STOCK MARKET : FORECASTING & ANALYSIS USING ARIMA

Overview:

We are interested in understanding the growth for the US's top four grocery retail companies; Walmart, Costco, Kroger and Target. The project aims to compare the standing of these retailers by analysing the trends in monthly closing stock prices for these organizations and to predict the future price values using Autoregressive Integrated Moving Average (ARIMA) models for these stock prices.

Methodology:

This section explains the logical steps followed to analyse and predict the stock trends for the above mentioned companies. Following steps are followed in the analysis and forecasting of Walmart, Costco, Kroger and Target monthly closing stock prices.

- Getting the Data: Monthly closing stock prices are collected for the past 15 years for these four companies and stored in a tidy data format which is manipulated for further analysis.
- Exploratory data analysis: Visual analysis of data pattern and central tendency statistics are observed along with a background information for each of these retail players.
- Decomposition: Understanding basic time series components by decomposing it into fundamental time series properties.
- Transforming data: Data is transformed using mathematical techniques to make variance stable,i.e. preparing it for better fits ARIMA models.
- Stationarity and ACF, PACF plots: Determining data stationarity, plotting ACF and PACF plots to get an intuition for ARIMA model parameters.
- Fitting and selecting ARIMA models: Fitting best seasonal ARIMA models (using auto.arima() in R) and evaluating their performance on out of sample data.
- Model features selection, forecasting and diagnostics: Understanding the best ARIMA model for a given company and predicting the stock prices for next three years and performing diagnostic checks on trained models.
- Conclusion and Future work: The predicted stock prices values are compared across these four companies., results and limitations of the model and commenting on the forward path from the project outcomes.

Data Collection and Manipulation: The data for this analysis obtained from Yahoo Finance website [1]. The historical data for Walmart, Costco , Kroger and Target is collected into separate .csv files. Since we are interested in monthly stock closing prices, only closing prices are selected from the historical dataset for individual companies featuring monthly opening, minimum, maximum and closing stock prices. Post filtering the datasets as per monthly closing prices, all four of these datasets are merged to form a final dataset. The final formed dataset features monthly stock closing prices of these four companies from January 2005 to December 2019. The data has been checked for missing values and anomalies, no missing values and anomalies are found in the dataset and data looks ready for analysis.

Hypothesis : The hypothesis for the stock price analysis assumes that closing price for all of these companies will continue to show an upward trend which is an indication of a rising market for the next three years i.e. from 2020 to 2023 without any major dip.

Exploratory data analysis:
In order to juxtapose the monthly stock closing prices for these top four grocery-retail companies, the time series for monthly stock prices is plotted for the years 2005 to 2020.

This plot (on the left) shows the stock price trends for grocery retail giants; Walmart, Costco, Kroger and Target. The Horizontal axis represents time in years and the vertical-axis shows the closing prices of stocks for these retailers. Looking at these trends shown in the plot (plotted on the left) following observations can be made about these companies:

Walmart: The plot shows Walmart stock's growth in the long run, with some significant dips in stock price in August 2015 and August 2018. The overall growth pattern in the closing stock can be expected as it is number one ranked company in the fortune 500 list [2] and has dynamic internal structure that keeps the stock momentum going upwards. The summary statistics of the closing price of Walmart's stocks shows that it attained a maximum of 119.09 USD in November 2019 & minimum of 43.63 in August 2007. The closing price has mean value of 67.12 USD & a median value 64.63 USD of with standard deviation of 19.06 USD.

Costco: It can be seen from the below graph that the overall plot is of increasing nature. The sudden rise of the stock price from 2015 to 2019 was primarily driven by the continuous increase in Total Revenue and net income margin [3]. The summary statistics

of the closing price of Costo's stocks shows that it attained a maximum of 299.81 USD in November 2019 & minimum of 40.63 in April 2005. The closing price has a mean value of 112.56 USD, and median value 97.87 USD of with a standard deviation of 64.47 USD.

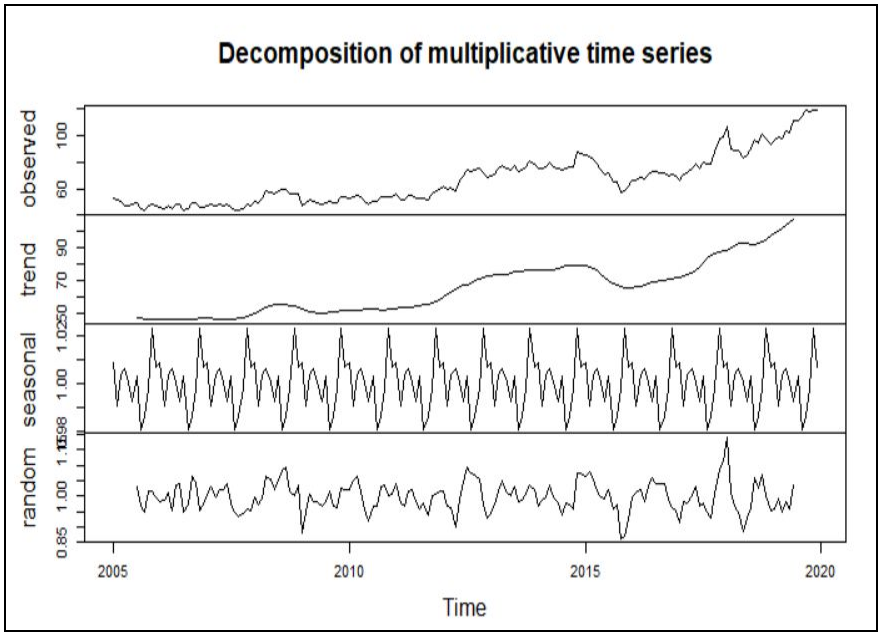
Kroger: As can be observed from the above plot, there is an overall upward trend of the closing price of Kroger. The closing price has increased rapidly from the year 2013 to 2016 & then decreased till 2017. This dip may be due to some internal structure change or due to the acquisition of Wholefood market by Amazon which was announced in the year 2017 [4]. The summary statistics of the closing price of Kroger stocks shows that it attains the maximum of 41.83 USD in December 2015 & minimum of 7.89 in April 2005. The closing price has a mean value of 19.12 USD,& median value of 14.28 USD with a standard deviation of 9.34 USD.

Target: Overall the graph shows an upward trend showing the organization's growth over the years with two major dips in 2008 and 2016 as the discount retail giant struggled to cope with the "rapidly changing" behavior of consumers. Also, failed expansion into the Canadian market produced major losses in 2014 as the data breach sent customer traffic down, forcing the retailers to slash prices to clear inventory. The summary statistics of the closing price of Target's stocks shows that it attained a maximum of 128.21 USD in December 2019 & minimum of 28.31 in February 2009. The closing price has a mean value of 61.86 USD, & a median value of 59.31 USD with a standard deviation of 14.95 USD.

In order to dive further into patterns observed, the stock prices trends are observed by decomposing the time series into basic components; trend, seasonality and residuals. On observing the above plot (Stock closing price trend from 2005 to 2020), it can be said that seasonal patterns seem to be multiplicative in nature hence multiplicative decomposition of time series is performed to understand these patterns.

Decomposition: Multiplicative decomposition is carried out to understand the hidden patterns in the time series for stock prices of above-mentioned organisations. The decomposed time series for Walmart stock's closing prices are shown below (the decomposition plots for Costo, Kroger's and Target are shown in Appendix A). Following observations can be made about this time series data by looking at the corresponding decomposition plot:

1. **Trend:** The overall time series shows an increasing trend. Thus, in the long run, the closing stock price tends to increase with time.
2. **Seasonality:** The decomposition shows multiplicative seasonality, observations from the seasonal component of the plot indicate some yearly seasonal patterns in stock closing data.
3. **Random:** These values seem to distribute around zero, with non-fixed variance values. The variance can be brought to a constant value by smoothening the series using logarithmic or box-cox transformations.



To better fit the ARIMA models, various time series of transformed and original data are used to forecast the future values. Most common transformations such as l**ogarithmic** and **square-root** are applied to smoothen the data. The performances of best ARIMA (done using **auto.arima()** in **R**) models are used to select the combination of ARIMA model and transformation to be used to forecast the future values.

Before exploring the fitted and forecasted data using ARIMA models, let us understand the basic working of ARIMA models, associated assumptions and parameters, as explained below.

ARIMA model:

ARIMA stands for Autoregressive Integrated Moving Average. The model's goal is to predict future patterns in time series data by examining the differences between values in the series instead of through actual values. An ARIMA model can be understood by outlining each of its components as follows:

- *Autoregression (AR)* refers to a model that shows a changing variable that regresses on its own lagged, or prior, values. It is a form of regression analysis that gauges the strength of one dependent variable relative to other changing variables.
- *Integrated (I)* represents the differencing of raw observations to allow for the time series to become stationary, i.e., data values are replaced by the difference between the data values and the previous values.
- *Moving average (MA)* incorporates the dependency between an observation and a residual error from a moving average model applied to lagged observations.

Assumptions of ARIMA model

ARIMA model can only be generalized if the assumptions of the ARIMA model are met, these assumptions are explained below:

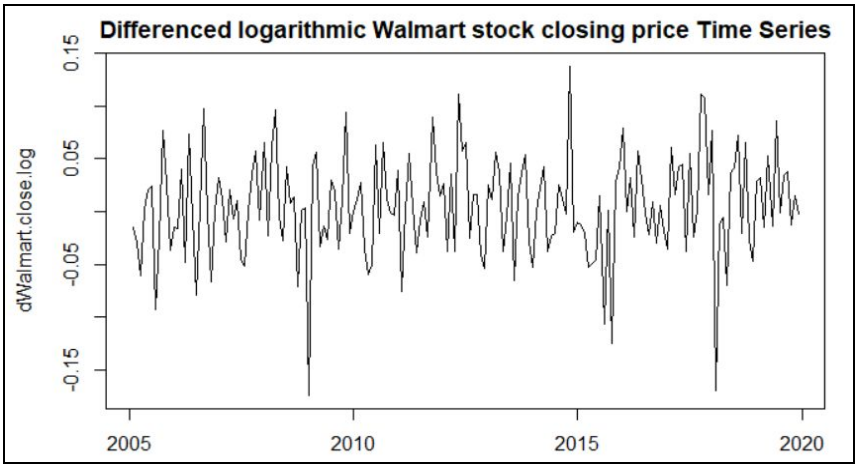
- Data should be univariate
- Data must be stationary i.e. the properties of the series must not depend on the time when it is captured. A series with cyclic behavior and white noise series can also be considered as stationary series.

