


Residuals vs. Fitted
Residuals
Fitted Values
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.20
−0.30
−0.25
−0.20
−0.15
−0.10
−0.05
0.00
0.05


Normal Q-Q
Standardized Residuals
Theoretical Quantiles
2
1
0
−1
−2
−2
−1
0
1
2

5. Century Plyboards India Ltd



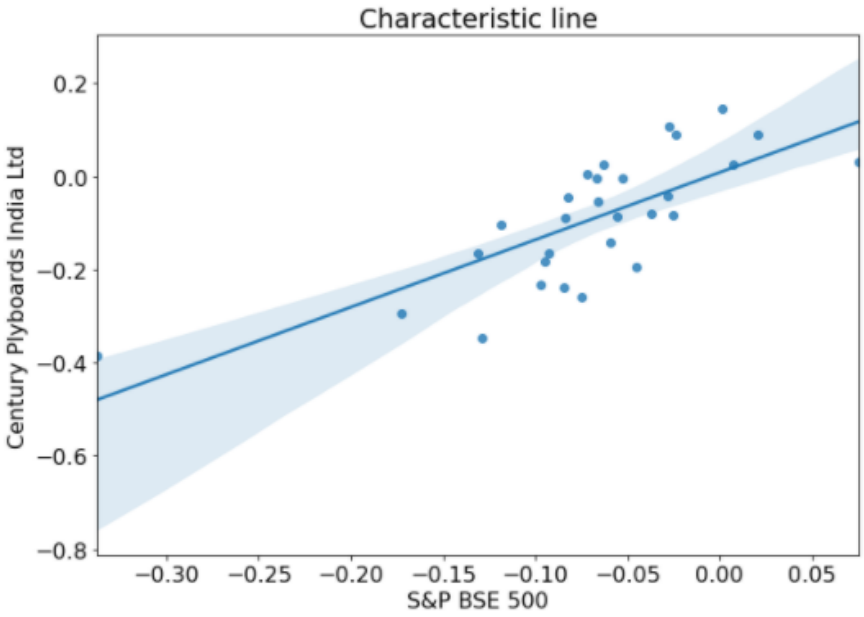
OLS Regression Results

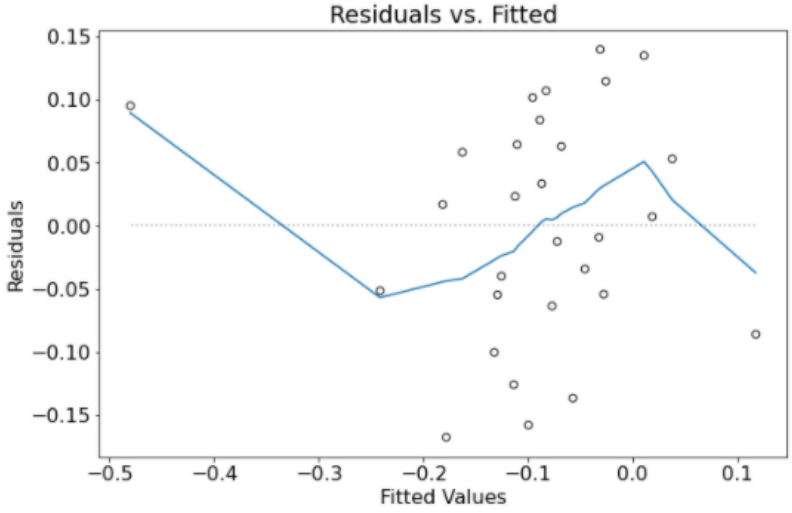
Dep. Variable:	y(t)	R-squared:	0.573
Model:	OLS	Adj. R-squared:	0.557
Method:	Least Squares	F-statistic:	36.24
Date:	Wed, 28 Oct 2020	Prob (F-statistic):	2.01e-06
Time:	15:39:28	Log-Likelihood:	29.289
No. Observations:	29	AIC:	-54.58
Df Residuals:	27	BIC:	-51.84
Df Model:	1		
Covariance Type:	nonrobust		

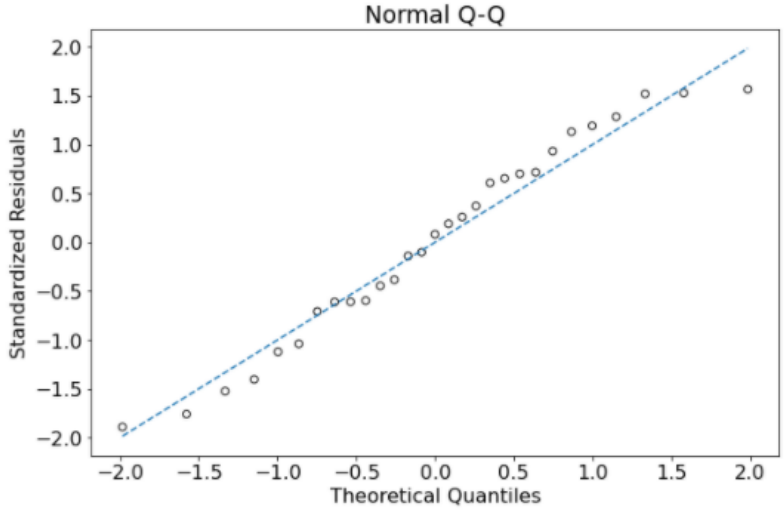
	coef	std err	t	P>|t|	[0.025	0.975]
const	0.0083	0.024	0.350	0.729	-0.041	0.057
x(t)	1.4461	0.240	6.020	0.000	0.953	1.939

