

The goal is to turn data into information, and information into insight.

—Carly Fiorina

Single Index Model.....

$$R = \alpha + \beta R_m + \varepsilon$$

- ...gives us the estimation of β ;
- ...gives us the ideas and the estimation of Systematic Risk and Unsystematic Risk

Getting more meanings out of the following!!!

SUMMARY OUTPUT		Beta Estimation of Maruti Suzuki India Ltd.				
Regression Statistics						
Multiple R	0.57111					
R Square	0.32617					
Adjusted R Square	0.32481					
Standard Error	0.01104					
Observations	498					
ANOVA						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	1	0.02926	0.02926	240.08557	0.00000	
Residual	496	0.06044	0.00012			
Total	497	0.08970				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>		
Intercept	-0.00007	0.00050	-0.14772	0.88262		
B S E Sensex - Return	1.11360	0.07187	15.49469	0.00000		

The Model

$$DE = a + b \text{ Beta} + e$$

Regression Statistics

Multiple R	0.34195692
R Square	0.11693454
Adjusted R Square	0.10792367
Standard Error	1.1299848
Observations	100

**INTERCEPT
TERM**

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	16.5699496	16.5699496	12.97705	0.000497368
Residual	98	125.1328344	1.27686566		
Total	99	141.702784			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	-0.39566	0.376896	-1.04979	0.2964	-1.1435989	0.35228	-1.1436	0.35228
Beta	1.1786884	0.327198284	3.60236729	0.0004974	0.529374066	1.8280027	0.52937407	1.82800272

*Remember-
Life is full of challenges!!!*

Now... is the time to take on challenges that
come in way of Financial Modeling!!!!

Interpret the parameters of the following two models...

$$\text{Operating_Profit} = \alpha + \beta \text{Rev_size} + \varepsilon$$

$$\ln(\text{Operating_Profit}) = \alpha + \beta \ln(\text{Rev_size}) + \varepsilon$$

What is the insight we get?

She is working on a research project related to energy consumption and income of households...she wants to determine the elasticity of energy consumption ...



She got the data as follows...

ENERGY CONSUMPTION PER YEAR (IN UNITS-WATT)	ANNUAL INCOME (in Rs. Lakhs)
330	43.00
120	28.00
360	35.00
270	33.00
220	44.00
170	19.00
70	20.00
210	22.00
200	21.00
300	40.00

She run simple Regression on it and get the following result...



<i>Regression Statistics</i>	
Multiple R	0.515
R Square	0.265
Adjusted R Square	0.239
Standard Error	69.382
Observations	30

<i>ANOVA</i>					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	48546.870	48546.870	10.085	0.004
Residual	28	134789.797	4813.921		
Total	29	183336.667			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	64.745	48.779	1.327	0.195	-35.174	164.663
ANNUAL INCOME	4.680	1.474	3.176	0.004	1.661	7.698

Getting more meanings out of the following!!!

Then, somebody suggested her to use Log-Log Regression and the output of the same is given below...

<i>Regression Statistics</i>	
Multiple R	0.598
R Square	0.358
Adjusted R Square	0.335
Standard Error	0.382
Observations	30

<i>ANOVA</i>						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	1	2.280	2.280	15.597	0.000	
Residual	28	4.093	0.146			
Total	29	6.373				

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	1.868	0.866	2.156	0.040	0.093	3.643
ANNUAL INCOME (Log)	0.995	0.252	3.949	0.000	0.479	1.511

SUMMARY OUTPUT **Oil & Natural Gas Corpn. Ltd.**

<i>Regression Statistics</i>					
Multiple R	0.41386				
R Square	0.17128				
Adjusted R Square	0.17016				
Standard Error	0.01537				
Observations	743				
ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	0.03617	0.03617	153.15291	0.00000
Residual	741	0.17502	0.00024		
Total	742	0.21119			
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	
Intercept	-0.00111	0.00057	-1.96354	0.04996	
S & P B S E Sensex	0.92942	0.07510	12.37550	0.00000	

SUMMARY OUTPUT **Reliance Industries Ltd.**

<i>Regression Statistics</i>					
Multiple R	0.53501				
R Square	0.28623				
Adjusted R Square	0.28527				
Standard Error	0.01372				
Observations	743				
ANOVA					
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	0.05596	0.05596	297.15646	0.00000
Residual	741	0.13954	0.00019		
Total	742	0.19550			
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	
Intercept	0.00073	0.00050	1.43585	0.15147	
S & P B S E Sensex	1.15599	0.06706	17.23823	0.00000	

MULTIPLE REGRESSION MODEL

- The General form of the Multiple Regression Model is -

$$Y_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki} + \varepsilon_i ; i = 1, \dots, n$$

- Where-

- α is called the Intercept Parameter.
- β_i s are called the Slope Parameters in the relation between variables *Y and X's*.
- ε_i is called Error Term or Disturbance Term or Noise Term.

Example...(Multiple Regression)

Mr. A. S. Mittal, Director (HR) of a mid-size company has got the data describing the Salary earned during a year (Rs. in thousands) by a machinist in the factory along with the average performance rating over the past 3 years, the years of service, and the number of different machines each employee is certified to operate.

Mr. Mittal wants to build a model so that the average salary to be earned by an employee during a year can be estimated given his or her performance rating in a year, years of service, and certifications.

Observations	Salary (Annual)	Average Performance Rating	Experience in Years	Certifications
1	48.20	3.50	9	6
2	55.30	5.30	20	6
3	53.70	5.10	18	7
4	61.80	5.80	33	7
5	56.40	4.20	31	8
6	52.50	6.00	13	6
7	54.00	6.80	25	6
8	55.70	5.50	30	4
9	45.10	3.10	5	6
10	67.90	7.20	47	8
11	53.20	4.50	25	5
12	46.80	4.90	11	6
13	58.30	8.00	23	8
14	59.10	6.50	35	7
15	57.80	6.60	39	5
16	48.60	3.70	21	4
17	49.20	6.20	7	6
18	63.00	7.00	40	7
19	53.00	4.00	35	6
20	50.90	4.50	23	4
21	55.40	5.90	33	5
22	51.80	5.60	27	4
23	60.20	4.80	34	8
24	50.10	3.90	15	5

Getting more meanings out of the following!!!



Assume that you are working with Simple Regression Model...

$$Y = \alpha + \beta X_1 + \varepsilon$$

- What would happen to our results if we introduce another variable X_2 into our model?
- If we run a model only with X_1 and only with X_2 **separately**, can we say that total explained variation will be **the sum of their R^2** ?

SUMMARY OUTPUT

Regression Statistics

Multiple R	0.6671
R Square	0.4450
Adjusted R Square	0.4198
Standard Error	4.1698
Observations	24

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	306.7323	306.7323	17.6408	0.0004
Residual	22	382.5277	17.3876		
Total	23	689.2600			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	39.3477	3.7067	10.6154	0.0000	31.6605	47.0348
X1	2.8278	0.6733	4.2001	0.0004	1.4315	4.2241

lowing!!