Since the stock closing prices for each company mentioned form a univariate series the first assumption of univariate series is met. The stationarity of data is checked visually and statistically by plotting and performing ADF tests respectively.

Stationarity:

Stationarity is the basic assumption for ARIMA models, and it represents the stability in measures of central tendency for a given time series. The ADF test results *(p-value >0.05)* for the original and transformed series (for all four companies) show that these series are non stationary (refer Appendix B for results of ADF for all time series).

In order to make series stationary differenced series with unit lag are created, and ADF tests and time series plots for these series are visualized. The plot for differenced logarithmic Walmart stock closing price series is shown below. From the plot shown below (mean centered around zero with approximately fixed variance) and ADF test results (*Dickey-Fuller statistic = -6.1784 and p-value < 0.01*)**,** It can be said that stationarity is achieved by differencing with unit lag. Similar claims can be made about all the time series taken into consideration, results of which can be assessed form the Appendix B.

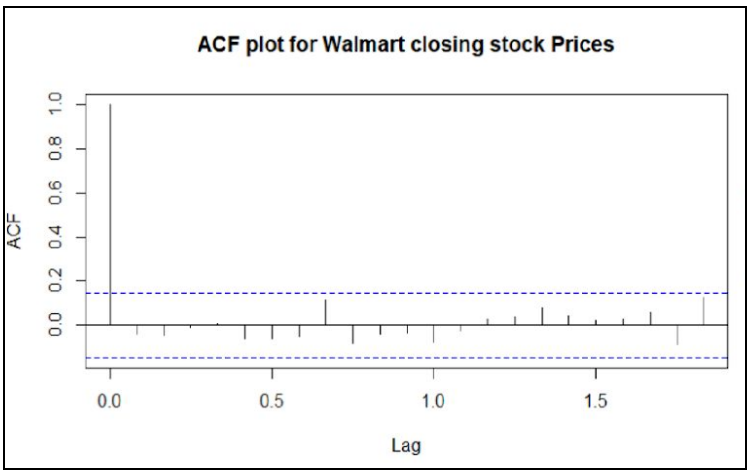


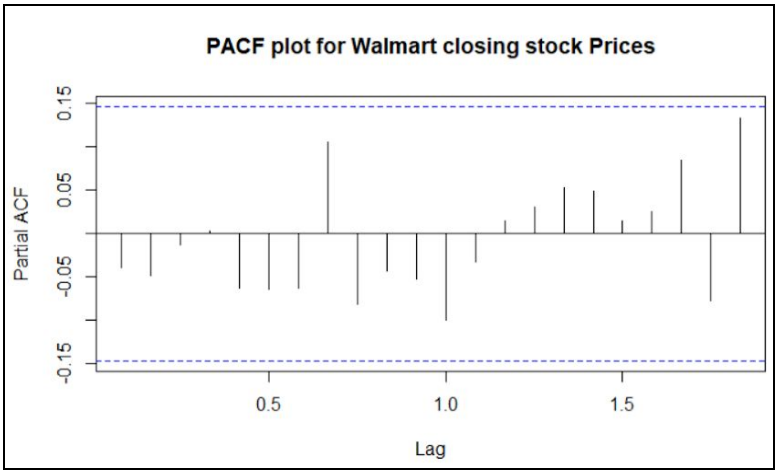
Parameters of ARIMA model: There are 6 main parameters associated with the ARIMA model. These can be divided into non-seasonal (p, d and q) and seasonal components (P, D, Q). P and p corresponds to the autoregressive part , d and D refers to differencing and integrating parts and q and Q corresponds to moving average parts. Autoregressive parameters can be predicted from significant lag values in partial autocorrelation plots, d and D are calculated by counting number of lags to make series general and season trend stationary, and Moving average parameters are calculated by looking at significant lags from autocorrelation plots. The intuition for these parameters for Walmart stock data is described using ACF and PACF plots.

ACF and PACF plots for stationary Walmart data and ACF and PACF plots for Walmart seasonality are shown below. The similar plots observed for Costco, Krogger and Target data as well and are exhibited in Appendix C.

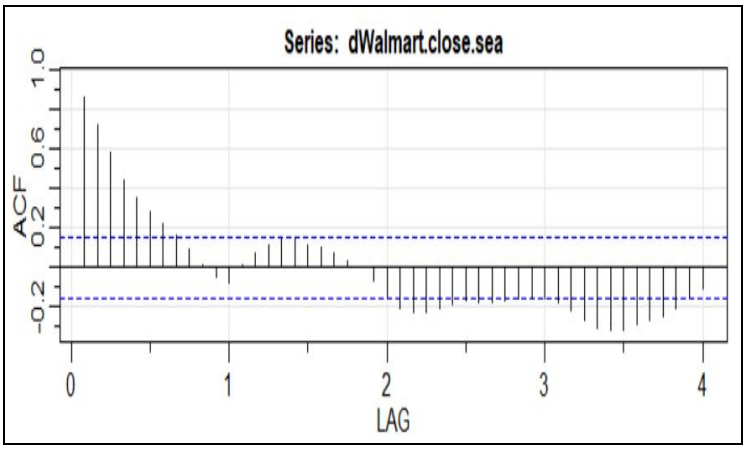
A seasonal ARIMA model is classified as an ARIMA (p,d,q) x (P,D,Q)S model, where P = number of seasonal autoregressive (SAR) terms, D = number of seasonal differences, Q = number of seasonal moving average (SMA) terms. S is the time span in a seasonal trend; for example, if we have S = 12, this means we are looking at monthly data.

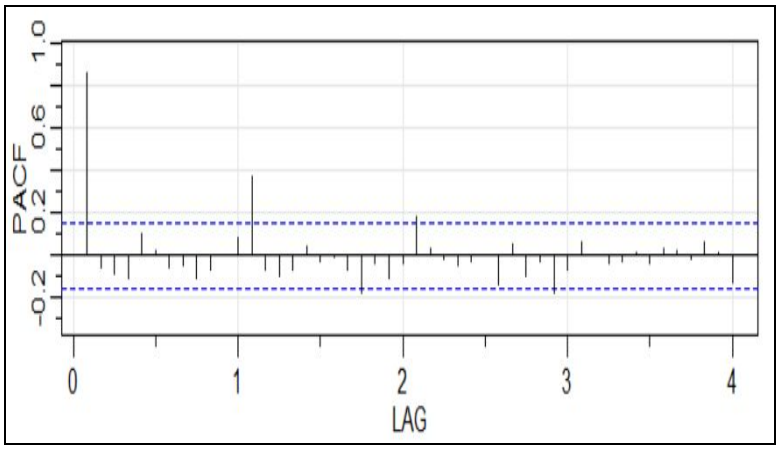
ACF plot and PACF Plots:





ACF and PACF plots for seasonality:





From the above stationarity tests, and ACF and PACF plots, the parameters for ARIMA model can be predicted as :

P,p: Looking at observations from PACF and Seasonal PACF plots, it is observed that no value (other than 0 lag) crosses significance line of |0.175| ,therefore the p and P values for this ARIMA model can be predicted as 0. **D,d**: The stationarity is obtained after the first lag difference time series *(-ve Dickey fuller statistic , p-value <0.05)*, thus d value for the ARIMA models can be predicted as 1. Similarly the institution for D can also be formed. **Q,q**: Looking at observations from ACF plot and Seasonal ACF plots (*no value, other than zero lag crosses significance line of |0.175|*), thus the q and Q values for the ARIMA model can be predicted as 0.

Fitting the ARIMA model

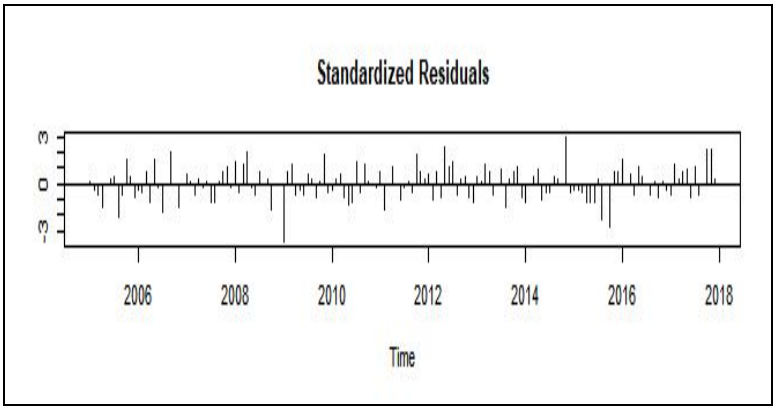
In order to fit the ARIMA model on the Stock closing prices,the time series data is split into two parts; training data and validation data. The training data features time series of closing stock price entries from January 2005 to December 2017, whereas validation data consists 24 month data from January 2018 To December 2019.Transformed (Logarithmic and square root) and original time series data is fitted to the ARIMA model using **auto.arima()** function and best models (**Lowest AIC value**) featuring seasonality components are considered. The performance of these ARIMA models is evaluated on validation data by calculating root mean square error, the model which performs best on validation data is used to forecast the closing stock prices for these companies. The AIC statistic associated with the exhaustive list of models is shown in Appendix D. The best models as per the **RMSE** (refer Appendix E for RMSE table) are explained below for each of these four companies.

