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GOOGLE STOCK PRICE

DATA REPORT

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1.Introduction:

Google, also known as Alphabet Inc., is one of the largest technology companies in the world and has been publicly traded on the NASDAQ stock exchange since 2004. The company's stock price has fluctuated over the years, reflecting changes in the broader market, as well as shifts in the company's financial performance and investor sentiment. Since its initial public offering (IPO) in 2004, Google's stock price has experienced significant growth. In the first year of trading, the stock price increased by nearly 100%, and it continued to rise steadily over the following years, reaching its all-time high in January 2020 at over $1,500 per share. However, like many companies, Google's stock price has also experienced periods of volatility and decline. For example, during the financial crisis of 2008-2009, the stock price fell sharply, losing more than 50% of its value at one point. In addition, the COVID-19 pandemic in 2020 also caused a significant drop in stock prices across many industries, including technology. Despite these fluctuations, Google's stock price has generally been on an upward trend over the long term. This reflects the company's strong financial performance and dominance in the tech industry, as well as investor confidence in its future growth prospects. It's important to keep in mind that stock prices can be affected by a variety of factors, including economic indicators, company performance, news events, and investor sentiment. It's always a good idea to conduct thorough research and analysis before making any investment decisions. The dataset provides a wealth of information for investors and analysts looking to gain insights into Google's stock performance. By analyzing the data over time, users can identify patterns and trends, evaluate the impact of external factors on stock price, and make informed investment decisions. The dataset is ideal for conducting advanced data analysis, including regression analysis, time series analysis, and predictive modeling. It can also be used to create informative visualizations, such as line graphs and candlestick charts, to better understand trends and patterns in Google's stock performance.

2.Literature review

1. "Google's Stock Price and Information: Efficiency and Non-Linearity" by Joachim Zietlow. This paper examines the efficiency and non-linearity of Google's stock price and finds evidence of non-linearity and inefficiency in the market.

"Stock Price Predictions with LSTM Recurrent Neural Networks" by François Chollet. This paper uses LSTM recurrent neural networks to predict Google's stock price and finds that the model is able to capture the long-term trends in the stock price.

"Forecasting Google's Stock Price Using Machine Learning Techniques" by Aditya Shah and Prashant Bharti. This paper compares the performance of machine learning techniques, including SVMs and neural networks, for forecasting Google's stock price and finds that neural networks outperform SVMs.

"The Impact of News on Stock Prices: Evidence from Google News" by Dirk Schiereck, Marc Simpson, and Markus Thomas Müllner. This paper examines the impact of news articles on Google's stock price and finds evidence of a significant effect on the stock price.

"Analysis of Google's Stock Price and Market Capitalization" by Diana Elena Popa and Raluca Andreea Popovici. This paper analyzes the relationship between Google's stock price and market capitalization and finds that there is a positive correlation between the two variables.

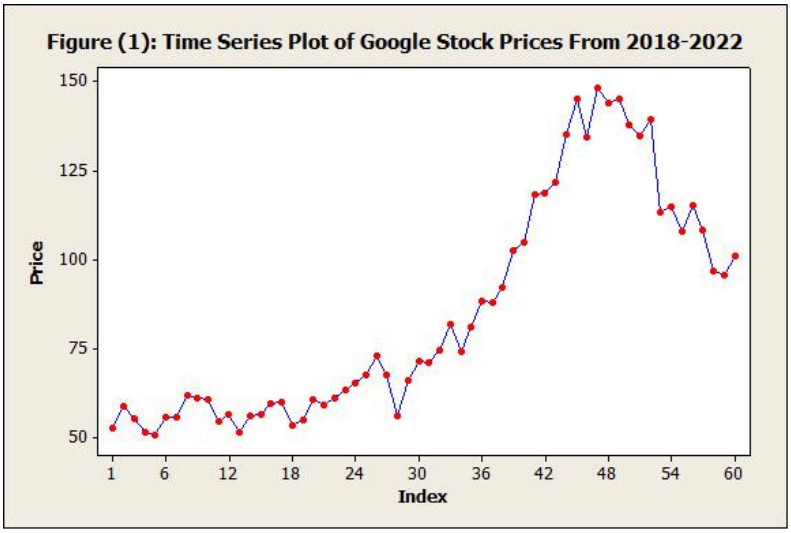
These papers provide a good overview of the different approaches and techniques used for analyzing Google's stock price and market behavior. They highlight the significance of factors such as market efficiency, non-linearity, news impact, and machine learning techniques in predicting and understanding Google's stock price. However, it's important to keep in mind that stock market analysis is not always accurate and should be used in combination with other analysis techniques.

3.Description of the data

The google stock price Data set available on Kaggle, updated till April 2023, is a collection of daily, weekly & monthly data on Google Stock Price. The Google Stock Price dataset contains historical price information for Google's stock, covering the period from May 2013 to the present. The dataset has a sample size of 119 monthly observations of stock price data, but we'll work on 60 observations which will be from Jan 2018 till Dec 2022 for the sake of accuracy and simplicity. Each observation includes 'date' column, which provides the date on which the stock price was recorded. 'price' column, which displays the opening price of the stock on the given date. 'high' column, which represents the highest price at which the stock was traded during the day. 'low' column, which displays the lowest price at which the stock was traded during the day. 'close' column, which represents the closing price of the stock on the given date. 'volume' column, which displays the total number of shares traded on the given date. 'adj close' column, which displays the adjusted closing price of the stock on the given date.