*Look at the
Values of
R²!*

SUMMARY OUTPUT

Regression Statistics

Multiple R	0.8586
R Square	0.7371
Adjusted R Square	0.7252
Standard Error	2.8698
Observations	24

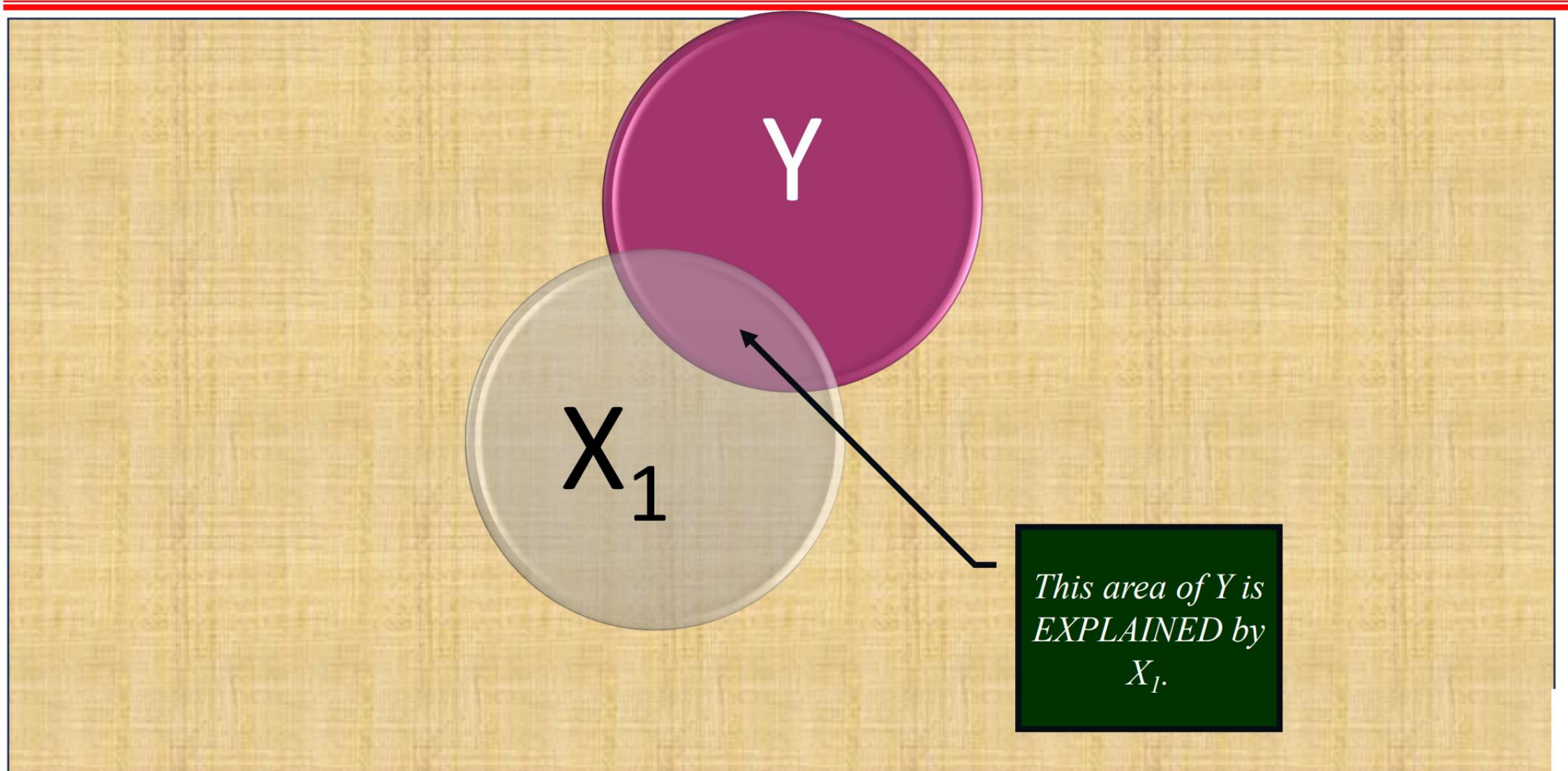
ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	508.0688	508.0688	61.6891	0.0000
Residual	22	181.1912	8.2360		
Total	23	689.2600			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	44.0478	1.4540	30.2944	0.0000	41.0324	47.0632
X2	0.4188	0.0533	7.8542	0.0000	0.3082	0.5294

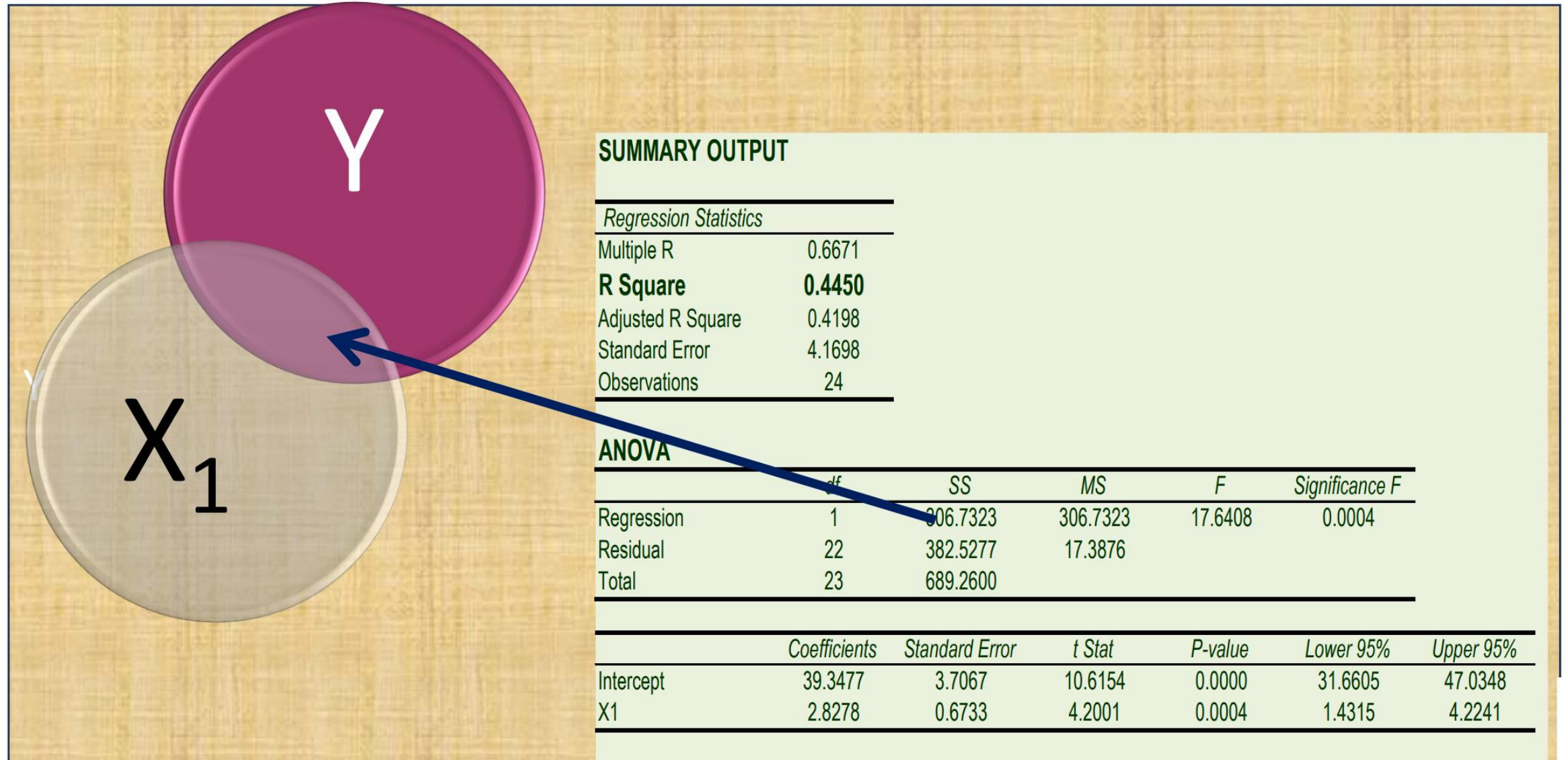
Let's understand Multiple Regression through Venn Diagrams

...