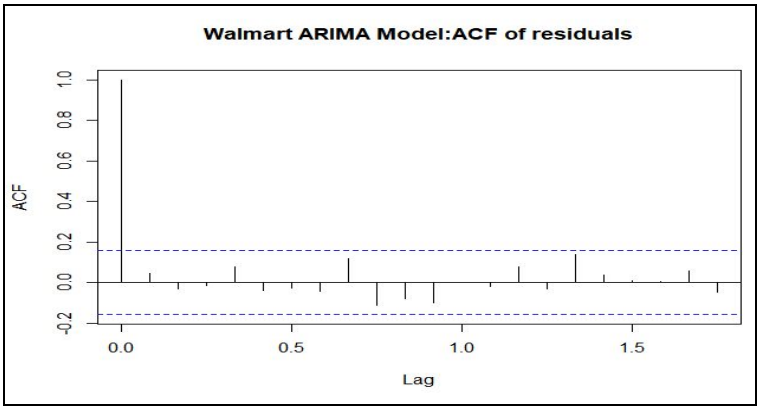
ARIMA Model for Walmart:

The best seasonal model for trend prediction for Walmart stock closing prices is obtained by using a log transformed series with ARIMA models as **"ARIMA (0,1,0)(0,0,1)[12]" (i.e p=0, d=1, q=0, P=0, D=0,Q=1, seasonal frequency= 12) with drift.** This model is chosen based on the lowest RMSE of 9.37 on validation data. Refer Appendix D for the recorded ARIMA model observations for original and transformed series. The result of Box-Ljung test (*X-squared = 8.2792, df = 12, p-value = 0.7629;* Null Hypothesis: residuals are independent) on model shows (*p-value > 0.05*) independence of residuals (refer Appendix F for residual plots), thus model can be generalized to predict future values. The model coefficients, estimated sigma squared values and log likelihood values are shown in the table I, along with the prediction plots for these four companies exhibiting forecasted stock prices for next three years. The diagnostics plots for checking residuals independence & homoscedasticity of Walmart ARIMA model are shown below (refer Standardized Residuals vs Time and Walmart ARIMA Model: ACF of residuals vs Lag plot).

ARIMA Model for Costco:

The best seasonal model for trend prediction for Costco stock closing prices is obtained by using a log transformed series with ARIMA models as **"ARIMA(0,1,0)(2,0,0)[12]" (i.e p=0, d=1, q=0, P=2, D=0,Q=0, seasonal frequency= 12) with drift.** This model is chosen based on the lowest RMSE of *37.72* on validation data. The result of Box-Ljung test (*X-squared = 13.182, df = 12, p-value = 0.356*; Null Hypothesis: residuals are independent) on model residuals show (*p-value > 0.05*) independence of residuals (refer Appendix F for residual plots), thus model can be generalized to predict future values.The model coefficients (along with standard error) ,estimated sigma squared values and log likelihood values are shown in the table 1.





ARIMA Model for Kroger:

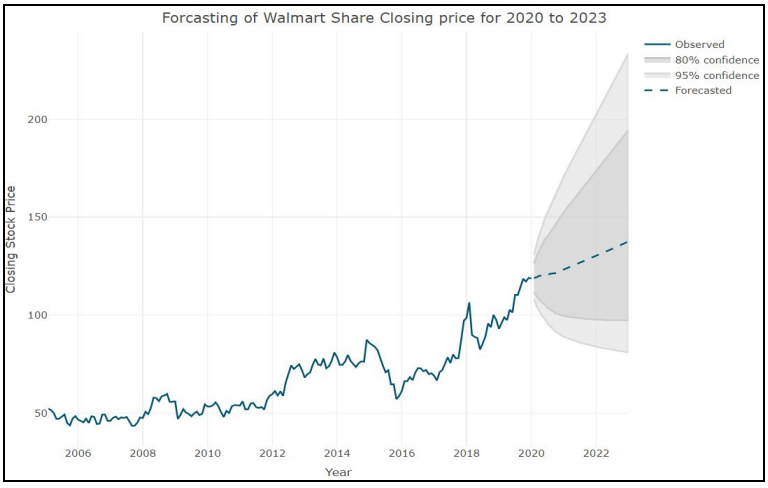
The best seasonal model for trend prediction for Kroggers stock closing prices is obtained with ARIMA model on original data as **"ARIMA(0,1,0)(0,0,1)[12]" (i.e p=0, d=1, q=0, P=0, D=0,Q=1, seasonal frequency= 12) with drift.** The model is chosen based on the lowest RMSE of 3.60 on validation data. The result of Box-Ljung test *(X-squared = 7.7518, df = 12, p-value = 0.8042*; Null Hypothesis: residuals are independent) on model shows (*p-value > 0.05*) independence of residuals (refer Appendix F for residual plots), thus model can be generalized to predict future values.The model coefficients (along with standard error) ,estimated sigma squared values and log likelihood values are shown in the table 1.

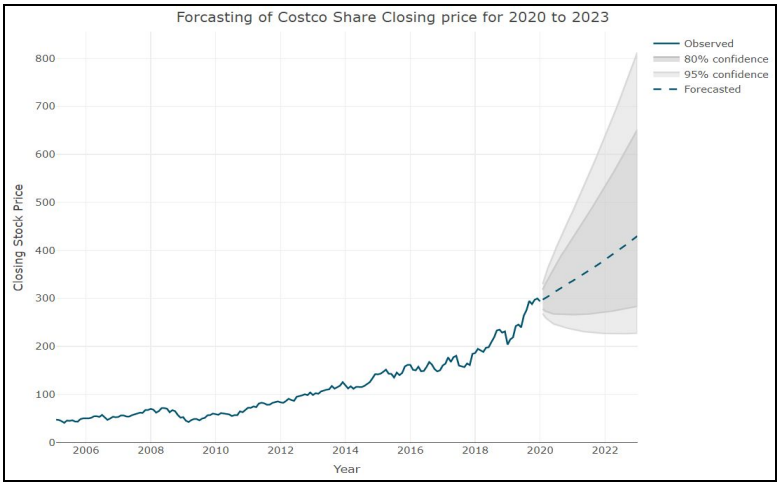
ARIMA Model for Target:

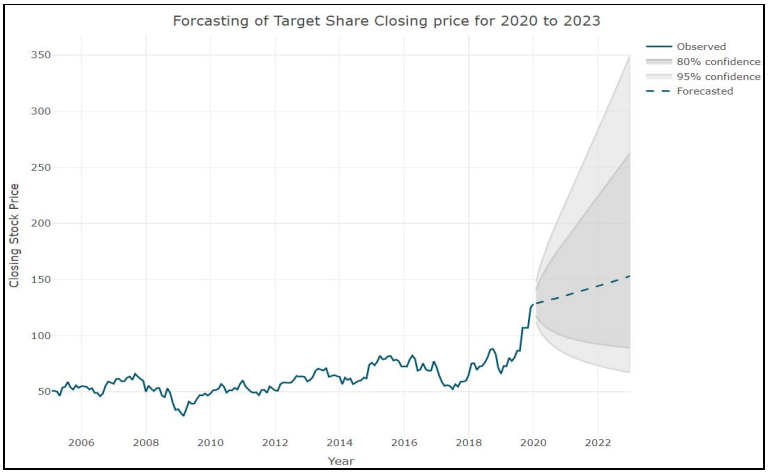
The seasonal best model for trend prediction for Target stock closing prices is obtained with ARIMA model as **"ARIMA(0,1,0)(0,0,1)[12]" (i.e p=0, d=1, q=0, P=0, D=0,Q=1, seasonal frequency= 12) with drift.** This model is chosen based on the lowest RMSE of *24.97* on validation data. The result of Box-Ljung test (*X-squared = 19.38, df = 12, p-value = 0.08*; Null Hypothesis: residuals are independent) on model shows (*p-value > 0.05*) independence of residuals (refer Appendix F for residual plots), thus model can be generalized to predict future values.The model coefficients (along with standard error) ,estimated sigma squared values and log likelihood values are shown in the table 1.

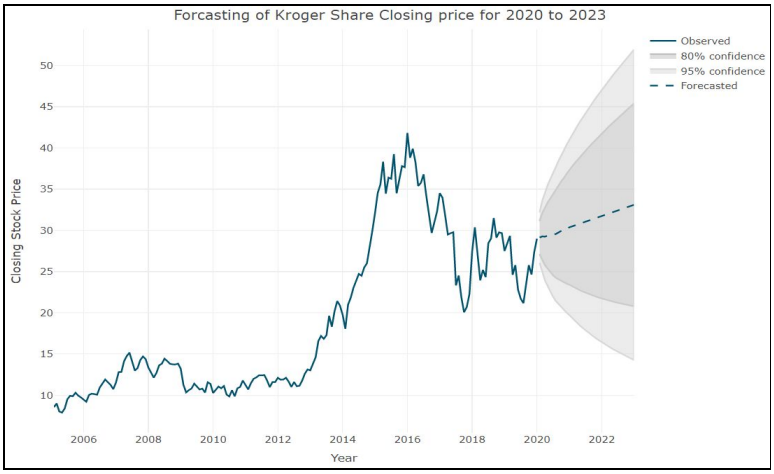
Series	ARIMA Model	Coefficients				Estimated Sigma-square	Log Likelihood
		SMA 1 (SE)	SAR1 (SE)	SAR2 (SE)	Drift (SE)		
Walmart Log Transformed	(0,1,0)(0,0,1)[12]	-0.07 (.09)	-	-	0.00 (.00)	0.002	254.31
Costco Log Transformed	(0,1,0)(2,0,0)[12]	-	0.03 (.09)	- 0.03 (.09)	0.01 (.00)	0.003	236.07
Kroger	(0,1,0)(0,0,1)[12]	0.09 (.07)	-	-	0.11 (.12)	2.017	-273.34
Target Log Transformed	(0,1,0)(0,0,1)[12]	0.02 (.08)	-	-	0.00 (.01)	0.005	196.67

Table 1: ***(SMA : Seasonal Moving Average, SAR: Seasonal Autoregression and SE: Standard error)***









The diagnostics for residuals independence, normality and homoscedasticity for all Costco, Kroger and Target are performed using Ljung-Box tests and residual plots shown in Appendix F and can be used as a basis to generalize the model results.

Table 2 : Prediction of stock price and growth

Company	Closing Stock Price						%Growth
	Stock Price on Dec 2019	Stock price predicted on Dec 2022	80% CI of predicted price		95% CI of predicted price		
			Lower	Upper	Lower	Upper	
Walmart	118.84	137.63	97.37	194.54	81.08	233.64	15.81
Costco	293.92	429.81	283.48	651.66	227.42	812.28	46.23
Kroger	28.99	33.1	20.78	45.41	14.27	51.93	14.17
Target	128.21	153.09	89.17	262.8	66.98	349.84	19.4

The table 2 (in the left) shows forecasted values for four retail giants from January 2020 to December 2022 with 80% and 95% confidence intervals. It can be clearly seen from Table 2 that Costco Wholesale Corporation stands out from the competition and is expected to surge by 46.2% in the next two years. Costco has been able to create a niche for itself on the back of growth strategies, better price management, strong membership trends and increasing penetration of e-commerce business [2]. On the other hand, the percentage growth of related corporations like Walmart and Target by the end of 2022 is predicted to 15.8% and 19.4% respectively which is much less than Costco. Taking into consideration the overall turnover of Kroger Corporation, its stock price has been showing better rising tendency with estimated percentage growth of 14.2% in next two years.