4.Graphical representation of the data:

We are going to use time series plot to graphically represent the data to reveal the most important characteristics of our phenomenon (google stock)



From figure (1), we can see that the data has an increasing trend, there is little fluctuations in the data, so seasonality might be apparent in the data & around January of 2022 there is a turning point as the price of google stock switched to a decreasing trend.

5.Decomposition Method:

From figure (1), it seems that the seasonality is dependent on the trend, therefore we will use the multiplicative model.

Seasonality analysis:

We need to check if seasonality exists in the time series & if it has a significant effect on the phenomenon.

Table (1): Seasonal indices for 12 months		
	month	seasonal index value
1	January	*98.945*
2	February	*100.562*
3	March	*99.427*
4	April	*99.966*
5	May	*98.874*
6	June	*97.404*
7	July	*97.118*
8	August	*102.800*
9	September	*106.788*
10	October	*99.152*
11	November	*98.327*
12	December	*100.636*

S_1: January decreases the stock price by 1.055 % of trend.

S_2: February increases the stock price by 0.562 % of trend.

S_3: March decreases the stock price by 0.573 % of trend.

S_4: April decreases the stock price by 0.034 % of trend.

S_5: May decreases the stock price by 1.126 % of trend.

S_6: June decreases the stock price by 2.596 % of trend.

S_7: July decreases the stock price by2.882 % of trend.

S_8: August increases the stock price by 2.8 % of trend.

S_9: September increases the stock price by 6.788 % of trend.

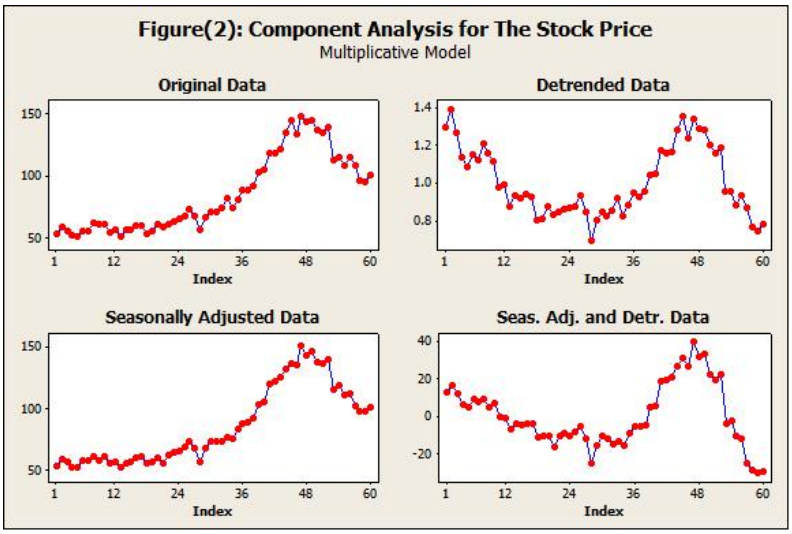
S_{10}: October decreases the stock price by 0.848 % of trend.

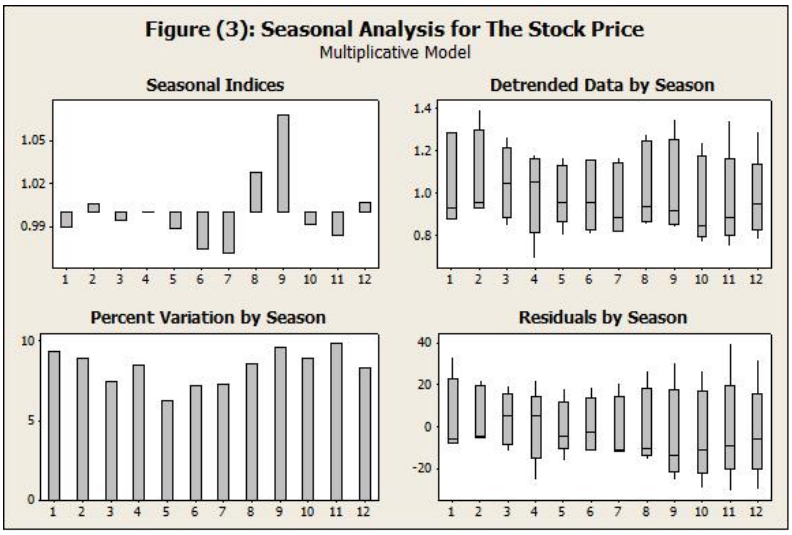
S_{11}: November decreases the stock price by 1.673 % of trend.

