BA/BBA

ECONOMETRICS

Semester – 07

Individual Assignment – II

ESTIMATION OF AR(1) MODEL WITH INTERPRETATION

Submitted to

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Date

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INTRODUCTION

Downloaded daily closing price data of TITAN for the past three years-743 observations to run and interpret the AR(1) model on the data. Autoregression models are run on stock market data to test the efficient market hypothesis.

METHODOLOGY AND DATA

Source: NSE

Time Period: 2020-2023

Auto Regressive Model: E-Views

Descriptive Statistics: Excel

DESCRIPTIVE STATISTICS

closing price	
Mean	2298.527
Standard Error	19.48159
Median	2423.875
Mode	3274.5
Standard Deviation	530.6722
Sample Variance	281612.9
Kurtosis	-0.86123
Skewness	-0.22715
Range	2064.8
Minimum	1274.7
Maximum	3339.5
Sum	1705507
Count	742

Mean (Average): The average value of the dataset is approximately 2298.53. This is calculated by summing up all the values and then dividing by the total number of observations (742).

Standard Error: The standard error of the mean is 19.48. It represents the precision of the sample mean as an estimate of the population mean. A lower standard error suggests a more accurate estimate.

Median (50th Percentile): The middle value of the dataset, known as the median, is 2423.88. This value separates the higher half from the lower half when the data is arranged in numerical order.

Mode: The mode of the dataset is 3274.5, indicating that this value occurs most frequently among all the observations.

Standard Deviation: The standard deviation, a measure of the amount of variation in the dataset, is 530.67. A lower standard deviation suggests that the values are closer to the mean.

Sample Variance: The square of the standard deviation, the sample variance, is 281612.9. It provides another measure of the spread of the data points.

Kurtosis: The kurtosis is -0.86123, indicating that the distribution is slightly less peaked than a normal distribution.

Skewness: The skewness is -0.22715, suggesting a slight leftward skew. This means that the tail on the left side of the distribution is longer or fatter than the right side.

Range: The range of the dataset is 2064.8, representing the difference between the maximum and minimum values.

Minimum: The smallest value in the dataset is 1274.7.

Maximum: The largest value in the dataset is 3339.5.

Sum: The sum of all the values in the dataset is 1705507.

Count: There are 742 observations or data points in the dataset.

NORMALITY OF DATA (on returns)

Unit Root Test: Augmented Dickey Fuller

Null Hypothesis: RT has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=19)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-26.99381	0.0000
Test critical values:	1% level	-3.438948	
	5% level	-2.865225	
	10% level	-2.568788	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RT)
Method: Least Squares
Date: 11/09/23 Time: 11:56
Sample (adjusted): 2 742
Included observations: 741 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RT(-1)	-0.994341	0.036836	-26.99381	0.0000
C	0.001423	0.000606	2.347877	0.0191

R-squared	0.496479	Mean dependent var	3.70E-05
Adjusted R-squared	0.495798	S.D. dependent var	0.023143
S.E. of regression	0.016434	Akaike info criterion	-5.376293
Sum squared resid	0.199574	Schwarz criterion	-5.363856
Log likelihood	1993.917	Hannan-Quinn criter.	-5.371498
F-statistic	728.6657	Durbin-Watson stat	1.993922
Prob(F-statistic)	0.000000		

H0: Data has unit root.

H1: Data does not have unit root.

INTERPRETATION:

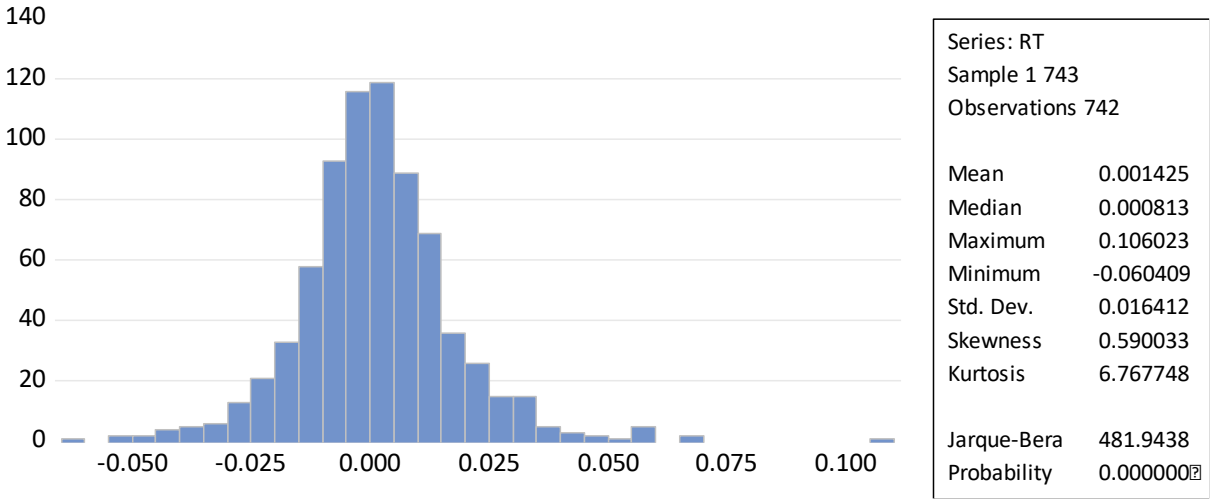
t-stat: -26.99381

P value of returns (0.000) < 0.05.

We reject H0 and accept H1.

Rt is stationery at I(0) level of integration that is at level.

Jarque-Bera Test



H0: Data is normally distributed.

H1: Data is not normally distributed.

INTERPRETATION:

Jarque-Bera stat: 481.9438

P value of JB (0.0000) < 0.05

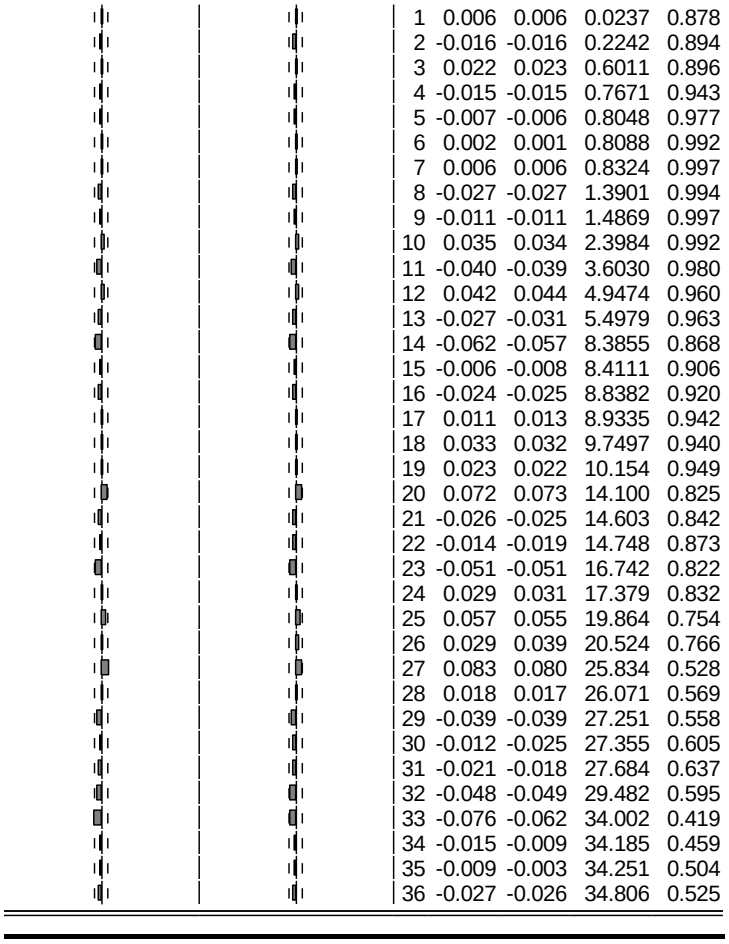
We reject H0 and accept H1.

Returns (Rt) are not normally distributed.

Skewness and Kurtosis is not equal to zero.