Conclusion:

Following points can be concluded from the above analysis performed & predictions generated:

1. The project uses the ARIMA model to decide which corporation's business among Walmart, Costco, Kroger and Target is growing. The designed model can be generalised to make future predictions which was verified while performing diagnostics of the model.
2. Based on forecasted values for the next three years, it can be said that all four retail chains will continue to grow over the long term as the stock prices and the hypothesis is tested to be true. However, the current consensus is to buy stock in Costco Wholesale Corporation which is a worthy investment.
3. The decreasing order of forecasted stock with 80% CI for Dec 2022 is: **Costco > Walmart > Kroger** (forecasted Target stock prices share 80% CI overlap with Costo and Walmart and hence we can not comment on its relative position with respect to Costo and Walmart).

Future work:

- As future work, it will be interesting to explore patterns between trading days or months which could be exploited for trading.
- The ARIMA model used in this project works with univariate data only. It will be striking to work with another group of statistical approaches which usually utilize multiple input variables such as Linear Discriminant Analysis (LDA), Quadratic Discriminant Analysis (QDA), and regression algorithms to extend this project.
- Also, volume measures the number of shares traded in a stock or contracts traded in futures or options and is an indicator of market strength. It is yet another significant parameter that can be used in future stock analysis. Along with this price-to-earnings ratio, or P/E ratio, can also be taken into consideration that helps to determine whether stock is a good investment or not.
- Future works can also deal with external factors such as COVID-19 pandemic in order to make better and extensive predictions regarding stock prices.

References:

1.https://ca.finance.yahoo.com/

2.https://fortune.com/fortune500/

3.https://www.forbes.com/sites/greatspeculations/2019/08/23/costco-why-did-the-stock-double-in-4-years/#31fb26464fc1

4. https://www.fool.com/investing/2017/07/05/why-the-kroger-co-stock-plunged-217-in-june.aspx

5. https://datascienceplus.com/time-series-analysis-using-arima-model-in-r/

6. https://www.udemy.com/course/r-applied-time-series-analysis-forecasting-r-projects-r-tutorials/

7. https://www.investopedia.com/

8. http://www.businessdictionary.com/definition/time-series.html

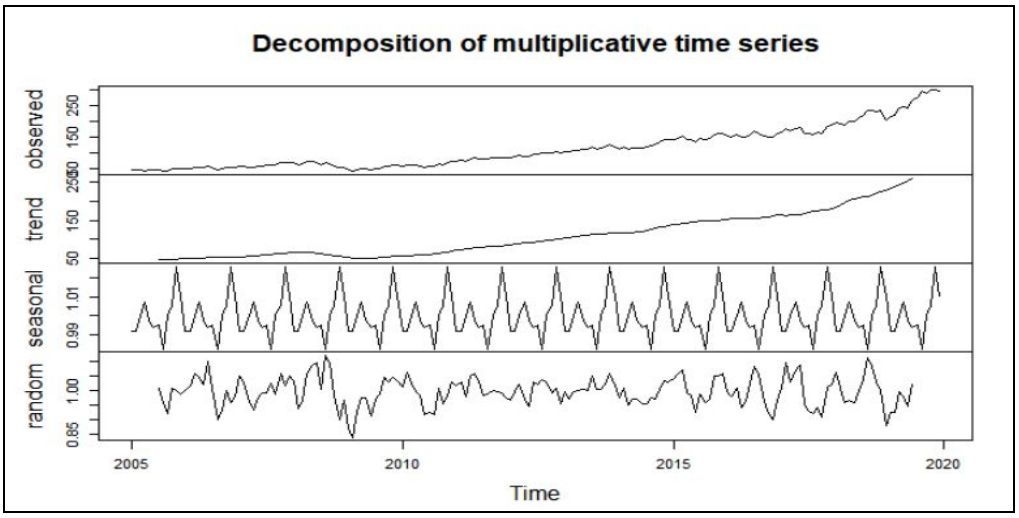
9. https://www.emathzone.com/tutorials/basic-statistics/components-of-time-series.html

10. https://towardsdatascience.com/almost-everything-you-need-to-know-about-time-series-860241bdc578

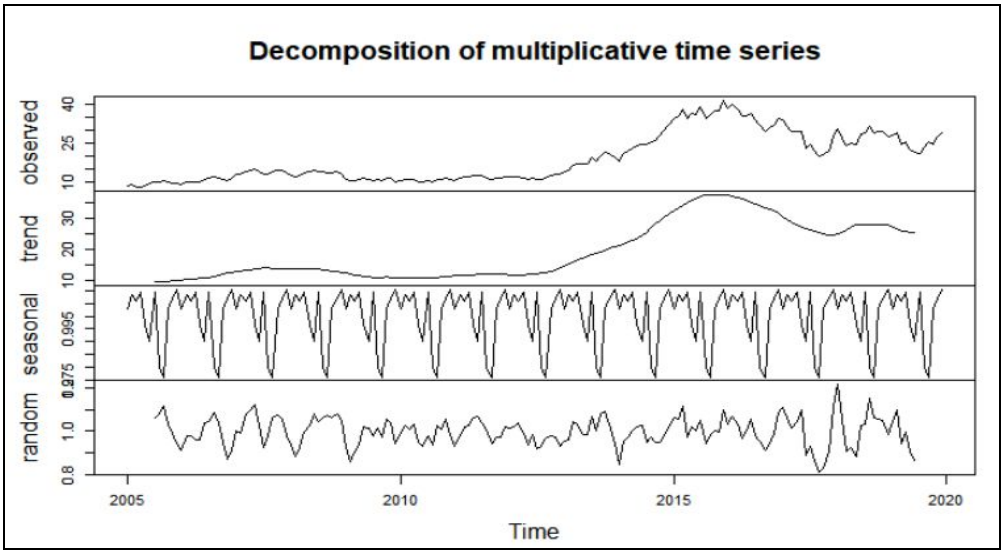
11. https://robjhyndman.com/hyndsight/cyclicts/

Appendix A
Decomposition of Time series data

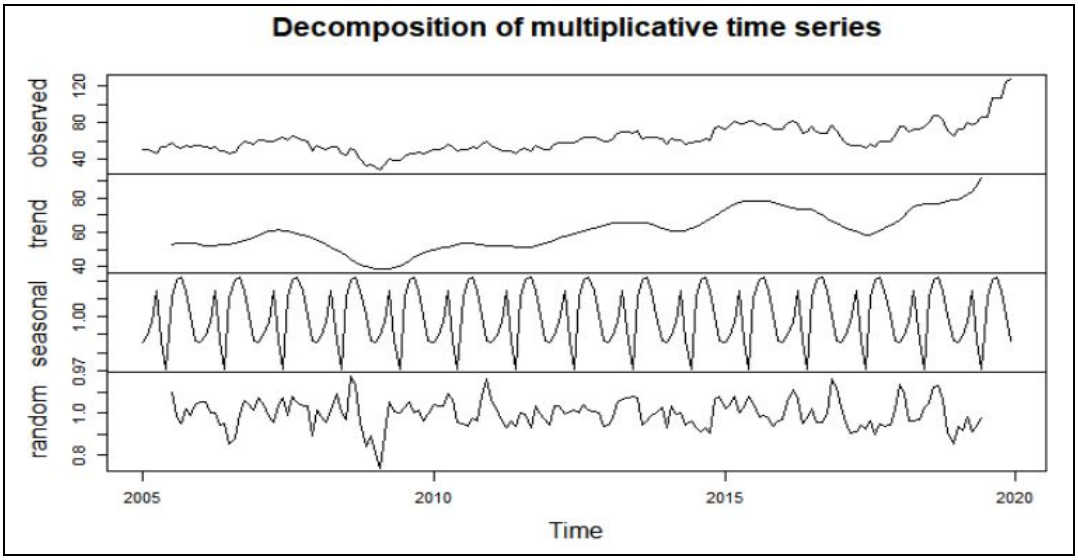
Costco



Kroger



Target



Appendix B
Stationarity tests and plots

(a) Dickey-Fuller test (for stationarity)

Walmart

Data	Test statistic	p- value
Original data	-1.5577	0.7611
Log transformed data	-2.6021	0.3246
Sqrt transformed data	-2.1204	0.5259
Differenced original data	-6.5094	0.01
Differenced log data	-6.1784	0.01
Differenced sqrt data	-6.352	0.01

Costco

Data	Test statistic	p- value
Original data	0.19594	0.99
Log transformed data	-2.5145	0.3612
Sqrt transformed data	-1.1718	0.9085
Differenced original data	-8.2117	0.01
Differenced log data	-6.3764	0.01
Differenced sqrt data	-7.4732	0.01

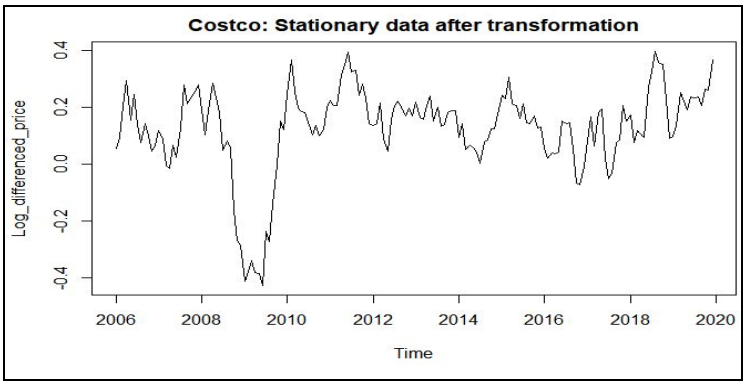
Kroger

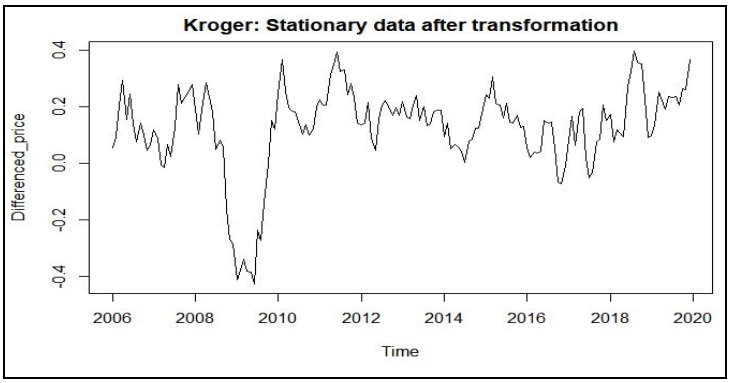
Data	Test statistic	p- value
Original data	-1.7908	0.6637
Log transformed data	-1.6497	0.7226
Sqrt transformed data	-1.7042	0.6998
Differenced original data	-5.039	0.01
Differenced log data	-5.2254	0.01
Differenced sqrt data	-5.0958	0.01