Omnibus:	2.592	Durbin-Watson:	1.936
Prob(Omnibus):	0.274	Jarque-Bera (JB):	1.429
Skew:	-0.220	Prob(JB):	0.489
Kurtosis:	2.005	Cond. No.	14.2

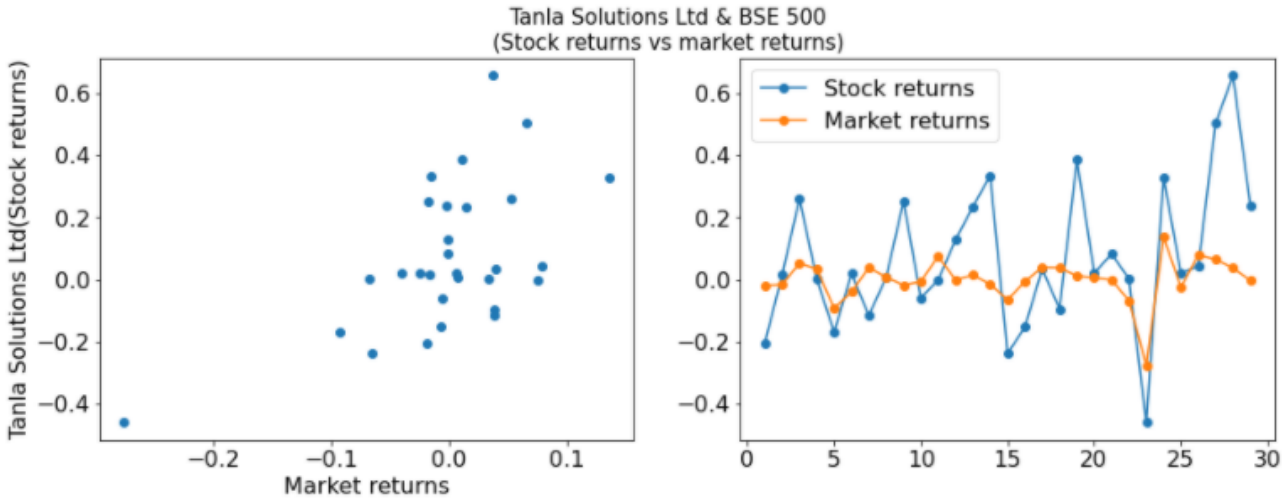
Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.


Characteristic line
Century Plyboards India Ltd
S&P BSE 500
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−0.30
−0.25
−0.20
−0.15
−0.10
−0.05
0.00
0.05


Residuals vs. Fitted
Residuals
Fitted Values
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.5
−0.4
−0.3
−0.2
−0.1
0.0
0.1


Normal Q-Q
Standardized Residuals
Theoretical Quantiles
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.0
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0

