Financial Econometrics (SVMJ.04.004)

Time Series Analysis of Performance of Environmental-Friendly Stocks:

A Case Study of TSLA and TM in Financial Econometrics

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INTRO:

In today's dynamic financial markets, understanding the performance of environmental-friendly and non-environmental friendly stocks is of increasing interest to investors, policymakers, and researchers. Time series analysis, combined with various econometric techniques, provides a powerful tool to analyze the dynamics of stock prices. In this article, we present a project conducted in RStudio that compares the performance of Tesla Inc. (TSLA), an environmental-friendly stock, and Toyota Motor Corporation (TM), a non-environmental friendly stock, from 2011 to 2022 using a range of descriptive statistics, box plots, autocorrelation function (ACF), partial autocorrelation function (PACF), ARIMA model, ARMAX model, Akaike Information Criterion (AIC), ARCH, GARCH, and RSI as an exogenous data.

METHODOLOGY:

The project involved collecting daily stock price data for TSLA and TM from a reliable data source and calculating the RSI as a technical indicator. Descriptive statistics, including mean, variance, median, minimum, maximum, and quantiles, were calculated to summarize the stock performance for both companies. Box plots were used to visualize the distribution of stock prices. ACF and PACF analysis were performed to identify potential lag orders for the ARIMA models. ARIMA models were estimated to capture the time series dynamics, and ARMAX models were estimated with RSI as exogenous data. AIC values were compared to select the best models. ARCH and GARCH models were estimated to capture volatility in the residuals.

RESULTS:

The project findings revealed important insights into the performance of Tesla (TSLA) and Toyota (TM) stocks.

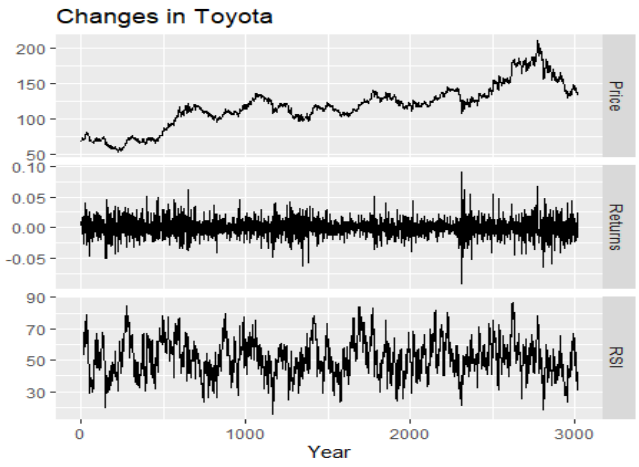
DESCRIPTIVE STATISTICS:

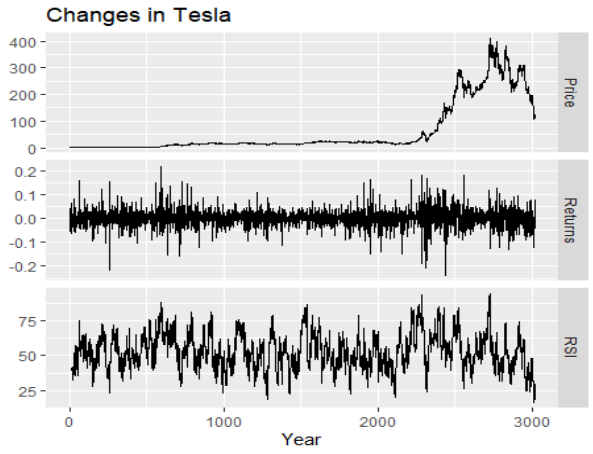
Descriptive statistics and box plots provided a summary of stock performance, with TSLA showing higher average returns compared to TM.