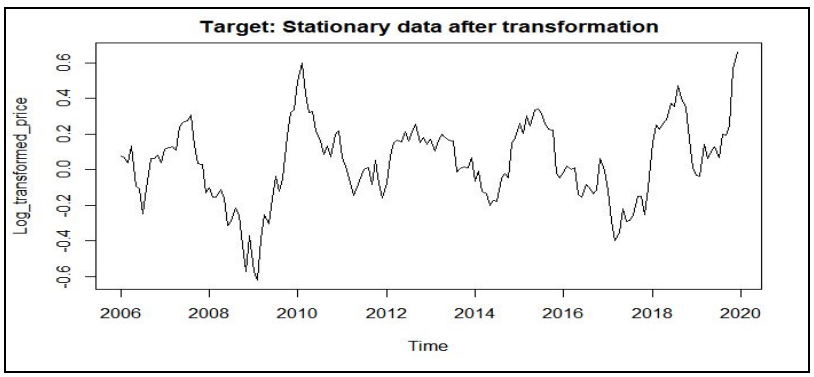
Target

Data	Test statistic	p- value
Original data	-1.5944	0.7457
Log transformed data	-2.5452	0.3484
Sqrt transformed data	-2.1267	0.5233
Differenced original data	-5.1788	0.01
Differenced log data	-6.1739	0.01
Differenced sqrt data	-5.7555	0.01

(b) Stationary Plots



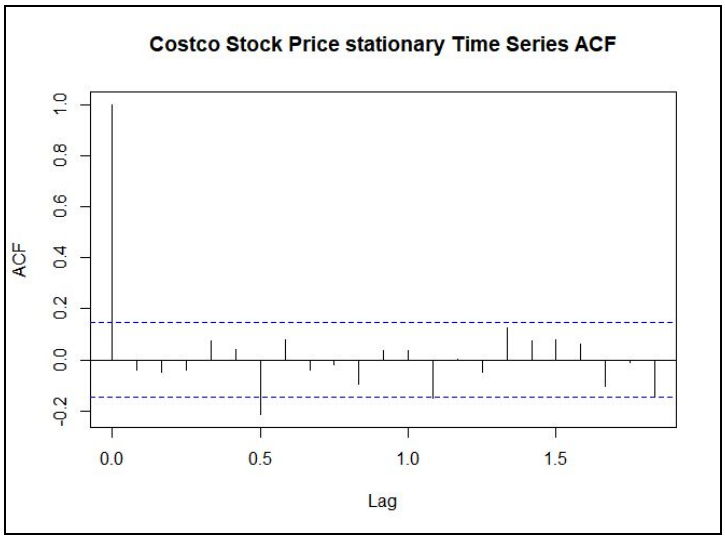


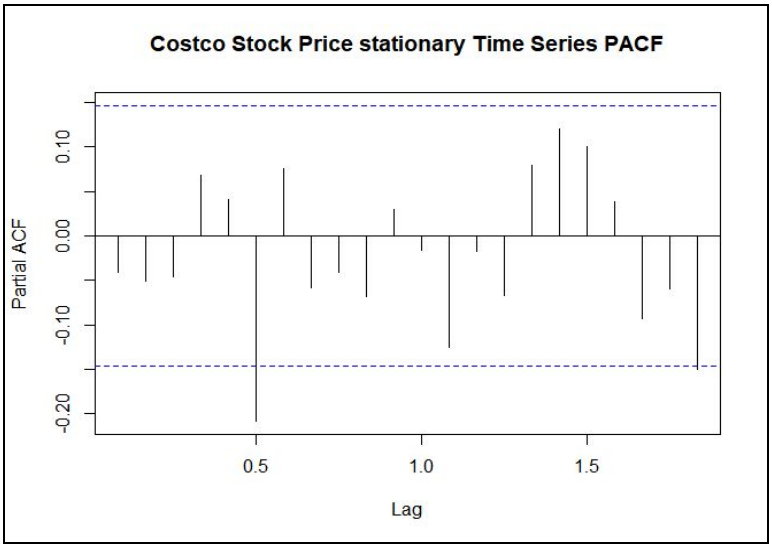


Appendix C
ACF & PACF (with seasonal ACF & PACF) Plots

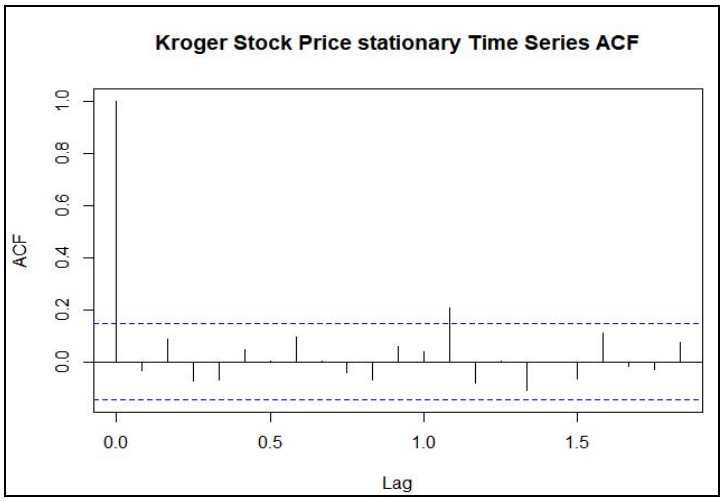
A. ACF, PACF plots for best models (Costco, Kroger and Target)

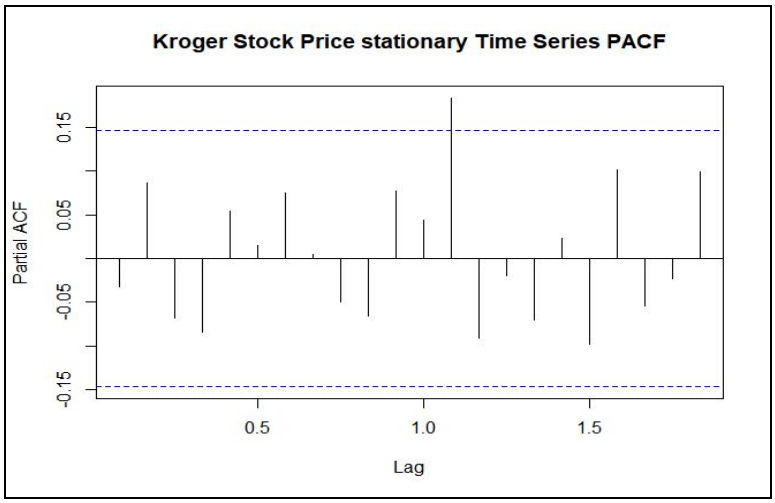
(a) Costco Plots for ACF & PACF (to find p & q)



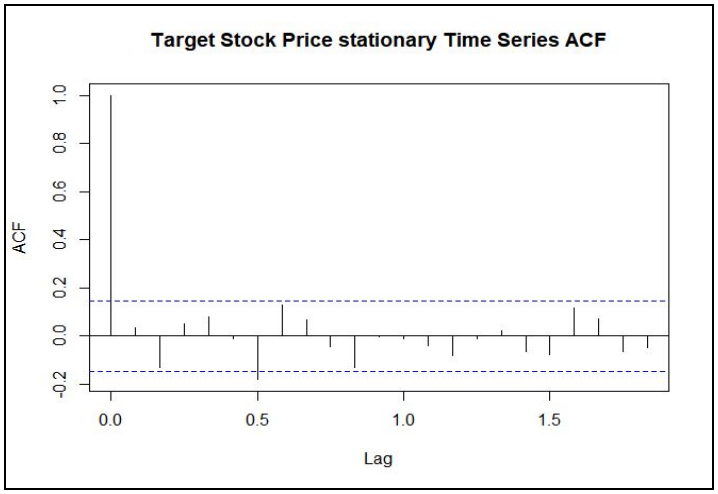


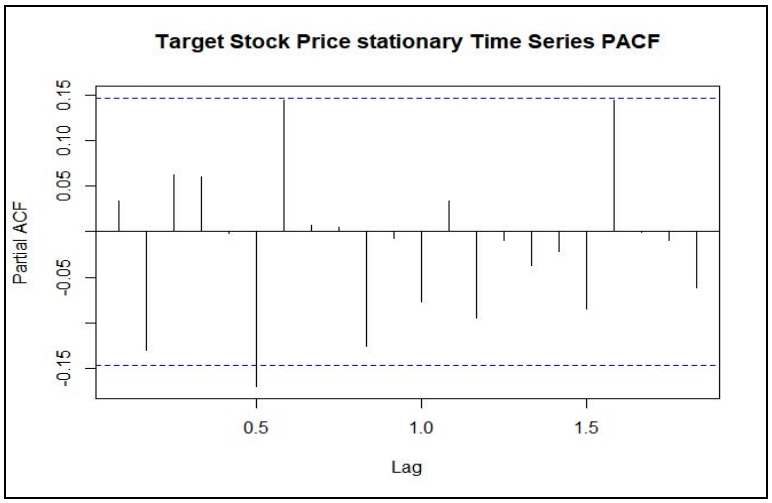
(b) Kroger Plots for ACF & PACF (to find p & q)