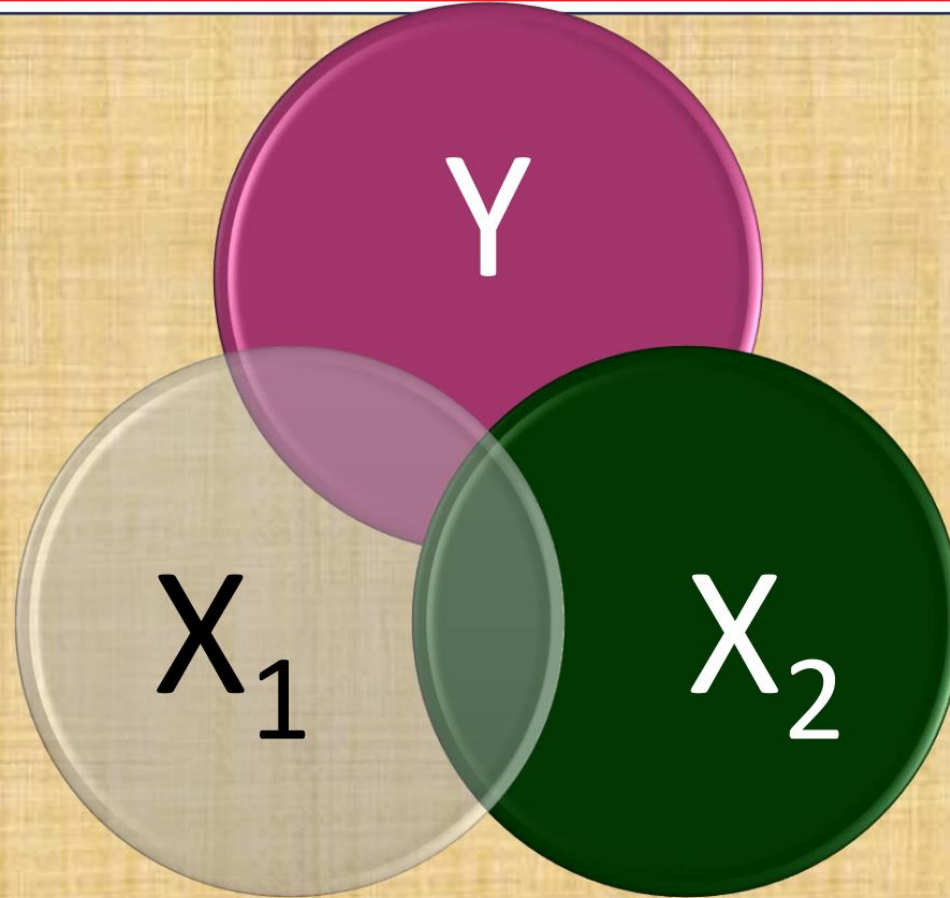


This Venn Diagram suggests the following regression model

...

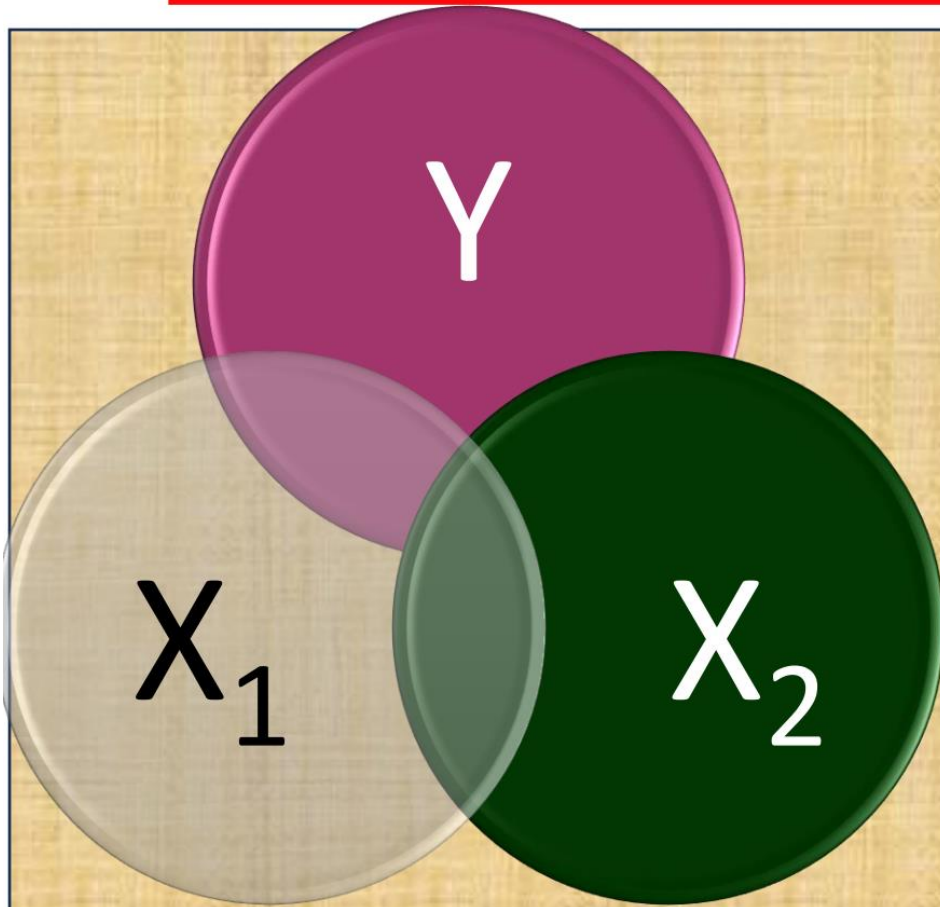


What X_2 is supposed to do in the regression model?



X_2 tries to explain that part of Y which is not explained by X_1 and through that which is NOT there already in X_1 .

It means that X_2 will explain the residuals of Y which are left after regressing with X_1 .



Will the whole of X_2 explain the residuals of Y ? NO.

Only that part of X_2 which is not contained in X_1 !!!

REGRESSION: Y WITH X1 & X2*Regression Statistics*

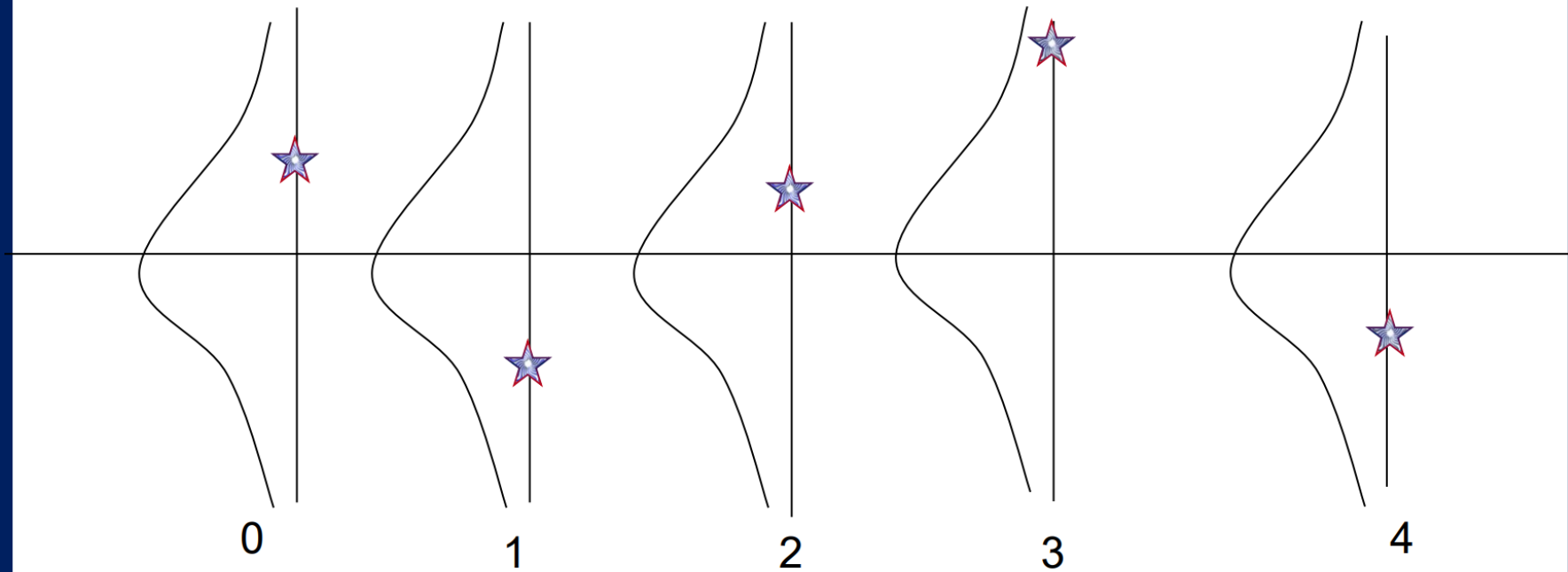
Multiple R	0.9098
R Square	0.8277
Standard Error	2.3778
Observations	24