S_{12}: December increases the stock price by 0.636 % of trend

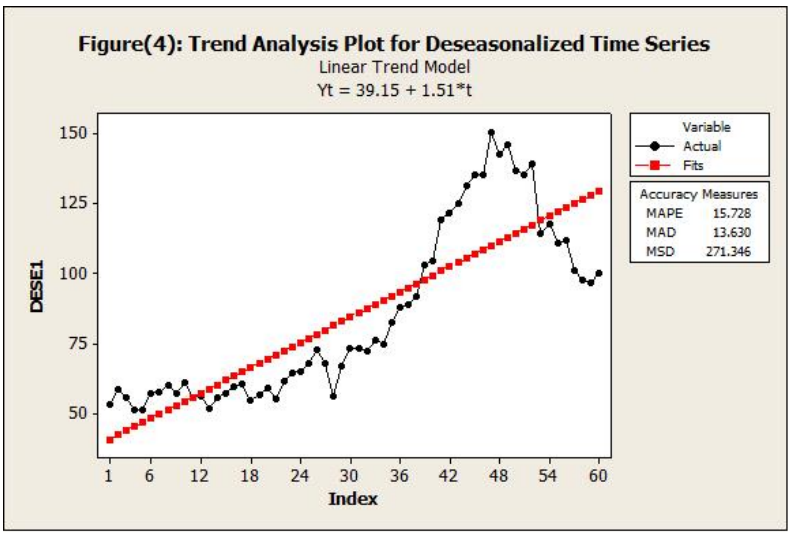
From table (1), the values of the seasonal indices are very close to 100% & from figure (2), the seasonally adjusted data graph is not that dissimilar from the original data graph. Same case goes for the detrended data & seasonally adjusted – detrended data graphs. Also from figure (3), the seasonal indices values are very close to 1 (100%), the detrended data by season doesn't indicate huge differences in the distribution & percent variation by season are almost the identical.

From the aforementioned paragraph, we can say the seasonality effect is very minimal or does not exist.





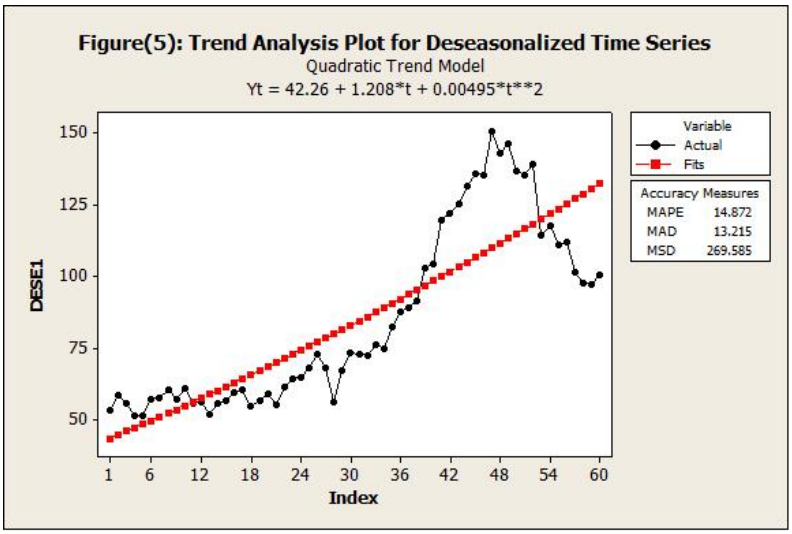
Trend Analysis:



After we Deseasonlise the time series, we can do trend analysis.

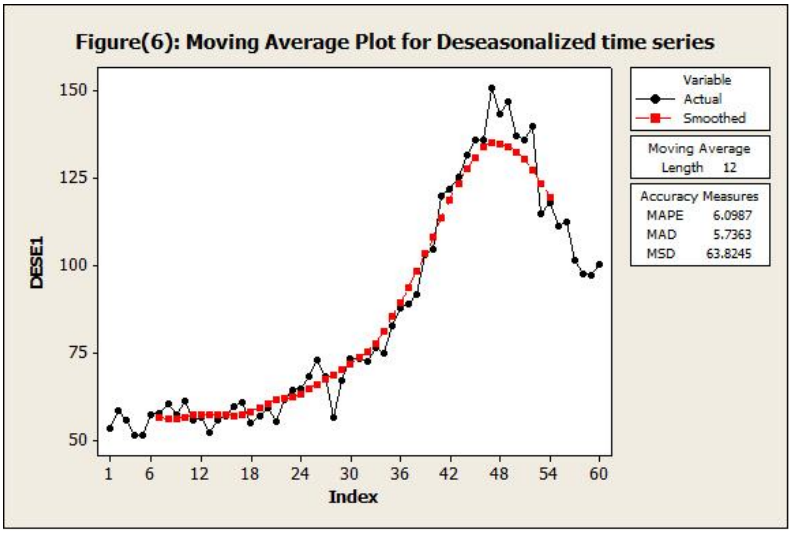
We have 2 methods for doing trend analysis: first, we can use regression analysis by applying the linear model & quadratic model; second, we can use the moving average to estimate the trend.

First: trend analysis using regression



We have fitted a linear & a quadratic trend models for our data. We will choose based on accuracy measures presented in figures 4 & 5. The Mean Absolute Percentage Error (MAPE), Mean Absolute Deviations (MAD) & Mean Square Deviations (MSD) for the linear model are greater than that of the quadratic model, hence quadratic model is better.

Second method is the Moving Average (MA): it uses an average of k = 12 (number of seasons) that reduces short term fluctuations (smoothing the trend). Since k is even, hence there is no predicted trend for the first & last 6 observations (k/2).