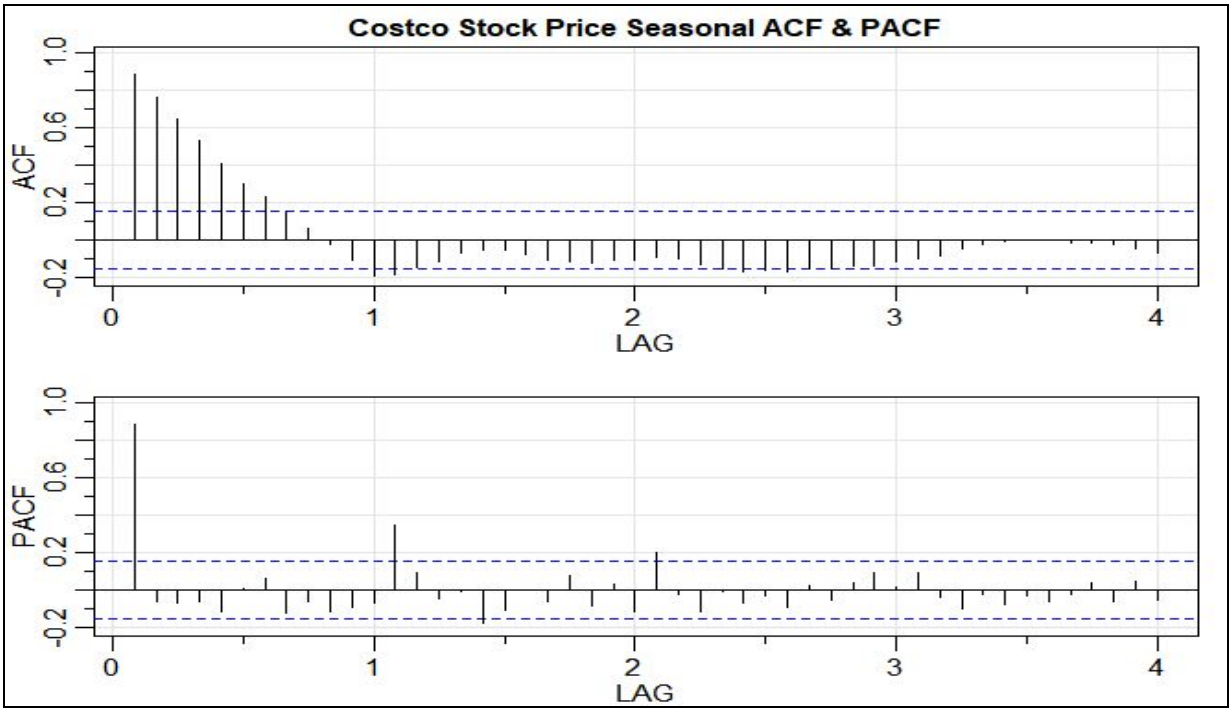
(c) Target Plots for ACF & PACF (to find p & q)



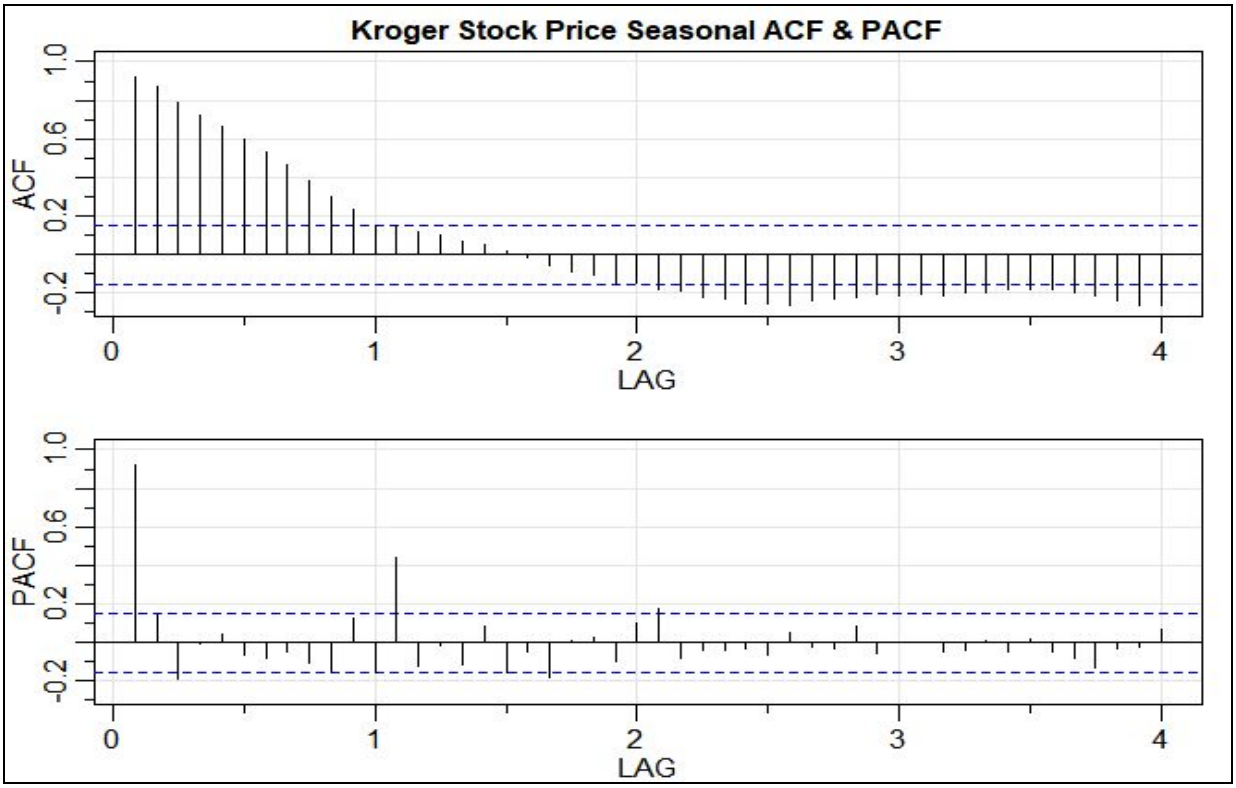


B. SEASONAL ACF, PACF plots for best models (Costco, Kroger and Target)

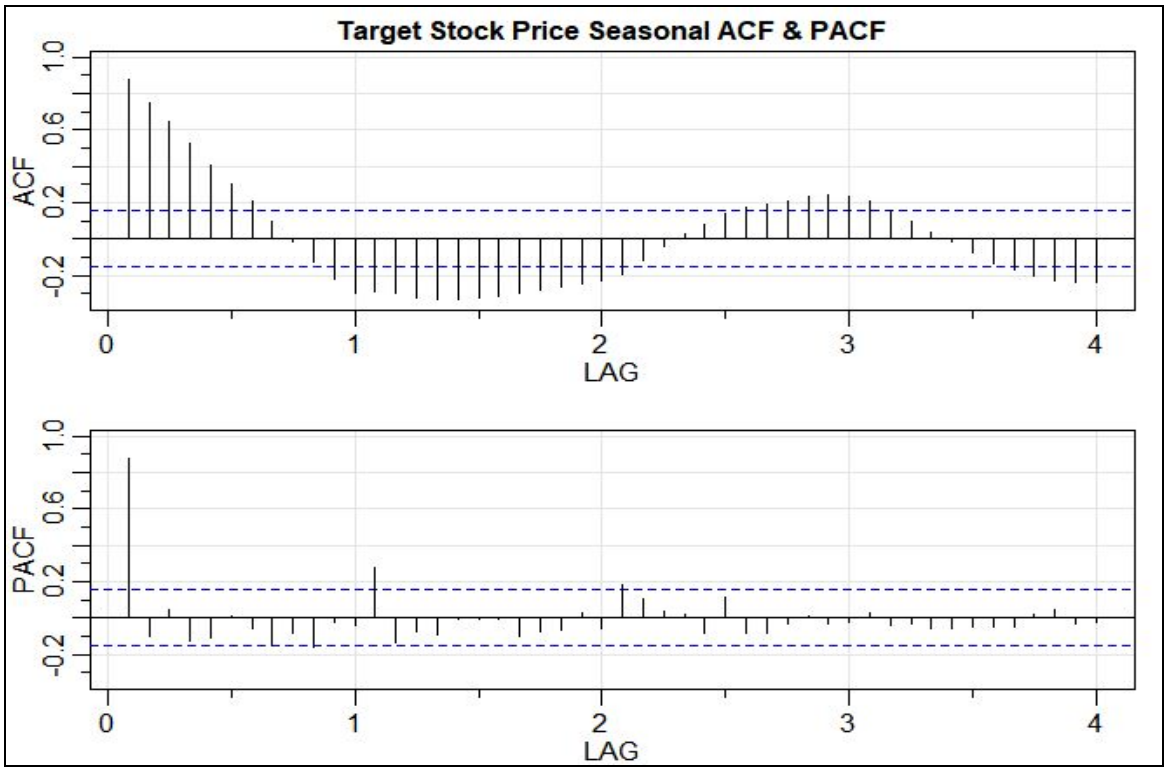
(a) Costco Plots for Seasonal ACF & PACF (to find P & Q)



(b) Kroger Plots for Seasonal ACF & PACF (to find P & Q)



(c) Target Plots for Seasonal ACF & PACF (to find P & Q)



Appendix D

Auto ARIMA Results

A. Auto.arima() models AIC values - For Best Transformation and seasonal

Walmart

Walmart Results for Auto ARIMA on Log-transformed data (seasonal components with drift)	p	d	q	P	D	Q	AIC
	2	1	2	1	0	1	Inf
	1	1	0	1	0	0	-492.54
	0	1	1	0	0	1	-494.27
	0	1	0	1	0	1	-495.42
	0	1	0	0	0	1	-496.37*
	0	1	0	1	0	1	-494.36

Costco

Costco Results for Auto ARIMA on Log-transformed data (seasonal components with drift)	p	d	q	P	D	Q	AIC
	2	1	2	1	0	1	Inf
	1	1	0	1	0	0	-460.11
	0	1	1	0	0	1	-458.18
	0	1	0	1	0	0	-463.06
	0	1	0	2	0	0	-465.47*
	0	1	0	2	0	1	-463.49
	0	1	0	1	0	1	-461.11
	1	1	0	2	0	0	-462.34
	0	1	1	2	0	0	-463.43
	1	1	1	2	0	0	-460.43

Kroger

Kroger Results for Auto ARIMA on Log-transformed data (seasonal components with drift)	p	d	q	P	D	Q	AIC
	2	1	2	1	0	1	567.64
	1	1	0	1	0	0	563.13
	0	1	1	0	0	1	553.39
	0	1	0	1	0	0	561.96
	0	1	0	0	0	1	552.04*
	0	1	0	1	0	1	561.81

Target

Target Results for Auto ARIMA on Log-transformed data (seasonal components with drift)	p	d	q	P	D	Q	AIC
	2	1	2	1	0	1	Inf
	1	1	0	1	0	0	-377.36
	0	1	1	0	0	1	-379.71
	0	1	0	1	0	0	-380.37
	0	1	0	0	0	1	-381.81*
	0	1	0	1	0	1	-380.76