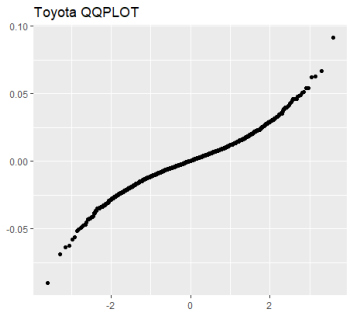
DESCRIPTIVE STATISTICS FOR TESLA			
	Price	Returns	RSI
Total	3019	3019	3006
Min.	1.455333	-0.23652	16.56413
Max.	409.97	0.218292	94.19798
Median	16.59467	0.001209	51.95768
Mean	61.29167	0.001404	53.16443
Var	9372.944	0.001251	167.9237
Coef. Var	1.579562	25.18616	0.243744

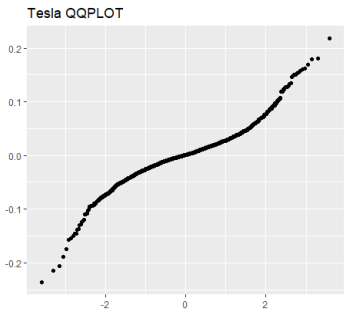
DESCRIPTIVE STATISTICS FOR TOYOTA			
	Price	Returns	RSI
Total	3019	3019	3006
Min.	53.08948	-0.09019	15.67879
Max.	211.37	0.091449	86.7754
Median	118.8234	0.000175	51.02196
Mean	118.1962	0.000228	51.5003
Var	925.0095	0.000188	134.0077
Coef. Var	0.257318	60.13977	0.224779

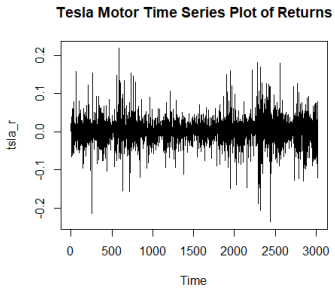
We check values that are missing (NA). If the mean and variance are not equal then it means the data is not symmetric. If the coefficient of variance is big then it means the data is very scattered or distributed.