Forecasting:

We will estimate the trend needed to generate forecasting by the linear model since this is what is available using the minitab software.

The estimated linear model is: $\hat{y}_t = 39.03 + 1.51*t$

$\hat{B}_0 = 39.03$: the mean price of google stock is 39.03$ holding the time constant.

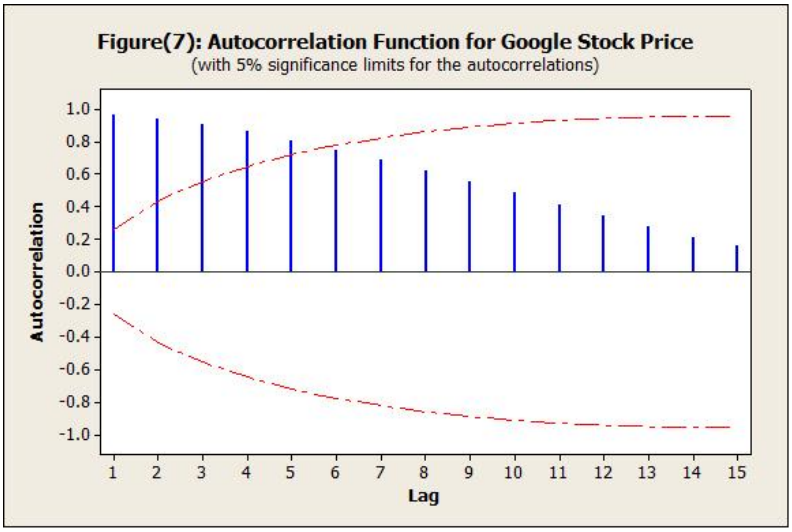
$\hat{B}_1 = 1.51$: as we increase the time by 1 month the average stock price of google increases by 1.51$

Since our model is multiplicative, the forecasts for the year 2023 (table (2)) will be estimated by multiplying the trend by the corresponding seasonal indices (stock price = $\hat{T}_t * S_i$)

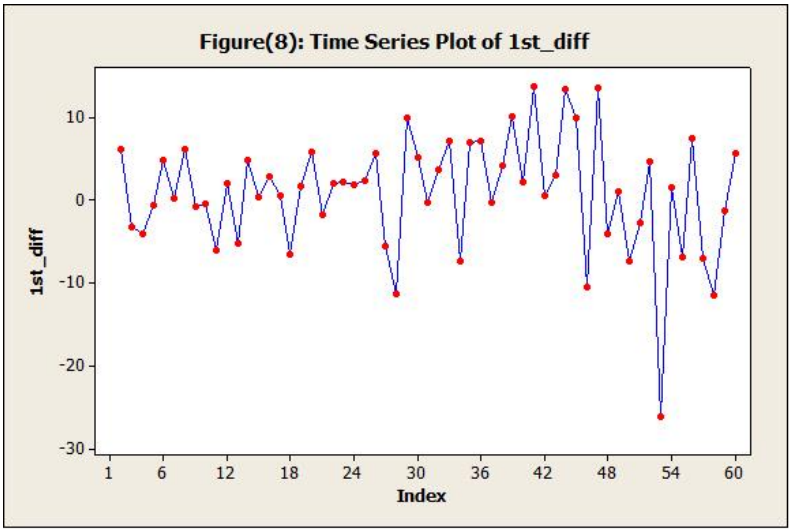
Table(2): Forecasts for google stock price in 2023	
January	129.850
February	133.490
March	133.484
April	135.716
May	135.726
June	135.180
July	136.248
August	145.771
September	153.039
October	143.593
November	143.882
December	148.780

6.Modern Approach:

Stationarity: to apply the modern approach on any time series, it has to be stationary first. Therefore, checking the stationarity is the first step. From figure (1), as we said trend is apparent in the time series plot, hence the time series is not stationary in the mean. By looking at figure (10), the Auto-Correlation function(ACF) dies down slowly. This is another indicator that the time series is not stationary.