Correlogram Test

Date: 11/09/23 Time: 12:12
Sample (adjusted): 1 742
Included observations: 742 after adjustments



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.006	0.006	0.0237	0.878
		2	-0.016	-0.016	0.2242	0.894
		3	0.022	0.023	0.6011	0.896
		4	-0.015	-0.015	0.7671	0.943
		5	-0.007	-0.006	0.8048	0.977
		6	0.002	0.001	0.8088	0.992
		7	0.006	0.006	0.8324	0.997
		8	-0.027	-0.027	1.3901	0.994
		9	-0.011	-0.011	1.4869	0.997
		10	0.035	0.034	2.3984	0.992
		11	-0.040	-0.039	3.6030	0.980
		12	0.042	0.044	4.9474	0.960
		13	-0.027	-0.031	5.4979	0.963
		14	-0.062	-0.057	8.3855	0.868
		15	-0.006	-0.008	8.4111	0.906
		16	-0.024	-0.025	8.8382	0.920
		17	0.011	0.013	8.9335	0.942
		18	0.033	0.032	9.7497	0.940
		19	0.023	0.022	10.154	0.949
		20	0.072	0.073	14.100	0.825
		21	-0.026	-0.025	14.603	0.842
		22	-0.014	-0.019	14.748	0.873
		23	-0.051	-0.051	16.742	0.822
		24	0.029	0.031	17.379	0.832
		25	0.057	0.055	19.864	0.754
		26	0.029	0.039	20.524	0.766
		27	0.083	0.080	25.834	0.528
		28	0.018	0.017	26.071	0.569
		29	-0.039	-0.039	27.251	0.558
		30	-0.012	-0.025	27.355	0.605
		31	-0.021	-0.018	27.684	0.637
		32	-0.048	-0.049	29.482	0.595
		33	-0.076	-0.062	34.002	0.419
		34	-0.015	-0.009	34.185	0.459
		35	-0.009	-0.003	34.251	0.504
		36	-0.027	-0.026	34.806	0.525

H0: Data does not have autocorrelation (AC) or partial autocorrelation (PAC).

H1: Data has autocorrelation (AC) or partial autocorrelation (PAC).

INTERPRETATION:

All P values > 0.05

We accept H0 and reject H1.

Returns (Rt) does not have autocorrelation (AC) or partial autocorrelation (PAC).

- **SINCE TWO OUT TO THREE TESTS (ADF AND CORRELOGRAM) SAYS THAT THE DATA IS NORMALLY DISTRIBUTED, WE ACCEPT IT AND RUN REGRESSION. IT IS A SEMI STRONG FORM OF MARKET.**

REGRESSION MODEL

Dependent Variable: RT
Method: Least Squares
Date: 11/09/23 Time: 13:00
Sample (adjusted): 2 742
Included observations: 741 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RT_1	0.005659	0.036836	0.153639	0.8779
C	0.001423	0.000606	2.347877	0.0191

R-squared	0.000032	Mean dependent var	0.001430
Adjusted R-squared	-0.001321	S.D. dependent var	0.016423
S.E. of regression	0.016434	Akaike info criterion	-5.376293
Sum squared resid	0.199574	Schwarz criterion	-5.363856
Log likelihood	1993.917	Hannan-Quinn criter.	-5.371498
F-statistic	0.023605	Durbin-Watson stat	1.993922
Prob(F-statistic)	0.877936		

Null Hypothesis- H_0: There is no relationship between the two variables.

Alternate Hypothesis- H_1: The two variables share a positive relationship.

- Returns (Rt): y (Dependent Variable)
- Previous Year Returns (Rt-1): x (Independent Variable)

Therefore, the function y = f(x) is y = 0.001423 + 0.005659x

Where $\beta_0 = 0.001423$ (constant) and $\beta_1 = 0.005659$

β_1 represents that 1% change in 'x' will lead to a 0.5% change in 'y'.

- The data above is the regression function drawn out of the current year returns being the dependent variable and previous year returns being the independent variable from the year 2020-2023.
- Probability of $\beta_1 = 0.8 > 0.01$ which shows that the coefficient is insignificant and that the hypothesis is not accepted at 90%, 95% and 99% confidence intervals. (p value is greater than alpha value at all levels of significance and hence are insignificant to the model)
- Durbin Watson stat at 1.99 shows that there is no positive or negative autocorrelation.