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	2	570.5268	285.2634	50.4537	0.0000
Residual	21	118.7332	5.6540		
Total	23	689.2600			

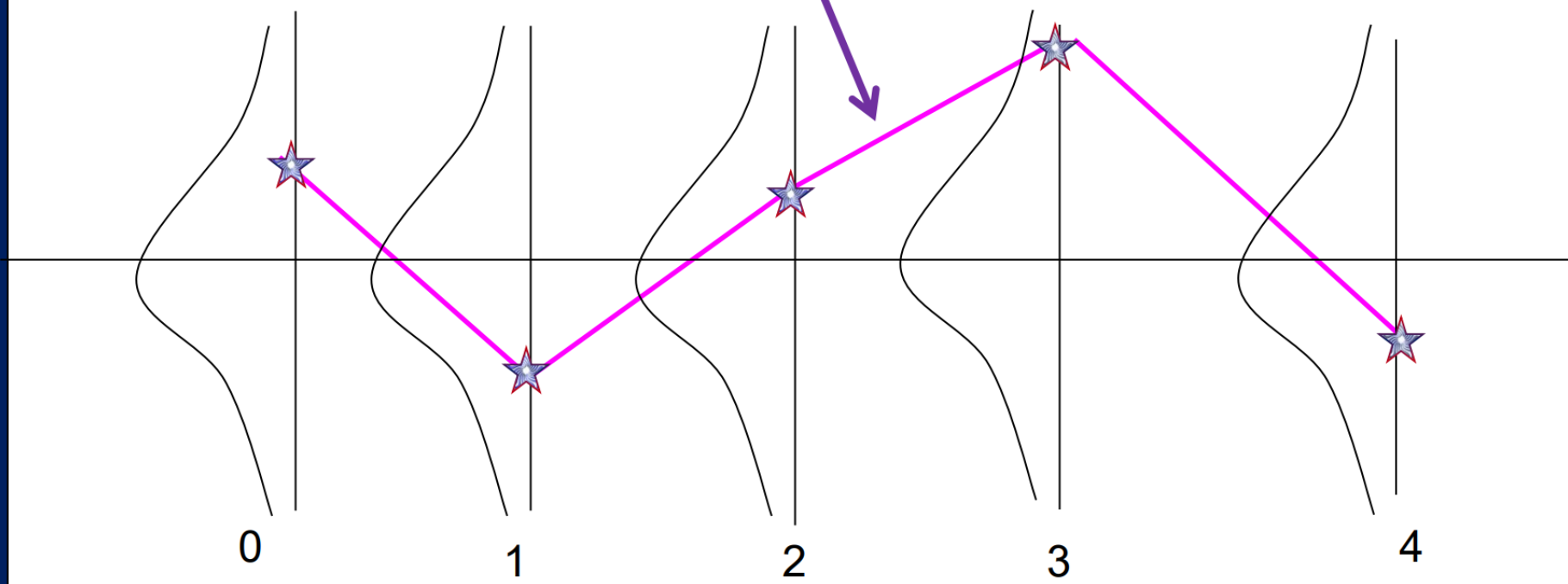
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	38.2508	2.1198	18.0448	0.0000
X1	1.4430	0.4342	3.3237	0.0032
X2	0.3412	0.0500	6.8306	0.0000

How many possible values can happen on day zero?

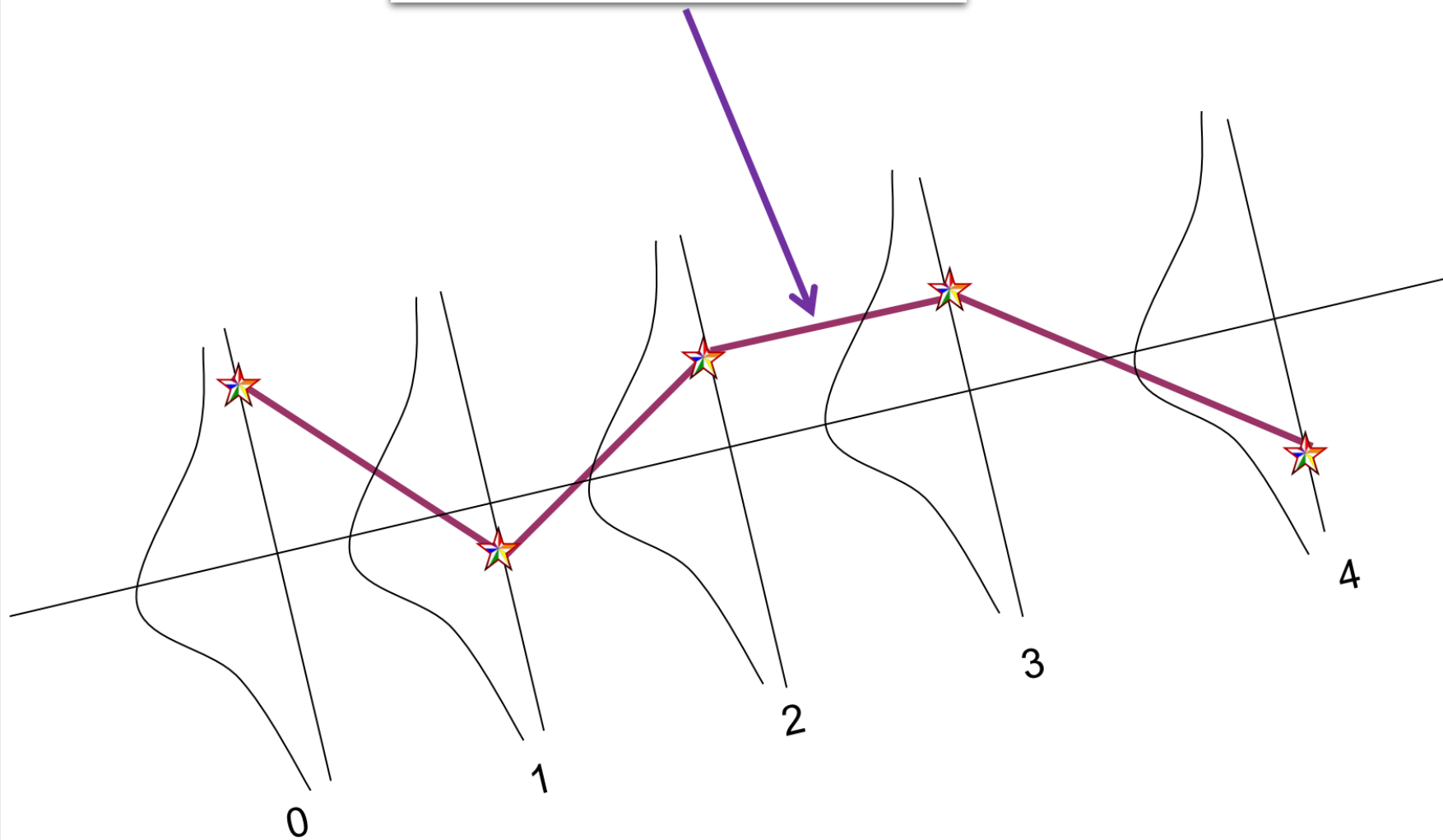


But, we realized only **ONE!!!** Similarly, for other days.