Appendix E
Performance on RMSE values

RMS Error				
Data	Walmart	Costco	Kroger	Target
Original data	9.642	56.117	3.603*	25.038
Log transformed data	9.37*	37.718*	4.74	24.967*
Sqrt transformed data	9.536	46.096	4.006	25.011

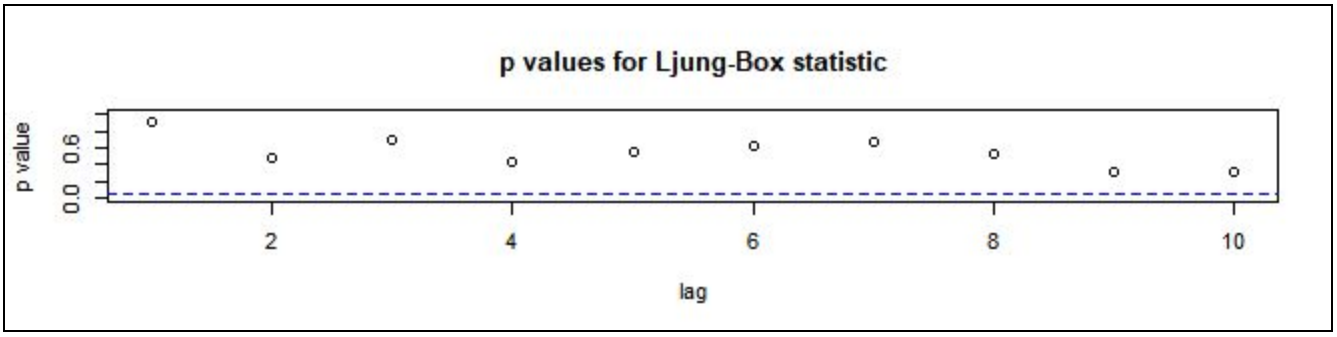
Appendix F
Diagnostic plot of models

(a) Ljung-Box Test to check for uncorrelated residuals

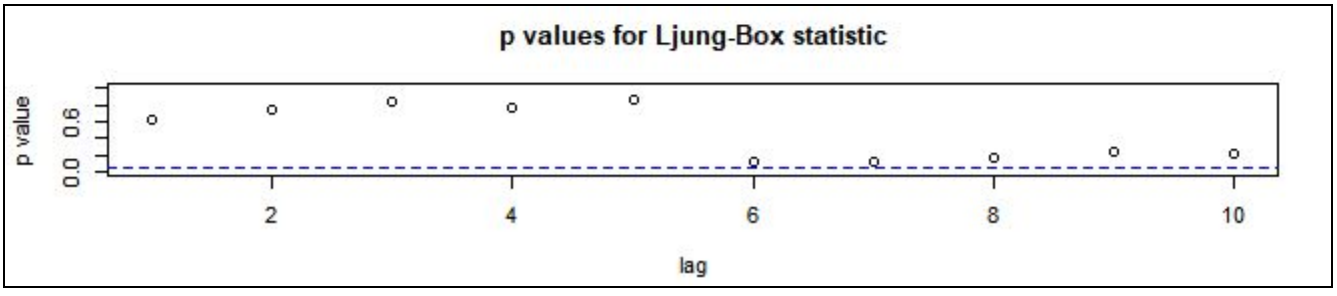
(i) Results of Ljung-Box Test

Ljung-Box test on ARIMA model				
Company	Walmart	Costco	Kroger	Target
Data Transformation	Log-transformed	Log-transformed	Original data	Log-transformed
X-squared	8.28	13.18	7.752	19.38
p-value	0.7629	0.356	0.8042	0.08