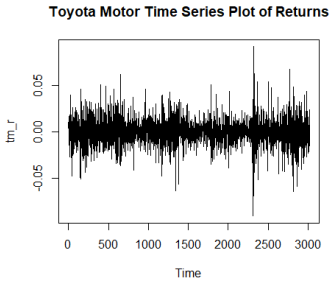


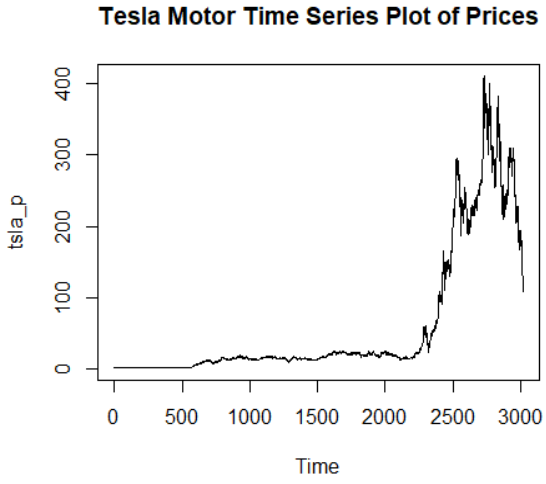


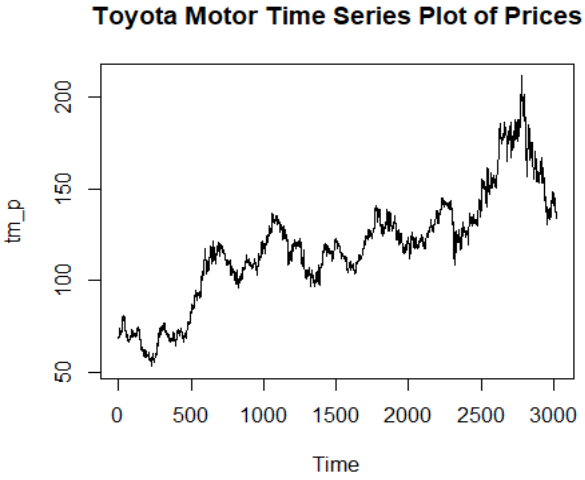


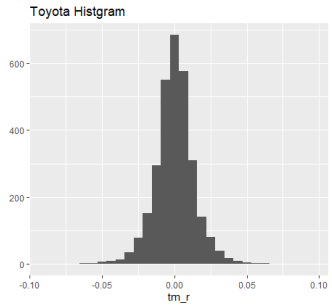


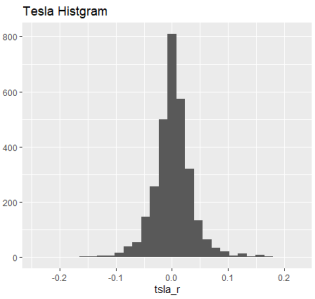


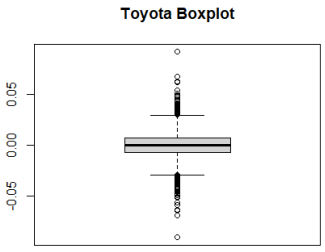


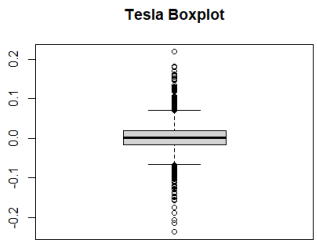






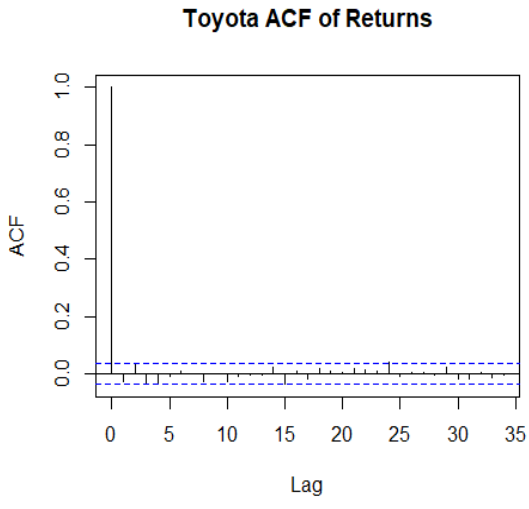


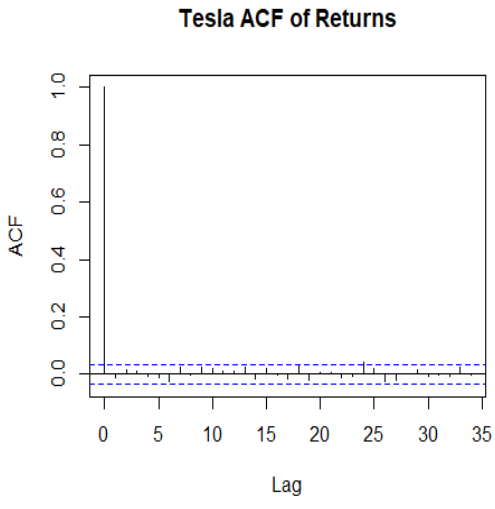




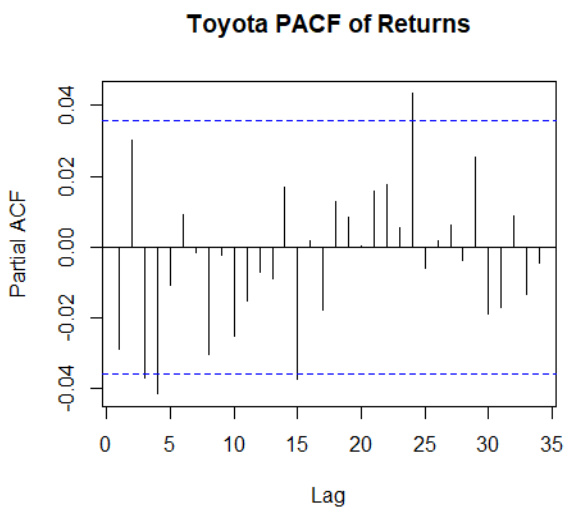
ACF, PACF & ARMA:

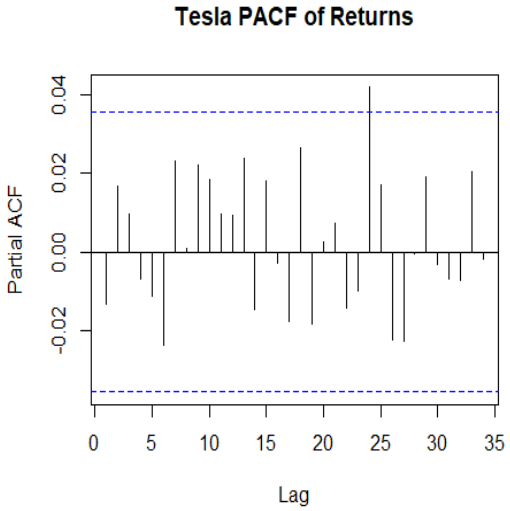
ACF and PACF analysis helped identify appropriate lag orders for the ARMA models.





We can see that the first line is significant because it is above the blue line while the others are below. This seems to be following the AR(1) model process. The autocorrelation function (ACF) measures the correlation between a time series and its lagged values. “Standardized residuals” shows no clustering, no patterns revolving around zero, and similar to a white noise process. The ACF shows no autocorrelation between the residuals because other lines are within the blue dashed lines, hence the model seems to be statistically fitting the data.





The partial autocorrelation function (PACF) measures the correlation between a time series and its lagged values, while accounting for the influence of intermediate lags. An PACF result typically includes a plot or table of partial autocorrelation values at different lags. The interpretation of a PACF result involves examining the magnitude and sign of the partial autocorrelation values, as well as the significance of the values. Positive partial autocorrelation values suggest a positive relationship between a time series and its lagged values, while negative partial autocorrelation values suggest a negative relationship. Significance is often assessed through hypothesis testing, with partial autocorrelation values that exceed a certain threshold indicating potential significance.

AUTOCORRELATION TEST:

Tesla Box-Ljung Test			Toyota Box-Ljung Test	
Chi-square	16.414		Chi-square	27.909
df	20		df	20
p-value	0.6906		p-value	0.1116

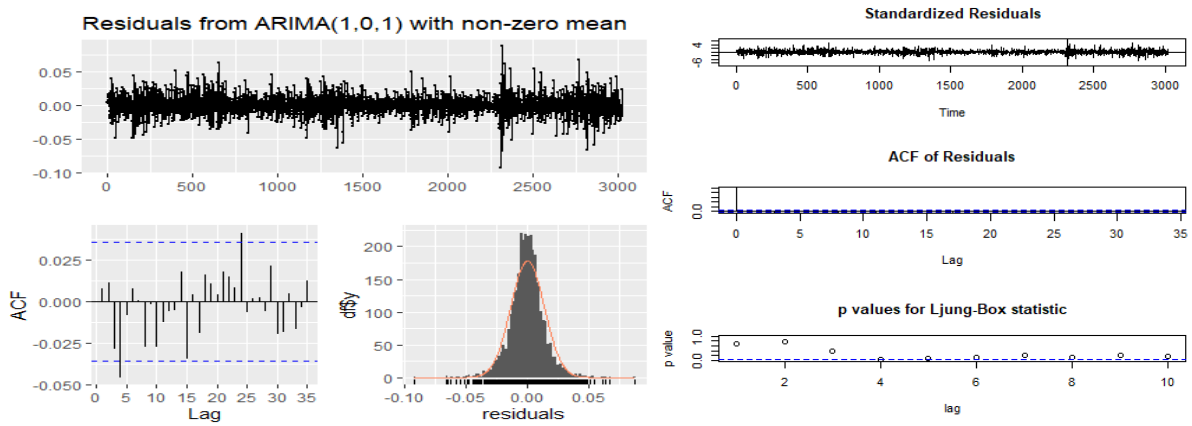
In the case of a Ljung-Box test, higher p-value (e.g., close to 1) suggests weak evidence against the null hypothesis, indicating that there is little or no autocorrelation in the time series data. Based on this result, it would be reasonable to conclude that there is no strong evidence of autocorrelation in the time series data being tested.