RESIDUAL DIAGNOSTICS

Breush-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.948434	Prob. F(2,737)	0.3878
Obs*R-squared	1.902267	Prob. Chi-Square(2)	0.3863

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 11/09/23 Time: 13:27
Sample: 2 742
Included observations: 741
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RT 1	-5.781138	4.437796	-1.302705	0.1931
C	0.008241	0.006355	1.296682	0.1951
RESID(-1)	5.781590	4.437935	1.302766	0.1931
RESID(-2)	0.016243	0.044600	0.364180	0.7158

R-squared	0.002567	Mean dependent var	2.25E-19
Adjusted R-squared	-0.001493	S.D. dependent var	0.016422
S.E. of regression	0.016435	Akaike info criterion	-5.373466
Sum squared resid	0.199062	Schwarz criterion	-5.348591
Log likelihood	1994.869	Hannan-Quinn criter.	-5.363876
F-statistic	0.632289	Durbin-Watson stat	1.998078
Prob(F-statistic)	0.594331		

H0: $\varphi=0$, Errors are not correlated.

H1: $\varphi\neq0$, Errors are correlated.

Prob (F) > 0.05.

We accept H0 and reject H1.

Errors are not correlated to each other.

$y_t = \beta_0 + \beta_1 y_{t-1} + E_t$

$y_t = 0.008241 - 5.781138 y_{t-1} + E_t$

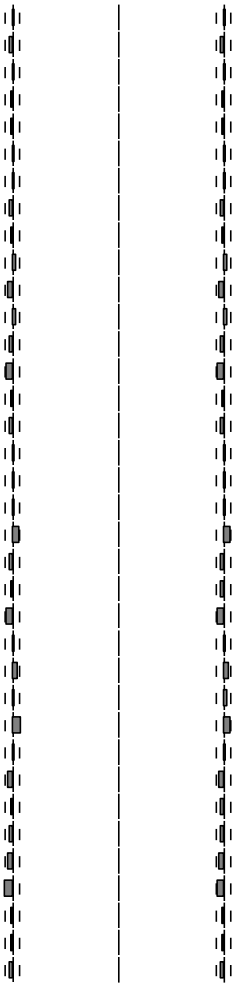
E_t creates one more regression function:

$\gamma_t = \alpha_0 + \alpha_1 y_{t-1} + 5.781590 E_{t-1} + 0.016243 E_{t-2} + \delta_i$

values other than zero says that both errors affects the current value.

Correlogram Test

Date: 11/09/23 Time: 14:02
Sample (adjusted): 2 742
Included observations: 741 after adjustments

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.000	0.000	0.0002	0.989
		2	-0.016	-0.016	0.2007	0.905
		3	0.023	0.023	0.5785	0.901
		4	-0.015	-0.015	0.7372	0.947
		5	-0.007	-0.006	0.7746	0.979
		6	0.002	0.001	0.7790	0.993
		7	0.005	0.006	0.7995	0.997
		8	-0.027	-0.027	1.3642	0.995
		9	-0.012	-0.012	1.4665	0.997
		10	0.035	0.034	2.3876	0.992
		11	-0.040	-0.040	3.6187	0.980
		12	0.042	0.044	4.9743	0.959
		13	-0.027	-0.031	5.5196	0.962
		14	-0.061	-0.057	8.3791	0.869
		15	-0.005	-0.008	8.4007	0.907
		16	-0.024	-0.025	8.8289	0.920
		17	0.011	0.013	8.9243	0.943
		18	0.033	0.032	9.7299	0.940
		19	0.022	0.021	10.105	0.950
		20	0.072	0.074	14.104	0.825
		21	-0.026	-0.024	14.609	0.842
		22	-0.014	-0.019	14.749	0.873
		23	-0.051	-0.051	16.728	0.822
		24	0.029	0.030	17.360	0.833
		25	0.056	0.055	19.784	0.758
		26	0.028	0.039	20.395	0.772
		27	0.083	0.080	25.650	0.538
		28	0.017	0.018	25.881	0.580
		29	-0.039	-0.039	27.072	0.568
		30	-0.011	-0.025	27.172	0.614
		31	-0.020	-0.018	27.495	0.647
		32	-0.047	-0.048	29.215	0.608
		33	-0.076	-0.063	33.699	0.433
		34	-0.015	-0.009	33.871	0.474
		35	-0.009	-0.002	33.928	0.520
		36	-0.027	-0.026	34.492	0.540

H0: Errors does not have autocorrelation (AC) or partial autocorrelation (PAC).