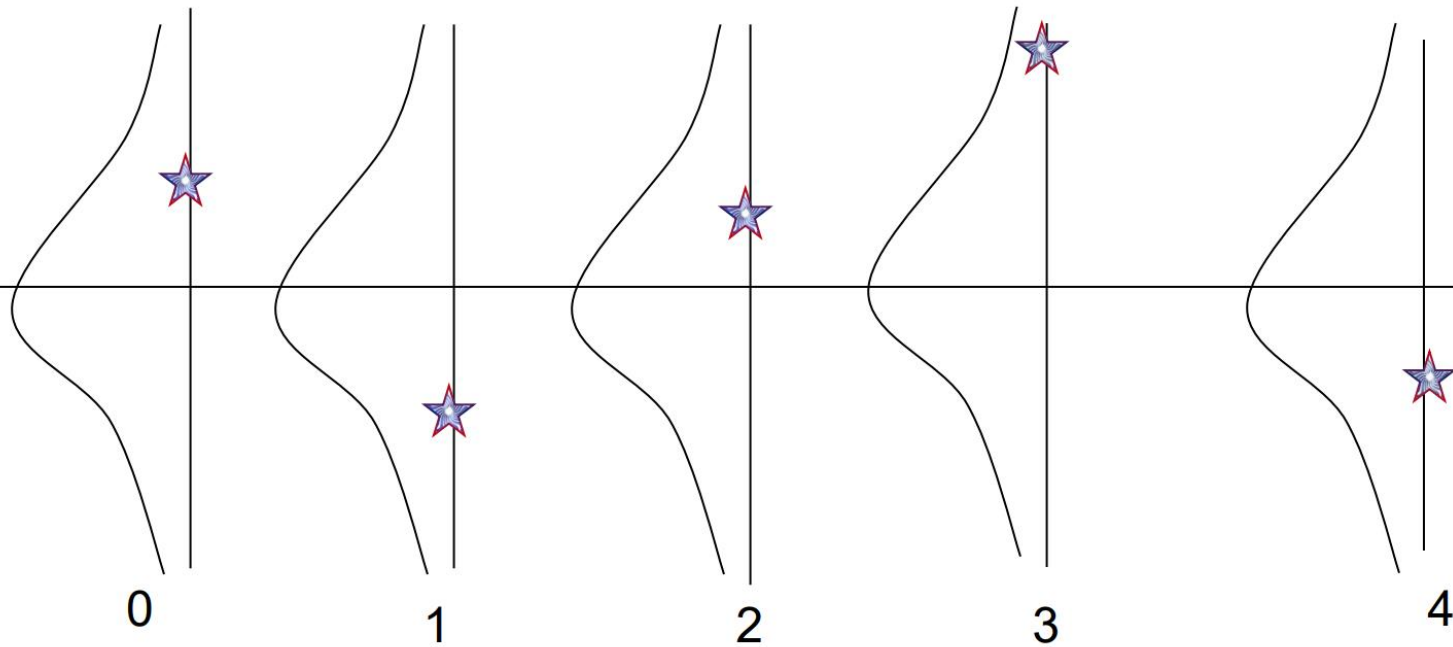
This is time series!!!



This is time series!!!

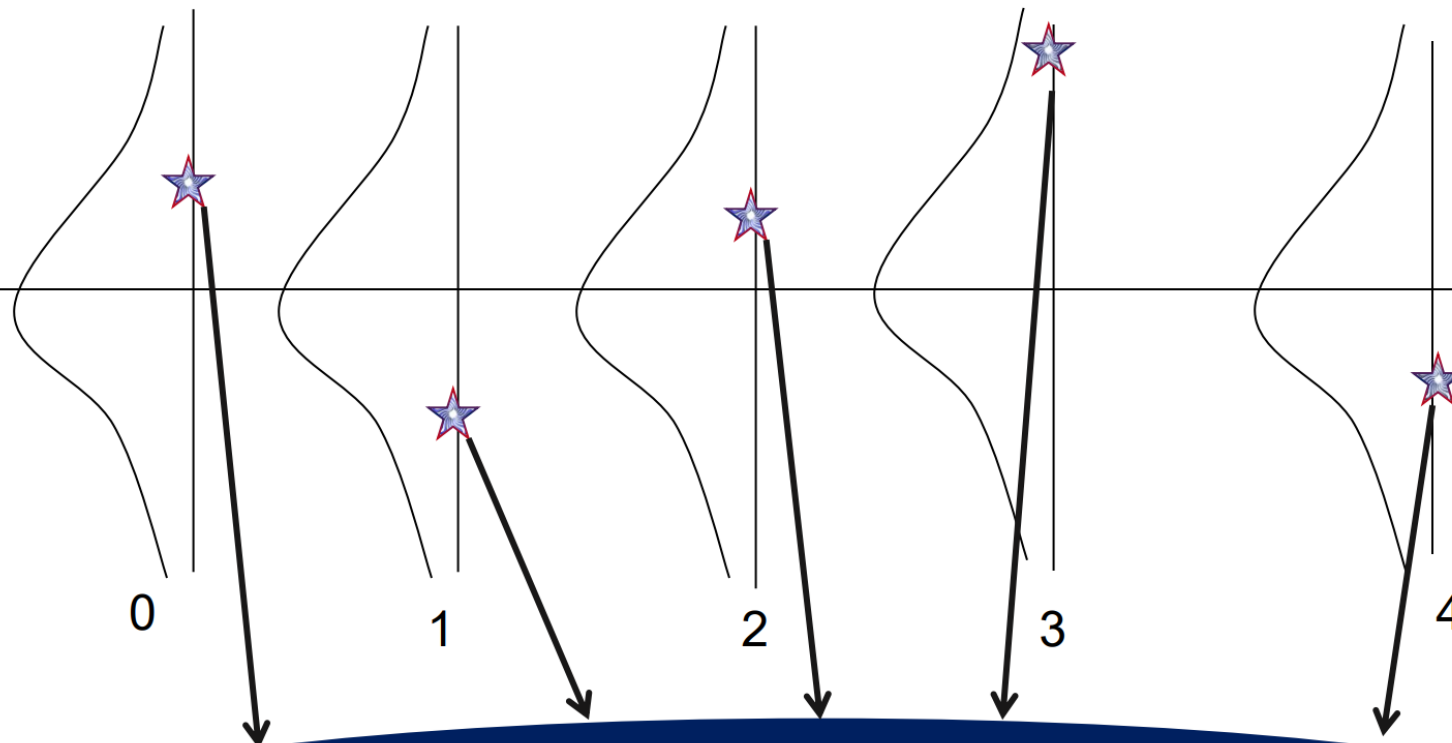


Important thing to note is ... that ...



Time Series deals with ONE realization out of infinite possibilities.

And, this one realization is the result of some underlying stochastic process!