ARMA:

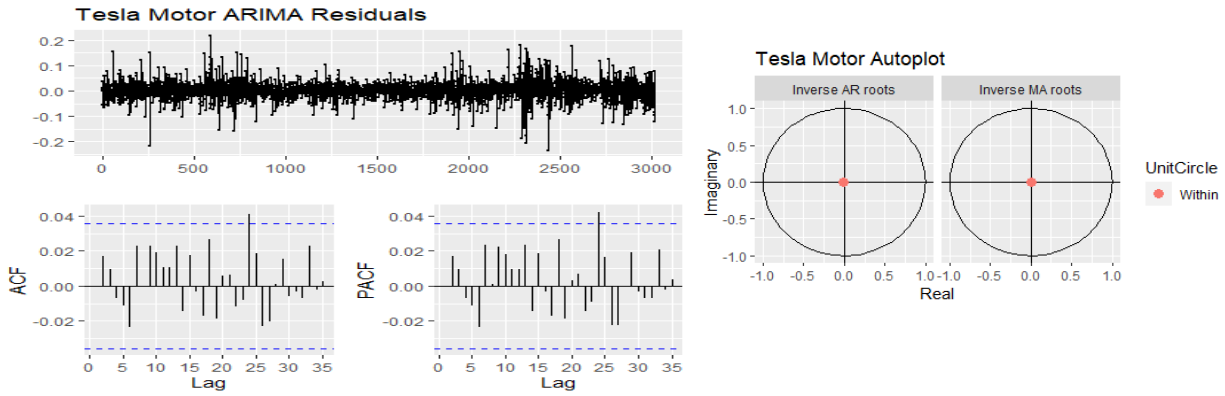
The estimation of ARMA and ARMAX models provided insights into the impact of RSI as exogenous data on stock prices. AR(1) and MA(1) seemed to be the best fit because they produced the lowest AIC when compared to other values. This indicates that the model takes into account the previous observation and the error term from the previous observation to make its predictions. This model may be useful for capturing short-term dependencies in the data and making predictions based on recent information.

Tesla ARIMA TEST			Toyota ARIMA TEST	
ar1	-0.007		ar1	-0.5539
ma1	-0.0061		ma1	0.5188
intercept	0.0014		intercept	0.0002
AIC	-17336.87		AIC	-11603.86

After conducting the ARMA test, the AIC value was -11603.86. The AIC values were compared to select the best models.



ACF test was performed to ensure there is no autocorrelation, together with a time series plot to confirm the residuals have constant zero mean, and a histogram chart to confirm that the graph is bell shaped.

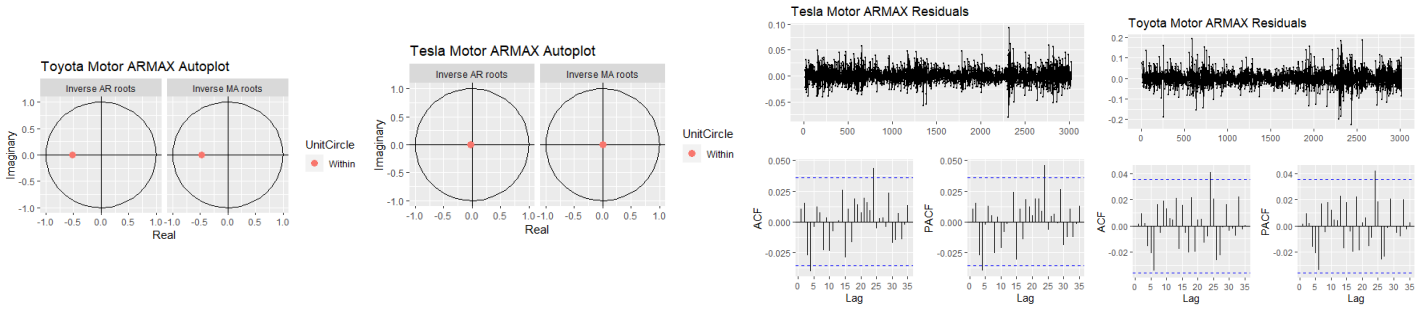


When a red dot falls between the circles on an ARMA autoplot chart, it suggests that the model's predictions, represented by the circles, are relatively close to the actual values, represented by the red dot. This indicates that the ARMA model is providing reasonably accurate predictions for the data.