H1: Errors have autocorrelation (AC) or partial autocorrelation (PAC).

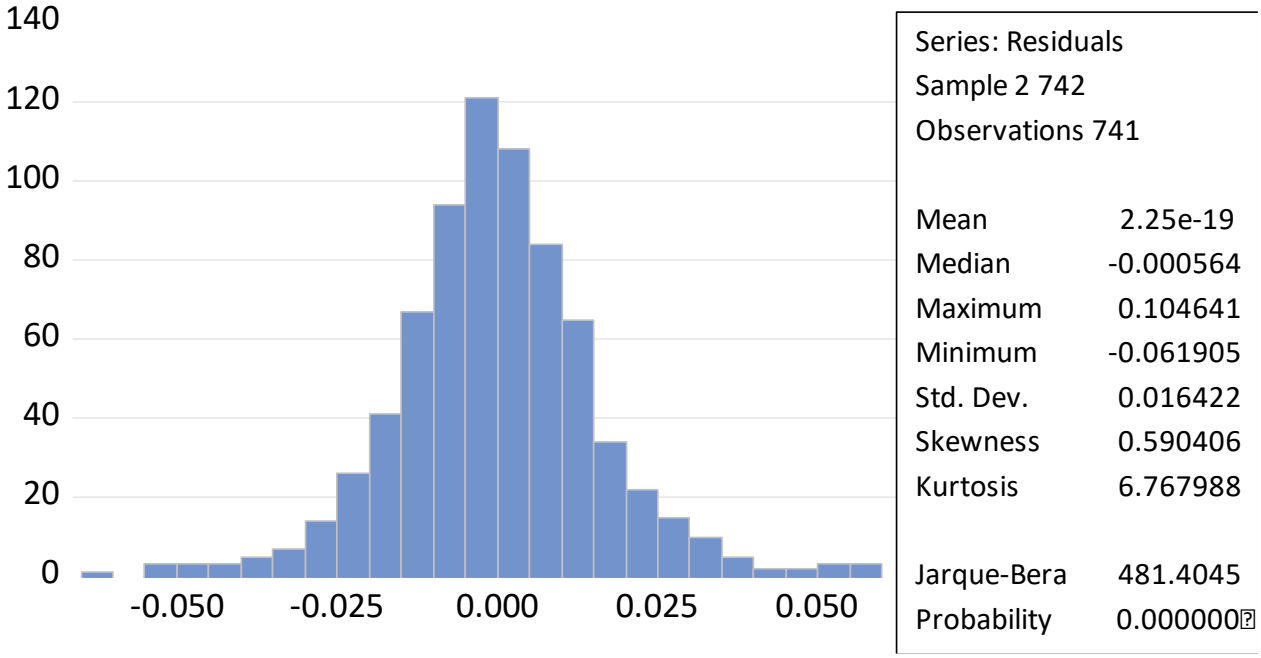
INTERPRETATION:

All P values > 0.05

We accept H0 and reject H1.

Errors (E) does not have autocorrelation (AC) or partial autocorrelation (PAC).

Jarque-Bera Test



H0: Errors are normally distributed.

H1: Errors are not normally distributed.

INTERPRETATION:

Jarque-Bera stat: 481.4045

P value of JB (0.0000) < 0.05

We reject H0 and accept H1.

Errors (E) are not normally distributed.

- **SINCE TWO OUT TO THREE TESTS (BG-LM AND CORRELOGRAM) SAYS THAT THE ERROS ARE NORMALLY DISTRIBUTED AND ARE NOT CORRELATED TO EACHOTHER, IT IS A SEMI STRONG FORM OF MARKET.**

TESTS TO CHECK HETEROSKEDASTICITY

Glejser Test

Heteroskedasticity Test: Glejser
Null hypothesis: Homoskedasticity

F-statistic	0.319241	Prob. F(1,739)	0.5722
Obs*R-squared	0.319966	Prob. Chi-Square(1)	0.5716
Scaled explained SS	0.427634	Prob. Chi-Square(1)	0.5132

Test Equation:
Dependent Variable: ARESID
Method: Least Squares
Date: 11/09/23 Time: 14:27
Sample: 2 742
Included observations: 741