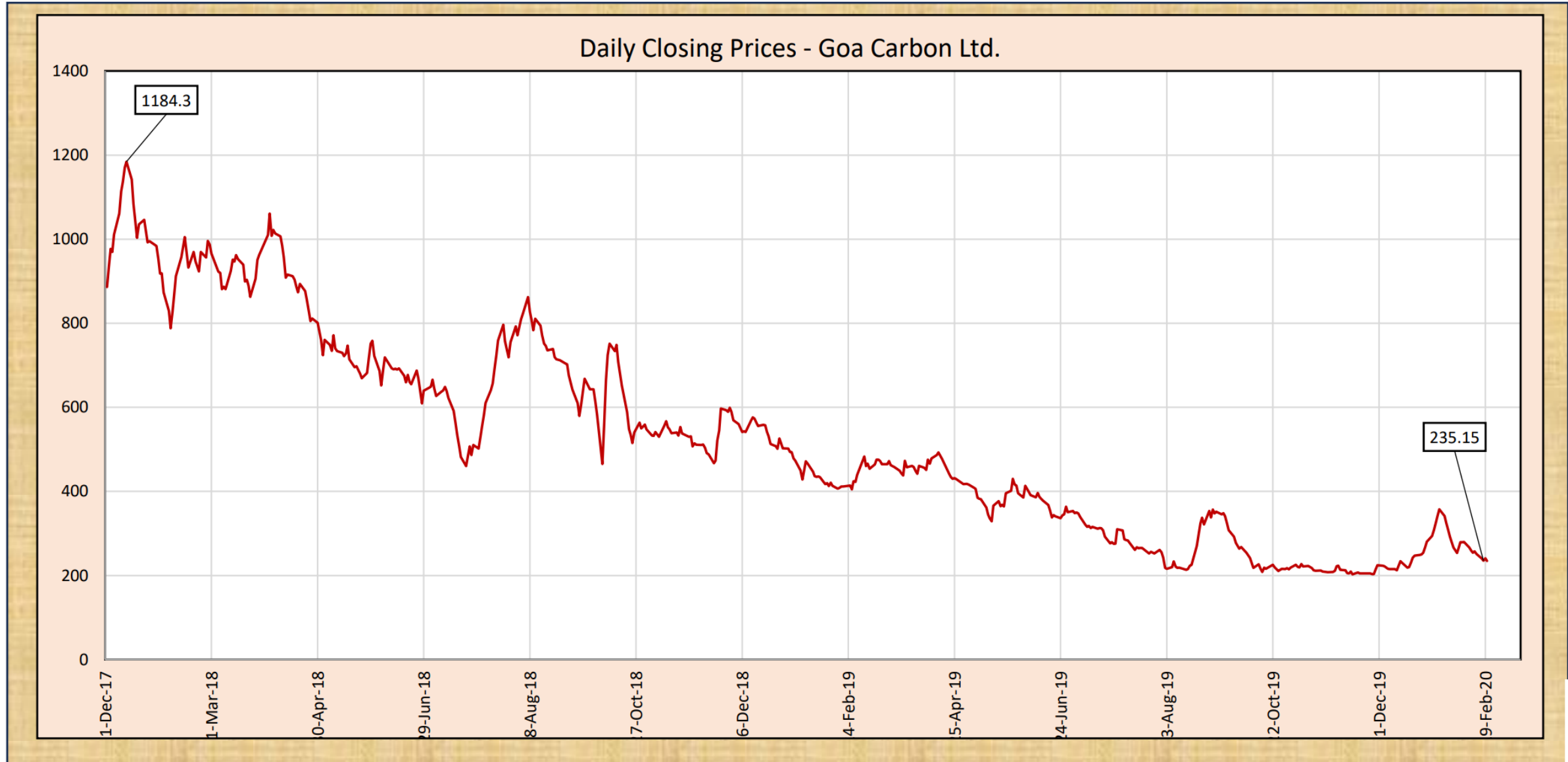


All these realizations are the result of SOME underlying stochastic process whose behaviour is modeled through Normal Probability Distribution.

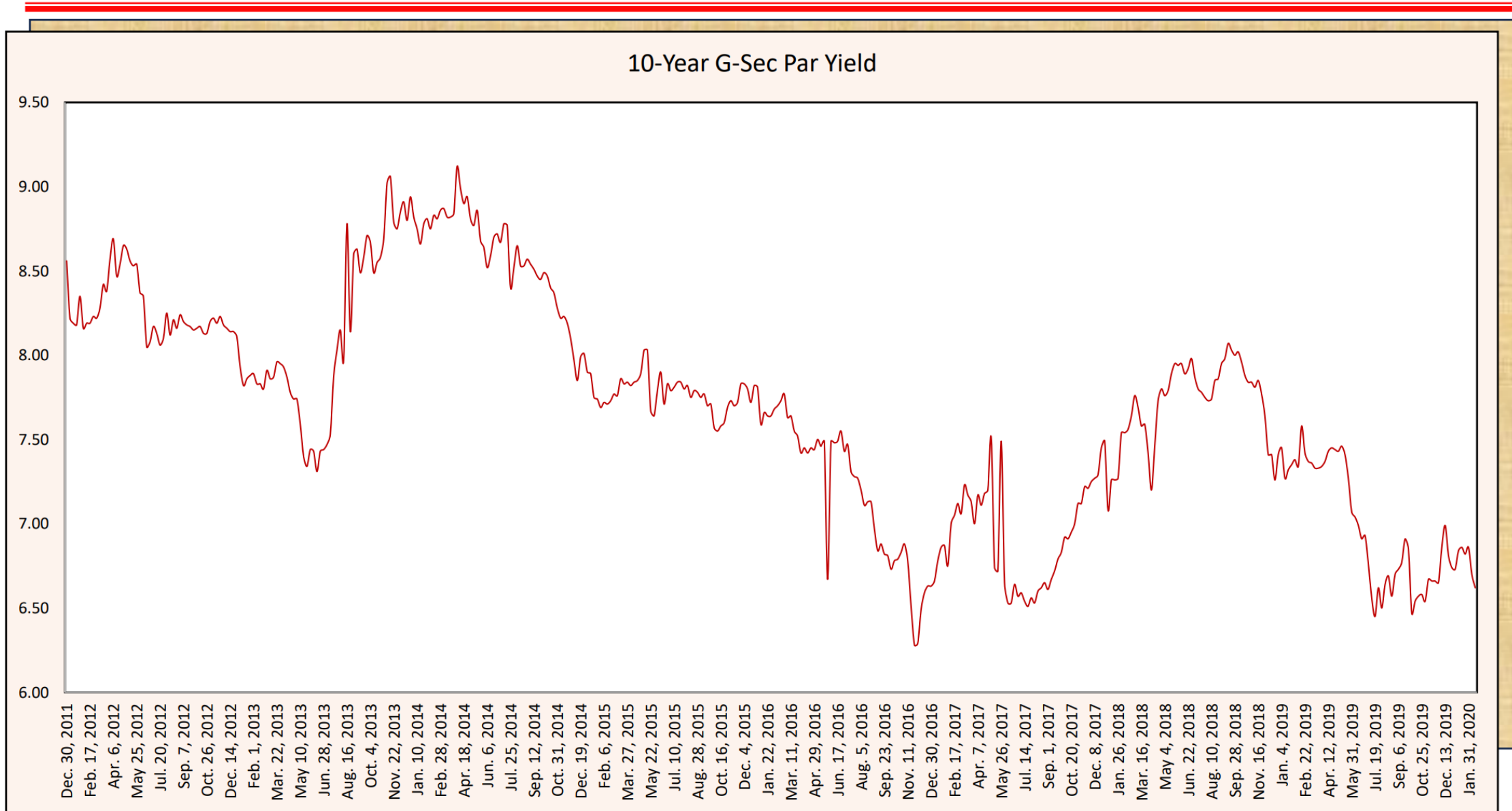
What difference you find in the share price data?



Look at the share prices of Goa Carbon Ltd.



Look at the behaviour of 10-Year GOI bonds



Think...

What kind of data you are seeing?

Do we have some challenges in analyzing the data?

Can we use OLS for the analysis of such data for meaningful inferences?

Issues related to Time Series

Issues:

- **FORECASTING**
- **ESTIMATION**
- **ESTABLISHING THE RELATION**

Specific issues in Finance related to Time Series

Issues:

- **Forecasting** – Share Prices, Interest Rates.
- **Estimating** – Mean (Return) and Variance (Risk)
- **Establishing the relation** – Relation between the spot rates and forward rates

Features of Time Series Data

Time Series data may be related to their own past

- *(such as autoregressive process, moving average process)*

They may be subject to deterministic trends, seasonality, cycles etc.