ARMAX:

The exogenous data (RSI) was tested using the ADF test (Augmented Dickey-Fuller test) to confirm that the data was stationary. The chart was also plotted to show that they have a constant zero mean.

Tesla ARMAX Model			Toyota ARMAX Model	
ar1	-0.0256		ar1	-0.5195
ma1	-0.0019		ma1	0.4815
intercept	-0.0483		intercept	-0.0202
rsi	0.0009		rsi	0.0004
aic	-11946.69		aic	-17632.97



The ARMAX autoplot chart shows a red dot that falls between the circles. This indicates that the actual values of the data, represented by the red dot, are relatively close to the predicted values, represented by the circles, suggesting that the ARMAX model is performing reasonably well in predicting the data. This ARMAX model with an AR and MA order of 1, and RSI data as the exogenous data indicates that the model takes into account the previous observation, the error term from the previous observation, and the RSI values as additional inputs to make its predictions. The AR term captures the linear relationship between the current observation and the previous observation, the MA term captures the linear relationship between the current observation and the error term from the previous observation, and the RSI values provide additional information based on the market's relative strength for prediction. This model may be useful for capturing short-term dependencies in the data while considering the RSI values as potential predictors.

ARCH & GARCH:
The ARCH and GARCH models estimated the volatility of residuals, which could be useful for risk management.

Tesla ARCH Test of Returns			Toyota ARCH Test of Returns	
Chi-square	176.64		Chi-square	331.48
df	12		df	12
p-value	2.2E-16		p-value	2.2E-16

A p-value of 0.00000000000022 in an ARCH (Autoregressive Conditional Heteroscedasticity) test suggests very strong evidence against the null hypothesis of no ARCH effect, indicating that there is likely significant heteroscedasticity in the time series data being tested.

Before moving on to GARCH model, we tested to know which GARCH model is suitable (the ARCH and GARCH order).

Tesla Test for Arch & Garch Order			Toyota Test for Arch & Garch Order	
a0	0.00109		a0	0.0001589
a1	0.05		a1	0.05
b1	0.05		b1	0.05

Alpha represents the arch order and beta represents the GARCH order. From the result above, alpha = 1 and beta = 1. Now we can create our GARCH models. A p-value of 0.00000000000022 in a GARCH (Generalized Autoregressive Conditional Heteroscedasticity) test suggests very strong evidence against the null hypothesis of no GARCH effect, indicating that there is likely significant autoregressive conditional heteroscedasticity in the time series data being tested.

Tesla Forecast For The Next 5 Days				Toyota Forecast For The Next 5 Days		
T+1	0.001084	0.0462		T+1	0.0007115	0.01252
T+2	0.001014	0.04613		T+2	0.0001224	0.01255
T+3	0.001048	0.04605		T+3	0.0006011	0.01258
T+4	0.001031	0.04598		T+4	0.0002121	0.0126
T+5	0.001039	0.04591		T+5	0.0005282	0.01263

DISCUSSION:
The time series analysis project in RStudio using various econometric techniques provided valuable insights into the performance of environmental-friendly and non-environmental friendly stocks. The findings can be interpreted in terms of the impact of environmental sustainability and technical indicators on stock prices and volatility. The results can be useful for investors, policymakers, and researchers interested in understanding the dynamics of environmental-friendly and non-environmental friendly stocks and their potential implications for the financial markets.

CONCLUSION:
The project demonstrated the application of time series analysis and financial econometrics techniques in RStudio to compare the performance of environmental-friendly and non-environmental friendly stocks using descriptive statistics, box plots, ACF, PACF, ARMA models, ARMAX models, AIC, ARCH, GARCH, and RSI as exogenous data. The findings provide valuable insights into the stock market performance of TSLA and TM, and the potential impact of environmental sustainability and technical indicators on stock prices and volatility. Further research and analysis can be conducted to deepen our understanding of the dynamics of environmental-friendly and non-environmental friendly stocks and their implications for the financial markets.