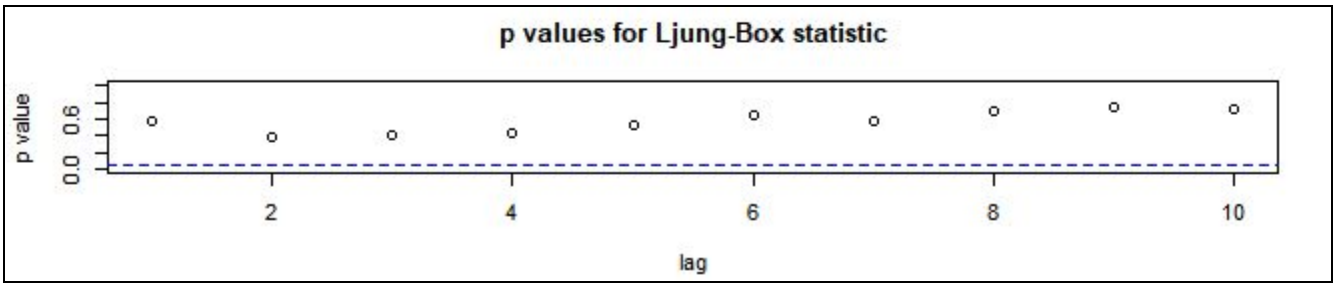
(a) Walmart



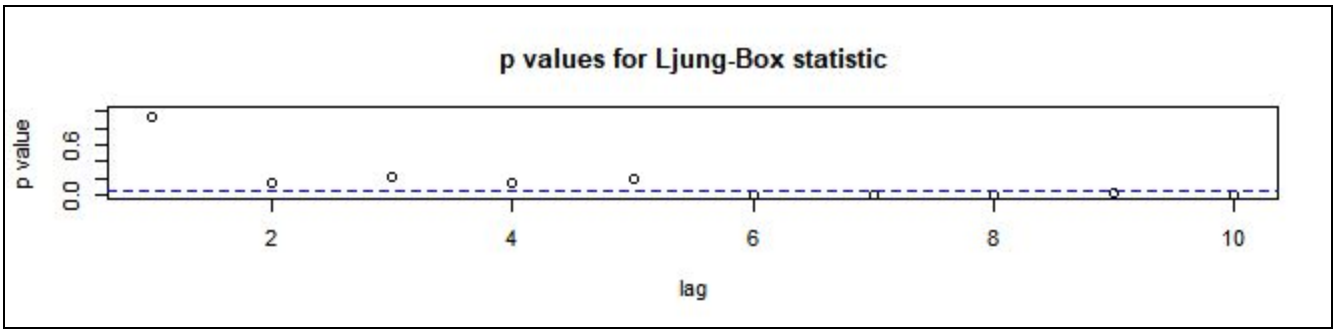
(b) Costco



(c) Kroger

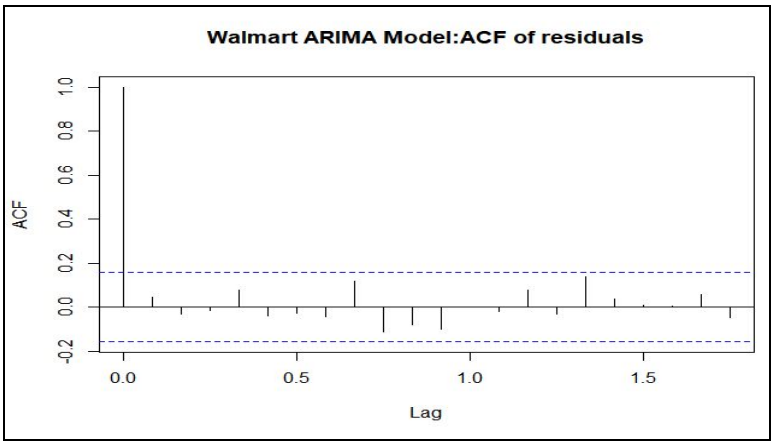


(d) Target

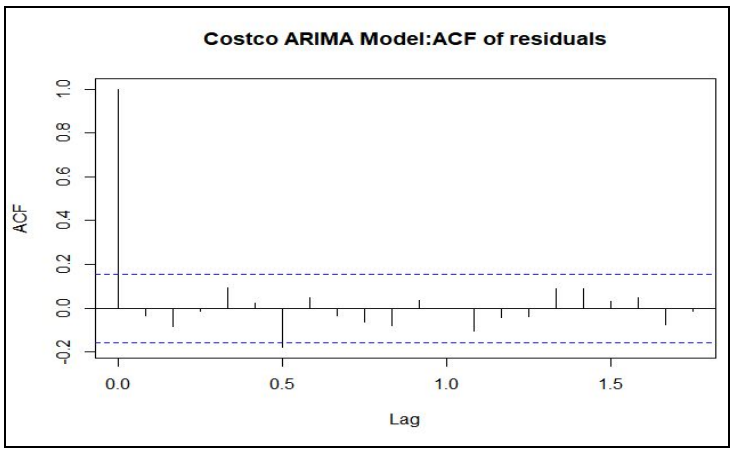


(ii) Plots of ACF of residuals

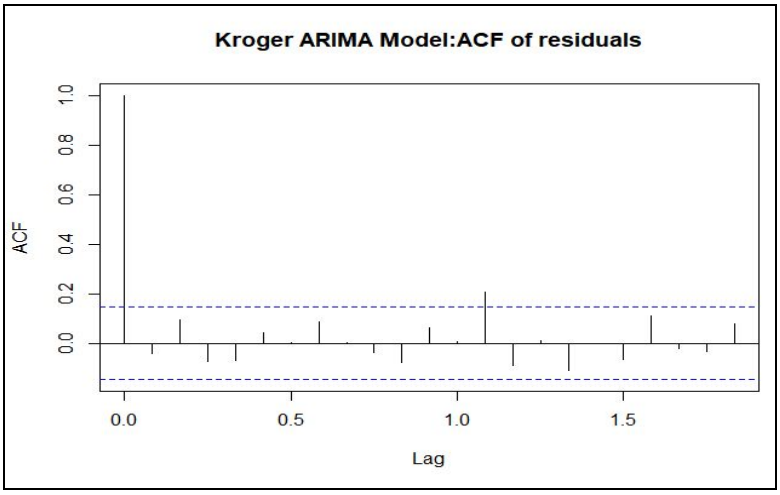
Walmart



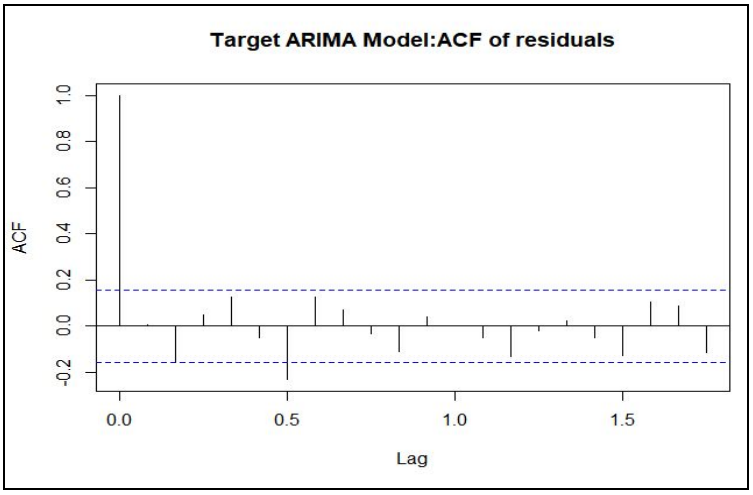
Costco



Kroger

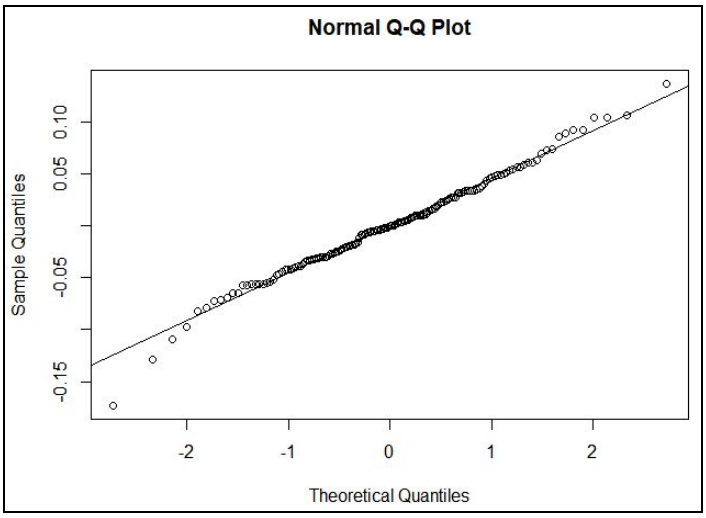


Target

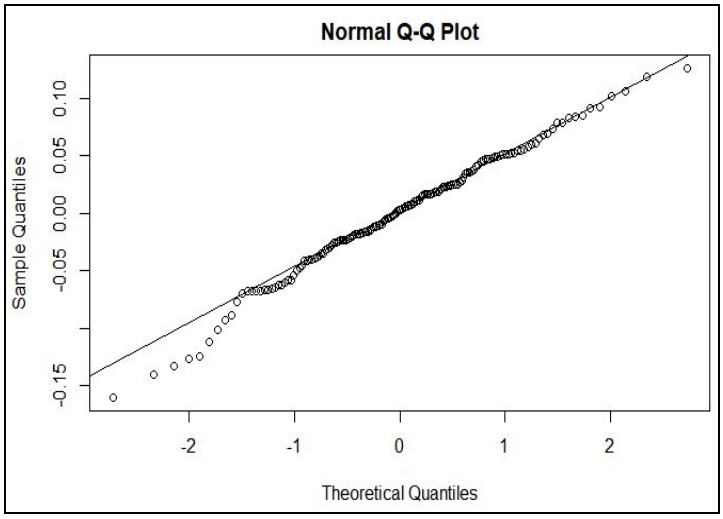


(b) QQ plots to check normality of residuals

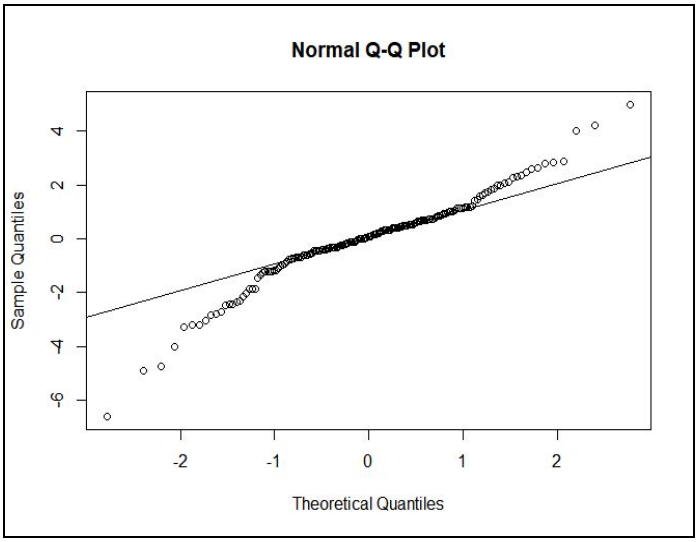
Walmart



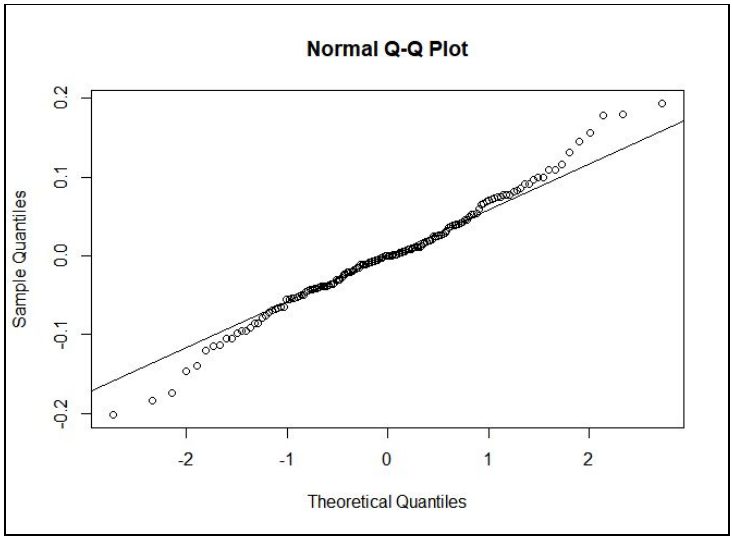
Costco



Kroger

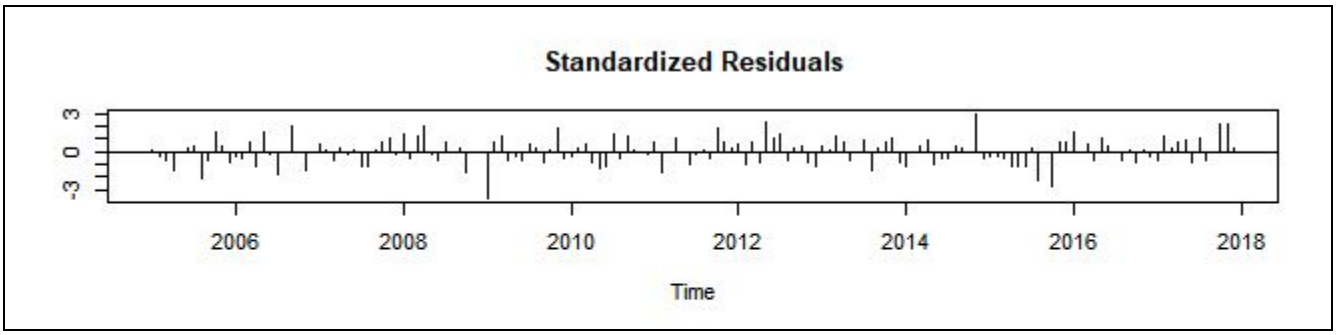


Target

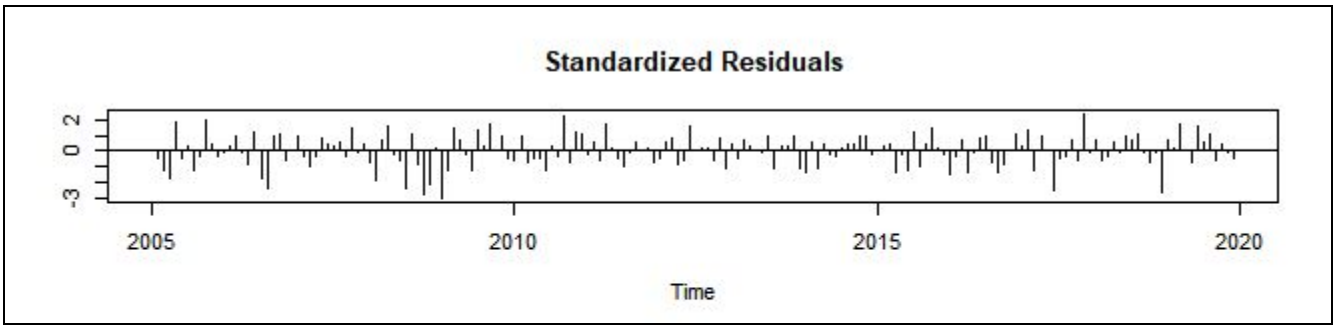


(c) Homoscedasticity of residuals

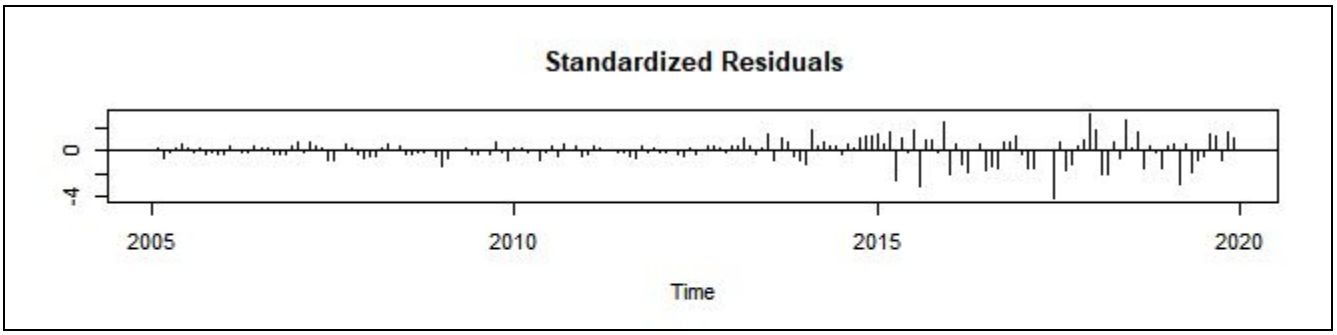
(i) Walmart



(ii) Costco



(iii) Kroger



(iv) Target