- *(Such trend in sales, growth rate of profit)*

In multi-variate context, they may have cross-correlations.

- *(For example; advertisement expenses for the month of January will affect the sale not only in the month of January but may affects the sale of February and coming months.)*

Revisit the purposes for which time series are used ...

- Forecasting
- Estimation
- Establishing relation

*For all these, we
need
INFORMATION!*

*But, where is the
INFORMATION
hidden in a time
series?*

Where is the information hidden in a time series?

Is it in **TIME**?

Is it in the **OWN PAST** of a time series?

Is it in **OWN RESIDUAL**?

Is it in **SOME OTHER TIME SERIES**?

The whole fight in a time series modeling is ...

Identify the source of information in a time series which can be used for forecasting, estimation and establishing relation.

Once the source of information is identified, how to use the same to estimate the parameters of the model to get the **BEST** **estimators!**

Take a pause, meditate on what we have discussed and learned so far!



When we run from SILENCE, we run from OURSELVES; please come back to yourself!

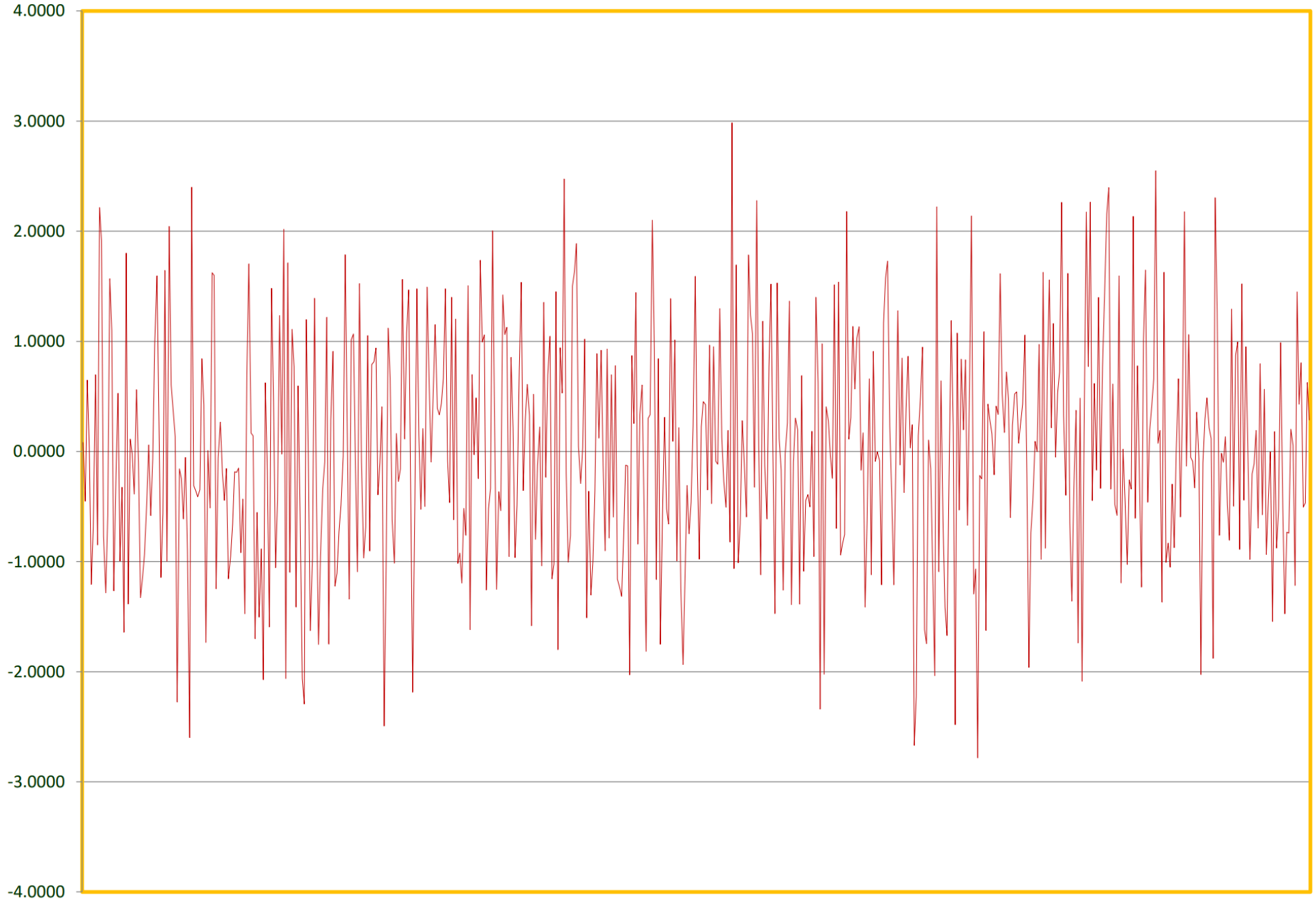
Tools to Identify a underlying behavior of Time Series