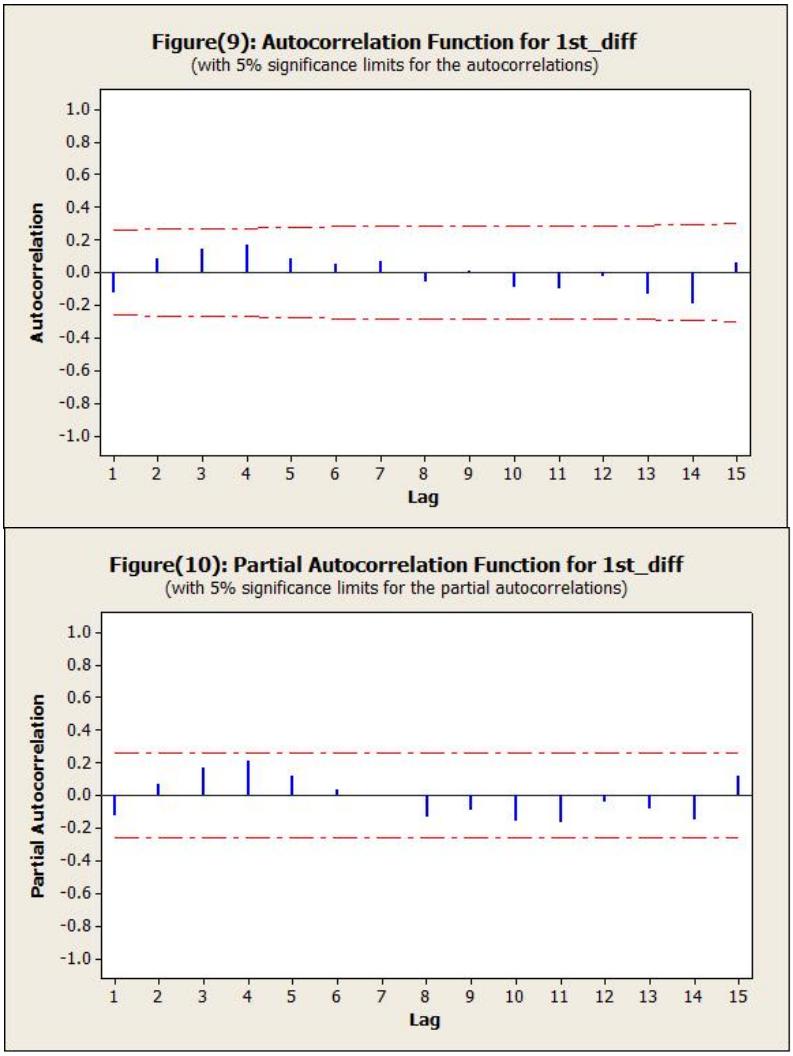


we can take the first difference to transform the time series into a stationary one. After taking the first difference, the majority of the points are fluctuating around the zero line (check figure (11)). Accordingly, the time series loses its trend & becomes stationary. From figure (12), the ACF of the first difference decreases exponentially; this is another basis for stationarity.



ACF & PACF:

Now, we have to check the ACF & Partial Auto-Correlation function (PACF) of the first difference to give us an indication about our initial model for analysis.



from figure (12), ACFs are all zeros.

From figure (13), the PASFs are all zeros as well.

This does not give us much of an indicator for our initial model. Accordingly, we will try different models to find which one fits our data the best.

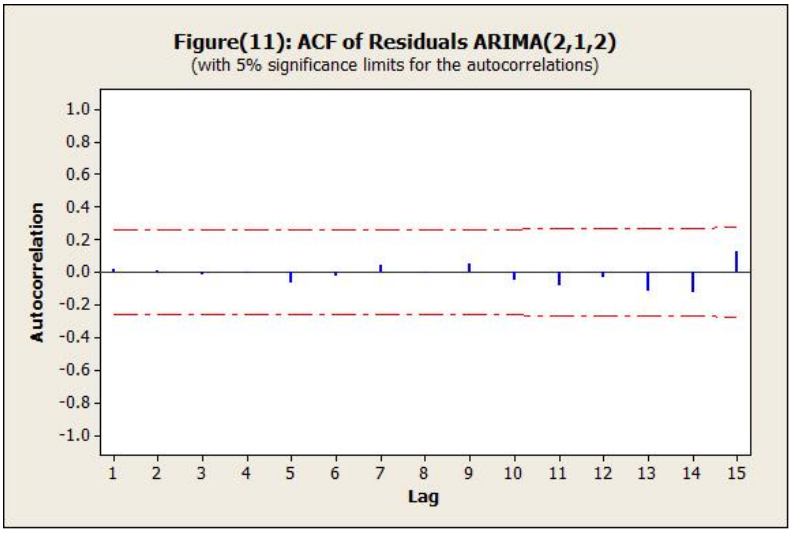
Our initial model is ARIMA (1,1,1)

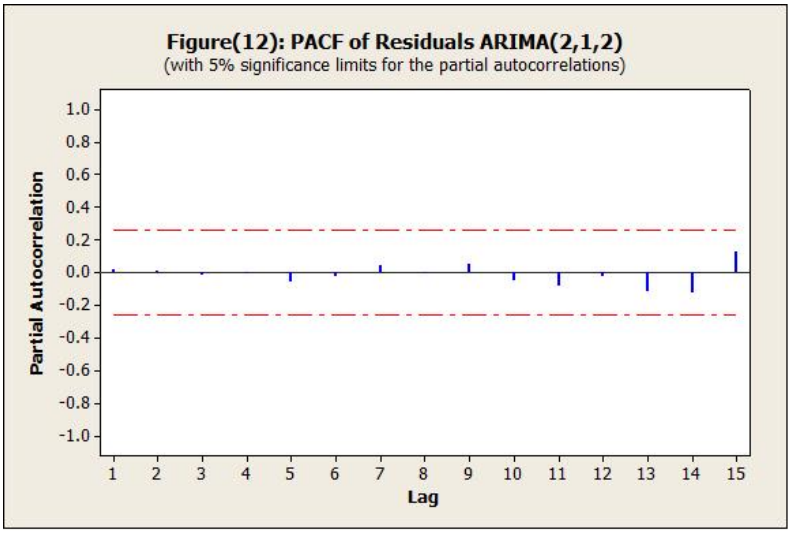
Box & Jenkins Analysis:

The initial model (ARIMA (1,1,1)) fell short, as its parameters Φ & θ are both statistically insignificant (p-value > 0.05). (Check appendix. Table (7)).