6. Tanla Solutions Ltd



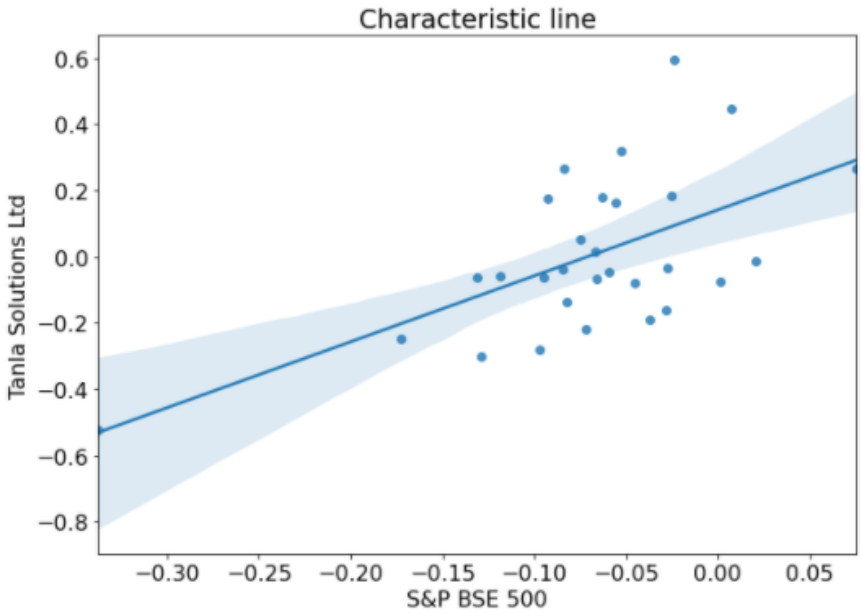
OLS Regression Results

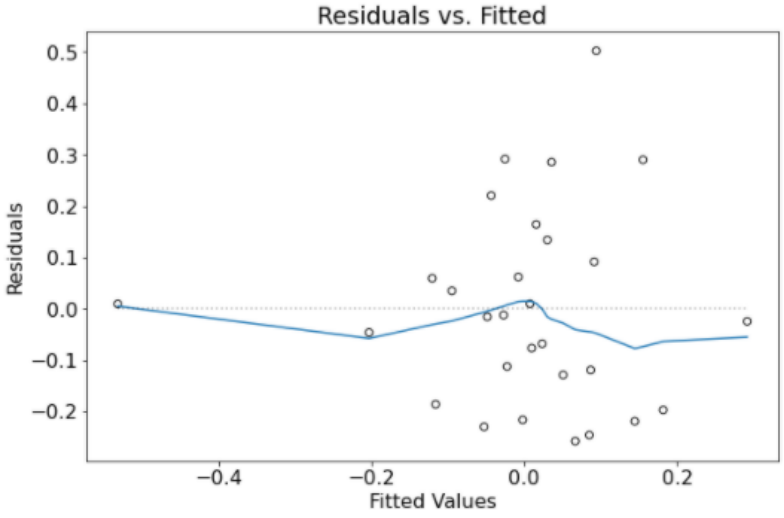
Dep. Variable:	y(t)	R-squared:	0.360
Model:	OLS	Adj. R-squared:	0.337
Method:	Least Squares	F-statistic:	15.20
Date:	Wed, 28 Oct 2020	Prob (F-statistic):	0.000578
Time:	15:39:33	Log-Likelihood:	7.3956
No. Observations:	29	AIC:	-10.79
Df Residuals:	27	BIC:	-8.057
Df Model:	1		
Covariance Type:	nonrobust		

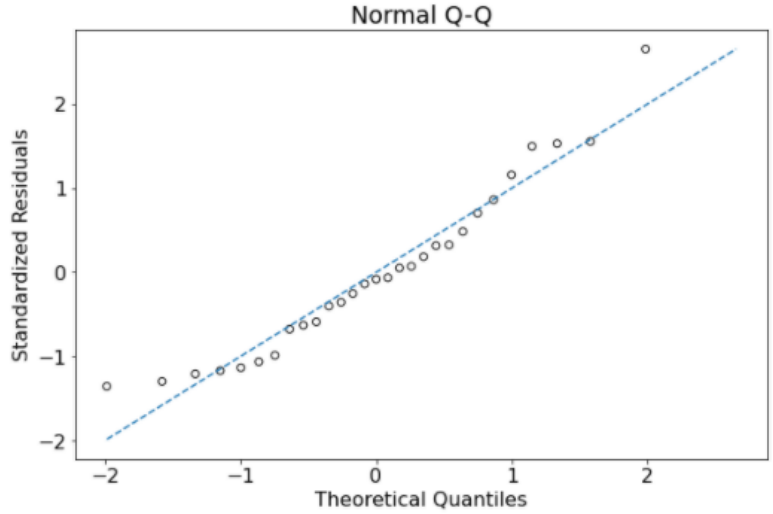
	coef	std err	t	P>|t|	[0.025	0.975]
const	0.1411	0.051	2.785	0.010	0.037	0.245
x(t)	1.9927	0.511	3.899	0.001	0.944	3.041

Omnibus:	3.151	Durbin-Watson:	1.631
Prob(Omnibus):	0.207	Jarque-Bera (JB):	2.347
Skew:	0.697	Prob(JB):	0.309
Kurtosis:	2.986	Cond. No.	14.2

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.


Characteristic line
Tanla Solutions Ltd
S&P BSE 500
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−0.30
−0.25
−0.20
−0.15
−0.10
−0.05
0.00
0.05


Residuals vs. Fitted
Residuals
Fitted Values
0.5
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.4
−0.2
0.0
0.2


Normal Q-Q
Standardized Residuals
Theoretical Quantiles
2
1
0
−1
−2
−2
−1
0
1
2

Conclusion:

The stock returns of all the assigned companies are positively correlated with the market returns, though, the relation is not very strong.

Beta indicates how volatile a stock's price is in comparison to the overall stock market.

Monthly data of the assigned companies, GOI bond and S&P BSE 500 index for the period of 30 months from April 1, 2018 to September 30, 2020 is used to get the beta values.

Company	Beta	Volatility (w.r.t. to the overall market)
Dhanlaxmi Bank Ltd	1.6878	More volatile
Vidhi Specialty Food Ingredients Ltd	1.6257	More volatile
Indian Metals & Ferro Alloys Ltd	2.0672	More volatile
Gujarat Pipavav Port Ltd	0.8838	Less volatile
Century Plyboards India Ltd	1.4461	More volatile
Tanla Solutions Ltd	1.9927	More volatile

The stock returns of all the assigned companies follow the general market trend.