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.011775	0.000423	27.85601	0.0000
RT 1	-0.014521	0.025700	-0.565014	0.5722

R-squared	0.000432	Mean dependent var	0.011755
Adjusted R-squared	-0.000921	S.D. dependent var	0.011460
S.E. of regression	0.011465	Akaike info criterion	-6.096277
Sum squared resid	0.097145	Schwarz criterion	-6.083840
Log likelihood	2260.671	Hannan-Quinn criter.	-6.091482
F-statistic	0.319241	Durbin-Watson stat	1.818390
Prob(F-statistic)	0.572236		

H0: $\beta_1 = 0$, no relationship between u_i and x_i. (no heteroskedasticity)

H1: $\beta_1 \neq 0$, relationship between u_i and x_i. (heteroskedasticity)

INTERPRETATION:

Prob (F-stat) = 0.572236

Prob (F-stat) > 0.05.

We accept H0 and reject H1 since it is insignificant.

Errors are not heteroskedastic in nature and are homoscedastic.

White's Test

Heteroskedasticity Test: White
Null hypothesis: Homoskedasticity

F-statistic	0.799760	Prob. F(2,738)	0.4498
Obs*R-squared	1.602550	Prob. Chi-Square(2)	0.4488
Scaled explained SS	4.596829	Prob. Chi-Square(2)	0.1004

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 11/09/23 Time: 14:38
Sample: 2 742
Included observations: 741

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000265	2.57E-05	10.28219	0.0000
RT 1^2	0.027138	0.037956	0.714976	0.4748
RT 1	-0.001854	0.001527	-1.213925	0.2252

R-squared	0.002163	Mean dependent var	0.000269
Adjusted R-squared	-0.000541	S.D. dependent var	0.000647
S.E. of regression	0.000647	Akaike info criterion	-11.84300
Sum squared resid	0.000309	Schwarz criterion	-11.82435
Log likelihood	4390.833	Hannan-Quinn criter.	-11.83581
F-statistic	0.799760	Durbin-Watson stat	1.998978
Prob(F-statistic)	0.449826		

H0: There is no heteroskedasticity.

H1: There is heteroskedasticity.

INTERPRETATION:

Prob (F-stat): 0.4498

Prob (chi-square): 0.4488 & 0.1004

Prob (F- stat and chi-square) > 0.05

We accept H0 and reject H1.

Therefore, errors are homoscedastic.

Breusch-Pagan-Godfrey Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	1.089050	Prob. F(1,739)	0.2970
Obs*R-squared	1.090390	Prob. Chi-Square(1)	0.2964
Scaled explained SS	3.127727	Prob. Chi-Square(1)	0.0770

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 11/09/23 Time: 14:46
Sample: 2 742
Included observations: 741

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000271	2.39E-05	11.37508	0.0000
RT_1	-0.001514	0.001451	-1.043576	0.2970

R-squared	0.001472	Mean dependent var	0.000269
Adjusted R-squared	0.000120	S.D. dependent var	0.000647
S.E. of regression	0.000647	Akaike info criterion	-11.84501
Sum squared resid	0.000310	Schwarz criterion	-11.83257
Log likelihood	4390.577	Hannan-Quinn criter.	-11.84022
F-statistic	1.089050	Durbin-Watson stat	1.947272
Prob(F-statistic)	0.297023		

H0: There is no heteroskedasticity.

H1: There is heteroskedasticity.

INTERPRETATION:

Prob (F-stat): 0.2970

Prob (chi-square): 0.2964 & 0.0770

Prob (F- stat and chi-square) > 0.05

We accept H0 and reject H1.

Therefore, errors are homoscedastic.

CONCLUSION

- Two out of the three tests (ADF AND CORRELOGRAM) done to check the normality of data says that the data is normally distributed at level.
- Two out of the three tests (BG-LM AND CORRELOGRAM) done to check the stationarity of errors says that the errors are normally distributed at level.
- All the three heteroscedasticity tests (GEJSER TEST, WHITE'S TEST & BP-GODFREY TEST) done to check whether the errors are heteroscedastic or homoscedastic states that they are homoscedastic in nature.
- Hence, this a **semi-strong form of market** which states that the market analysis of the TITAN stock is based on both fundamental analysis and public information available.