After testing multiple models, ARIMA (2,1,2) measured up to the conditions of Box & Jenkins

- **Checking the ACF & PACF of the residuals and making sure they are insignificant.** From figure (14) & (15), the residuals of both the ACF & PACF are statistically insignificant





- **Modified Box-Pierce (Ljung-Box) Chi-Square statistic**.

Table (3): Modified Box-Pierce (Ljung-Box) Chi-Square statistic				
Lag	12	24	36	48
Chi-Square	1.4	10.8	19.3	22.9`
DF	8	20	32	44
P-Value	0.994	0.951	0.962	0.996

From table (3): all the p-values of the lags are greater than 0.05, hence the ACF is zero at all lags & the disturbance term is white noise.

- **Check the significance of the model parameters.**

Table (4): Final Estimates of Parameters ARIMA (2,1,2)					
Type		**Coef**	**SE Coef**	**T**	**P**
AR	**1**	**1.2929**	**0.1418**	**9.11**	**0.000**
AR	**2**	**-0.4893**	**0.1291**	**-3.79**	**0.000**
MA	**1**	**1.6128**	**0.0640**	**25.19**	**0.000**
MA	**2**	**-0.9436**	**0.0649**	**-14.55**	**0.000**

From table (4), all the parameters are statistically significant (p-value < 0.05).

- **Check the stationarity & the invertibility of the model.**

Invertibility: $\theta_1 = 1.6128$, $\theta_2 = -0.9436$, $\theta_1 + \theta_2 = 0.6692$, $\theta_2 - \theta_1 = -2.5564$

Since $-1 < \theta_2 < 1$,
$\theta_1 + \theta_2 < 1$ &
$\theta_2 - \theta_1 < 1$
therefore, the model is invertible.

Stationarity: $\Phi_1 = 1.2929$, $\Phi_2 = -0.4893$, $\Phi_1 + \Phi_2 = 0.8036$, $\Phi_2 - \Phi_1 = -1.7822$

Since $-1 < \Phi_2 < 1$,
$\Phi_1 + \Phi_2 < 1$,
$\Phi_2 - \Phi_1 < 1$
Therefore, the time series is stationary.

After doing the Box & Jenkins analysis for ARIMA (2,1,2), we concluded that it is a good fit for our time series.

Measures of Accuracy for ARIMA (2,1,2):

MAPE: 5.92234

MAD: 4.84820

MSD: 37.8656

Forecasting using ARIMA (2,1,2):

Table(5): Forecasts for google stock price in 2023

		95% Limits		
month	1st Difference Forecast	Lower	Upper	Forecast
January	100.205	87.711	112.699	201.225
February	99.808	84.698	114.918	301.033
March	99.694	82.104	117.283	400.727
April	99.740	78.660	120.820	500.467
May	99.856	74.129	125.583	600.323
June	99.983	68.860	131.106	700.306
July	100.091	63.330	136.852	800.397
August	100.168	57.903	142.433	900.565
September	100.215	52.784	147.645	1000.78
October	100.237	48.054	152.421	1101.017
November	100.244	43.716	156.772	1201.261
December	100.242	39.732	160.751	1301.503

7.Conclusions:

- From the decomposition method, we found that google stock price has an increasing trend & is not affected by seasonality.
- From the modern approach we estimated the time series using ARIMA (2,1,2) as time series is not stationary in mean (has trend). the estimated model is:
  $\hat{y}_t = 1.2929\, y_{t-1} - 0.4893\, y_{t-2} + 1.6128\, \varepsilon_{t-1} - 0.9436\, \varepsilon_{t-2} + \varepsilon_t$

Table(6): Comparing forecasts of decomposition & modern VS Actual for the year 2023

Month	Decomposition	Modern	Actual
January	129.850	201.225	89.59
February	133.490	301.033	98.71
March	133.484	400.727	89.98
April	135.716	500.467	102.39

- The forecasts we obtained from the modern approach are vastly different from those obtained from the decomposition method. Also the forecasts of the modern approach are increasing rapidly each month compared to forecasts of the decomposition method (an increase by a hundred each month)
- Since we have data for the stock prices for the first four months of 2023, therefore, we will use them as a benchmark in the comparison between the forecasts of the decomposition & modern approach. From table (6), we can see that the forecasts of the decomposition method are closer to the actual values than the forecasts of the modern approach. Accordingly, decomposition is a better approach to forecast the prices of google stock.
- The price of Google stock forecasts is very important; they could be used in investment decision making by helping investors make informed decisions like buying, selling or holding the google stock. It also helps in risk management. It gives insights into future financial performance of Google compared to other companies (competitive analysis)

8.APPENDIX

Table (7): Final Estimates of Parameters ARIMA (1,1,)					
Type		Coef	SE Coef	T	P
AR	1	-0.3473	0.9714	-0.36	0.722
MA	1	-0.2288	1.0090	-0.23	0.821