Time Series Plot

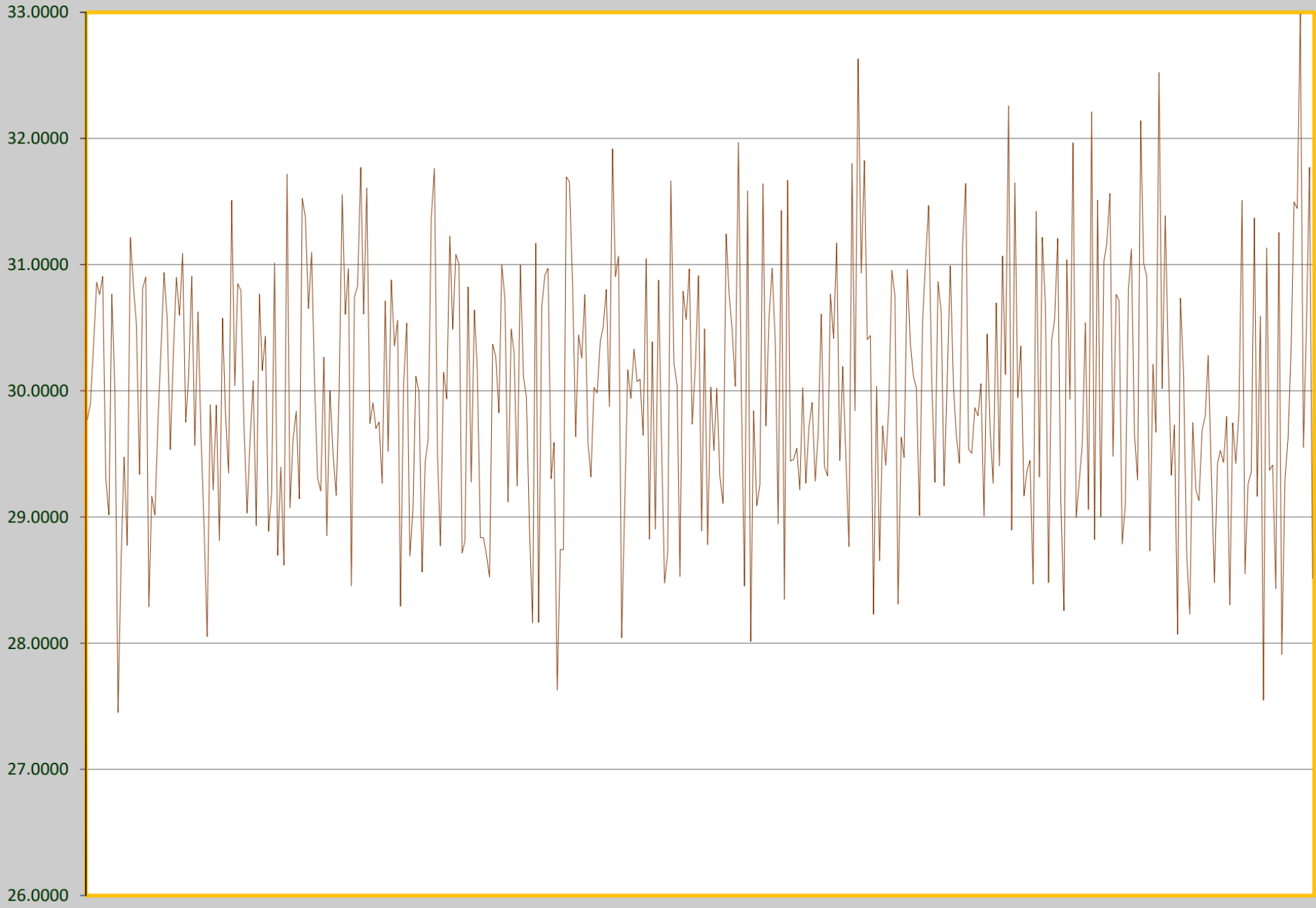
Correlogram

REALIZATION OF A VALUE WHICH IS PURELY RANDOM FOLLOWING NORMAL PROBABILITY DISTRIBUTION

A ξ



REALIZATION OF A VALUE WHICH IS PURELY RANDOM FOLLOWING NORMAL PROBABILITY DISTRIBUTION WITH A DRIFT



Another Time Series.....is its behaviour same as those of the earlier ones?



Another tool to understand the behaviour of a time series ...





















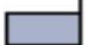

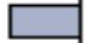



Correlogram ...

Correlogram

Date: 04/13/12 Time: 10:12

Sample: 1996 2010

Included observations: 15

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
		1	0.729	9.6842	0.002
		2	0.429	13.302	0.001
		3	0.168	13.900	0.003
		4	-0.025	13.914	0.008
		5	-0.069	14.035	0.015
		6	-0.104	14.340	0.026
		7	-0.134	14.913	0.037
		8	-0.170	15.961	0.043
		9	-0.209	17.822	0.037
		10	-0.248	20.959	0.021
		11	-0.283	26.048	0.006
		12	-0.264	31.965	0.001

ACF and PACF

- Autocorrelation function (ACF)

$$\rho(p_{or}q) = \frac{\text{cov}(y_t, y_{t-p_{or}q})}{\text{var}(y_t)}$$

- Partial ACF (PACF)

$$\phi(p) = \frac{\rho_p - \sum_{j=1}^{p-1} (\phi_{p-2,j} - \phi_{pp}\phi_{p-2,p-j})\rho_{p-j}}{1 - \sum_{j=1}^{p-1} (\phi_{p-2,j} - \phi_{pp}\phi_{p-2,p-j})\rho_j}, \quad p \geq 3$$

Autocorrelation and Partial Autocorrelation...

Autocorrelation is simple correlation between X_t and, say, X_{t+h} , it is a correlation between a series but with a lag.

While Partial Autocorrelation is a correlation between observations X_t and X_{t+h} after removing the linear relationship of all observations that fall between X_t and X_{t+h} .

Look...Think...Infer

Date: 04/27/16 Time: 19:28
 Sample: 1/01/2014 3/19/2014
 Included observations: 54

Autocorrelation	Partial Correlation	AC	PAC	Q-Sta...	Prob
		1 0.921	0.921	48.435	0.000
		2 0.854	0.035	90.871	0.000
		3 0.770	-0.14...	126.06	0.000
		4 0.697	0.011	155.46	0.000
		5 0.636	0.055	180.42	0.000
		6 0.520	-0.41...	197.43	0.000
		7 0.420	-0.01...	208.75	0.000
		8 0.310	-0.03...	215.08	0.000
		9 0.224	0.006	218.45	0.000
		1... 0.142	-0.07...	219.84	0.000
		1... 0.078	0.195	220.26	0.000
		1... 0.009	-0.13...	220.27	0.000
		1... -0.05...	0.004	220.46	0.000
		1... -0.10...	-0.03...	221.24	0.000
		1... -0.14...	0.051	222.75	0.000
		1... -0.15...	-0.04...	224.69	0.000
		1... -0.20...	-0.19...	228.03	0.000
		1... -0.24...	-0.10...	232.94	0.000
		1... -0.26...	0.182	239.03	0.000
		2... -0.28...	-0.09...	246.06	0.000
		2... -0.29...	-0.11...	253.79	0.000
		2... -0.29...	0.180	262.23	0.000
		2... -0.31...	-0.07...	271.88	0.000
		2... -0.28...	0.195	280.09	0.000

Dependent Variable: CLOSE_PRICE
 Method: Least Squares
 Date: 04/27/16 Time: 19:28
 Sample (adjusted): 1/02/2014 3/19/2014
 Included observations: 53 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	29.36246	20.49878	1.432400	0.1581
CLOSE_PRICE_1	0.922970	0.054046	17.07743	0.0000
R-squared	0.851155	Mean dependent var		379.0009
Adjusted R-squared	0.848237	S.D. dependent var		18.93627
S.E. of regression	7.376970	Akaike info criterion		6.871608
Sum squared resid	2775.404	Schwarz criterion		6.945959
Log likelihood	-180.0976	Hannan-Quinn criter.		6.900200
F-statistic	291.6384	Durbin-Watson stat		2.059933
Prob(F-statistic)	0.000000			

Dependent Variable: CLOSE_PRICE
 Method: Least Squares
 Date: 04/27/16 Time: 19:28
 Sample (adjusted): 1/03/2014 3/19/2014
 Included observations: 52 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	28.66232	21.27551	1.347198	0.1841
CLOSE_PRICE_1	0.889037	0.142718	6.229324	0.0000
CLOSE_PRICE_2	0.035967	0.142684	0.252076	0.8020
R-squared	0.851589	Mean dependent var		379.1365
Adjusted R-squared	0.845531	S.D. dependent var		19.09502
S.E. of regression	7.504823	Akaike info criterion		6.924930
Sum squared resid	2759.796	Schwarz criterion		7.037502
Log likelihood	-177.0482	Hannan-Quinn criter.		6.968087
F-statistic	140.5819	Durbin-Watson stat		1.978242
Prob(F-statistic)	0.000000			





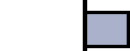













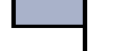





Correlogram...

Date: 04/13/12 Time: 10:12

Sample: 1996 2010

Included observations: 15

What is this?

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob	
		1	0.729	0.729	9.6842	0.002
		2	0.429	-0.218	13.302	0.001
		3	0.168	-0.122	13.900	0.003
		4	-0.025	-0.075	13.914	0.008
		5	-0.069	0.118	14.035	0.015
		6	-0.104	-0.117	14.340	0.026
		7	-0.134	-0.072	14.913	0.037
		8	-0.170	-0.081	15.961	0.043
		9	-0.209	-0.055	17.822	0.037
		10	-0.248	-0.116	20.959	0.021
		11	-0.283	-0.107	26.048	0.006
		12	-0.264	-0.006	31.965	0.001

A discussion on Ljung-Box Q statistic

- **Ljung-Box Q statistic**: The Ljung-Box Q-test is a quantitative way to test for autocorrelation at multiple lags jointly.
- **The null hypothesis** for this test is that the first m autocorrelations are jointly zero, $H_0: \rho_1 = \rho_2 = \dots = \rho_m = 0$.
- Alternatively, at least one of ρ_i is not zero.
- Note that it is a test related to AUTOCORRELATION.
- **Ljung-Box Q statistic** is having asymptotic χ^2 distribution























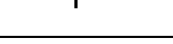

Correlogram...

Now, interpret the results!

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