Table (8) : Google Stock Monthly Data from 5/2013 to 4/2023							
	Date	Price	High	Low	Close	Volume	Adj Close
0	5/1/2013	20.6	23.04	20.43	21.8	1974715308	21.8
1	6/1/2013	21.85	22.79	21.2	22.03	1941280776	22.03
2	7/1/2013	22.18	23.22	21.91	22.22	2047770180	22.22
3	8/1/2013	22.4	22.77	21.16	21.19	1338144516	21.19
4	9/1/2013	21.38	22.67	21.37	21.92	1323615060	21.92
5	10/1/2013	22.03	26.06	21.1	25.79	2206771020	25.79
6	11/1/2013	25.82	26.73	25.15	26.52	1049213736	26.52
7	12/1/2013	26.61	28.05	26.25	28.05	1352374272	28.05
8	1/1/2014	27.91	29.69	27.08	29.55	2178287532	29.55
9	2/1/2014	29.51	30.75	28.23	30.42	1620230148	30.42
10	3/1/2014	30.2	30.71	27.58	27.89	1744505748	27.89
11	4/1/2014	28.03	29.42	25.55	26.74	1421285316	26.74
12	5/1/2014	26.71	28.88	25.55	28.58	829136000	28.58
13	6/1/2014	28.49	29.48	27.37	29.23	789784000	29.23
14	7/1/2014	29.38	30.45	28.6	28.98	771666000	28.98
15	8/1/2014	28.93	29.89	28.37	29.12	581574000	29.12
16	9/1/2014	29.15	30.27	28.85	29.42	708502000	29.42
17	10/1/2014	29.34	29.62	25.92	28.39	1109632000	28.39
18	11/1/2014	28.18	28.36	26.96	27.45	595410000	27.45
19	12/1/2014	27.25	27.44	24.86	26.53	1088686000	26.53
20	1/1/2015	26.63	27.27	24.55	26.88	1056926000	26.88
21	2/1/2015	26.72	28.47	26.09	28.13	808386000	28.13
22	3/1/2015	28.35	29.16	27.52	27.74	864144000	27.74
23	4/1/2015	27.74	29.24	26.45	27.44	874900000	27.44
24	5/1/2015	27.53	27.91	26.61	27.27	648434000	27.27
25	6/1/2015	27.44	28.28	26.94	27	704328000	27
26	7/1/2015	27.18	35.67	26.99	32.88	1370858000	32.88
27	8/1/2015	32.88	35.2	29.65	32.39	1106942000	32.39
28	9/1/2015	31.69	34.1	30.89	31.92	871504000	31.92
29	10/1/2015	31.9	37.63	31.56	36.87	1005286000	36.87
30	11/1/2015	36.73	39.15	36.57	38.14	751482000	38.14
31	12/1/2015	38.35	39.93	36.81	38.9	872694000	38.9
32	1/1/2016	38.11	38.46	34.39	38.07	1039984000	38.07
33	2/1/2016	38.56	40.52	34.1	35.86	1352946000	35.86

Table (8) : Google Stock Monthly Data from 5/2013 to 4/2023							
	Date	Price	High	Low	Close	Volume	Adj Close
34	3/1/2016	36.06	38.87	35.2	38.15	853314000	38.15
35	4/1/2016	37.86	39.55	35.16	35.39	933228000	35.39
36	5/1/2016	35.6	37.67	35.2	37.44	682046000	37.44
37	6/1/2016	37.42	37.57	33.63	35.18	839330000	35.18
38	7/1/2016	35.26	40.2	34.95	39.57	653244000	39.57
39	8/1/2016	39.33	40.69	39.25	39.49	577080000	39.49
40	9/1/2016	39.6	40.95	39.17	40.2	630896000	40.2
41	10/1/2016	40.13	41.95	39.81	40.49	707820000	40.49
42	11/1/2016	40.54	40.8	37.18	38.79	967068000	38.79
43	12/1/2016	38.93	41.22	37.67	39.62	687126000	39.62
44	1/1/2017	40.03	43.35	39.84	41.01	736654000	41.01
45	2/1/2017	41.2	42.69	40.6	42.25	529816000	42.25
46	3/1/2017	42.57	43.72	41.22	42.39	691002000	42.39
47	4/1/2017	42.44	46.79	41.73	46.23	574432000	46.23
48	5/1/2017	46.21	49.98	46.04	49.35	707186000	49.35
49	6/1/2017	49.55	50.43	46.48	46.48	881706000	46.48
50	7/1/2017	46.66	50.31	45.77	47.28	838172000	47.28
51	8/1/2017	47.39	47.86	45.93	47.76	656924000	47.76
52	9/1/2017	47.87	48.79	46.23	48.69	592524000	48.69
53	10/1/2017	48.78	53.18	48.1	51.65	737076000	51.65
54	11/1/2017	51.82	54	51.43	51.81	573720000	51.81
55	12/1/2017	51.52	54.32	50.12	52.67	598810000	52.67
56	1/1/2018	52.65	59.9	52.65	59.11	657748000	59.11
57	2/1/2018	58.8	59.37	49.85	55.2	1026814000	55.2
58	3/1/2018	55.48	58.91	49.2	51.86	1042336000	51.86
59	4/1/2018	51.38	54.88	49.71	50.93	984928000	50.93
60	5/1/2018	50.81	55.91	50.39	55	740734000	55
61	6/1/2018	55.64	60.07	55.3	56.46	803684000	56.46
62	7/1/2018	55.77	64.57	55.33	61.36	835654000	61.36
63	8/1/2018	61.96	63.6	60.2	61.59	685718000	61.59
64	9/1/2018	61.13	61.39	57.58	60.35	718518000	60.35
65	10/1/2018	60.65	61.23	50.36	54.53	1130942000	54.53
66	11/1/2018	54.57	55.5	50.11	55.48	786236000	55.48
67	12/1/2018	56.61	56.75	48.88	52.25	857436000	52.25
68	1/1/2019	51.36	56.38	51.12	56.29	697168000	56.29
69	2/1/2019	56.11	57.7	54.68	56.33	652174000	56.33
70	3/1/2019	56.55	61.82	56.51	58.84	663738000	58.84
71	4/1/2019	59.38	64.85	59.15	59.95	647446000	59.95
72	5/1/2019	59.88	59.96	55.17	55.33	742726000	55.33
73	6/1/2019	53.35	56.33	51.35	54.14	712452000	54.14
74	7/1/2019	55.05	63.42	54.77	60.91	715104000	60.91
75	8/1/2019	60.88	61.81	57.14	59.53	586310000	59.53

Table (8) : Google Stock Monthly Data from 5/2013 to 4/2023							
	Date	Price	High	Low	Close	Volume	Adj Close
76	9/1/2019	59.09	62.4	58.19	61.06	517072000	61.06
77	10/1/2019	61.12	64.96	58.16	62.94	603634000	62.94
78	11/1/2019	63.29	66.7	62.99	65.2	528780000	65.2
79	12/1/2019	65.13	68.35	63.85	66.97	559106000	66.97
80	1/1/2020	67.42	75.03	67.32	71.64	673594000	71.64
81	2/1/2020	73.08	76.54	63.41	66.96	830656000	66.96
82	3/1/2020	67.57	70.41	50.44	58.1	1570716000	58.1
83	4/1/2020	56.2	68.01	53.75	67.33	1124224000	67.33
84	5/1/2020	66.2	72.26	64.8	71.68	725130000	71.68
85	6/1/2020	71.29	73.79	67.58	70.9	814160000	70.9
86	7/1/2020	70.96	79.35	70.71	74.4	822998000	74.4
87	8/1/2020	74.55	82.64	73.2	81.48	614564000	81.48
88	9/1/2020	81.61	86.31	70.11	73.28	836634000	73.28
89	10/1/2020	74.18	84.07	71.66	80.81	854920000	80.81
90	11/1/2020	81.18	90.84	80.61	87.72	631912000	87.72
91	12/1/2020	88.33	92.19	84.7	87.63	608630000	87.63
92	1/1/2021	88	96.6	84.81	91.37	791662000	91.37
93	2/1/2021	92.23	107.26	92.23	101.1	678324000	101.1
94	3/1/2021	102.4	105.69	99.7	103.13	756694000	103.13
95	4/1/2021	104.61	121.57	104.57	117.68	702352000	117.68
96	5/1/2021	118.25	119.45	109.68	117.84	603480000	117.84
97	6/1/2021	118.72	123.1	116.48	122.09	544936000	122.09
98	7/1/2021	121.72	138.3	121.53	134.73	610808000	134.73
99	8/1/2021	135.12	145.97	133.32	144.7	461586000	144.7
100	9/1/2021	145	146.25	133.56	133.68	590840000	133.68
101	10/1/2021	134.45	148.65	131.05	148.05	720758000	148.05
102	11/1/2021	148.05	150.97	141.6	141.9	608378000	141.9
103	12/1/2021	144	149.1	139.32	144.85	619694000	144.85
104	1/1/2022	145.05	146.49	124.5	135.3	767206000	135.3
105	2/1/2022	137.59	151.55	124.95	135.06	928126000	135.06
106	3/1/2022	134.88	143.79	125.28	139.07	729162000	139.07
107	4/1/2022	139.5	143.71	112.74	114.11	761152000	114.11
108	5/1/2022	113.4	122.85	101.88	113.76	850450000	113.76
109	6/1/2022	114.86	119.35	105.05	108.96	770754000	108.96
110	7/1/2022	107.93	119.68	104.07	116.32	789529700	116.32
111	8/1/2022	115.3	122.43	107.8	108.22	515852700	108.22
112	9/1/2022	108.28	111.62	95.56	95.65	613278900	95.65
113	10/1/2022	96.76	104.82	91.8	94.51	681488300	94.51
114	11/1/2022	95.45	101.04	83.34	100.99	716522700	100.99
115	12/1/2022	101.02	102.25	85.94	88.23	603127800	88.23
116	1/1/2023	89.59	100.32	84.86	98.84	672897800	98.84
117	2/1/2023	98.71	108.18	88.58	90.06	952580200	90.06

Table (8) : Google Stock Monthly Data from 5/2013 to 4/2023							
	Date	Price	High	Low	Close	Volume	Adj Close
118	3/1/2023	89.98	106.59	89.42	103.73	859911400	103.73
119	4/1/2023	102.39	109.17	101.93	108.87	255598400	108.87

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