Module 3— Forecasting and Regression

ALY6050: Introduction to Enterprise Analytics

Lectured by

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INTRODUCTION

This project is used to demonstrate time series forecasting and regression analysis on the stocks to evaluate the effect of risk to make better decision under any ambiguity.

A time series is a collection of data points that appear in a logical sequence over a period. A time series, in fact, allows you to examine what causes impact specific variables from one period to the next. Time series analysis is important for determining how an asset, security, or economic variable change over time. In both fundamental and technical analysis, time series forecasting methods are applied.

Time series analysis is essential to determine how an asset, security, or economic variable evolves over time. It may also be used to correlate the changes related to a specific data point to changes in other variables over the same period.

To forecast future activity, time series forecasting employs information about previous values and patterns. This usually has to do with trend analysis, cyclical fluctuation analysis, and seasonality difficulties. Success is not assured with any forecasting strategy. Extrapolation is a term used in the traditional statistical treatment of time series data to make predictions about the future. Time series forecasting is a term used in more recent domains to describe the issue. Forecasting entails fitting models to past data and then utilizing those models to forecast future events. Descriptive models can borrow in the future (for example, to smooth or eliminate noise), but they simply want to explain the data as accurately as possible. The fact that the future is wholly unknown and can only be predicted from what has already occurred is a significant distinction in predicting.

Time series forecasting is the statistical process of studying time series data using statistics and modeling to create forecasts and informed strategic decisions. It's categorized under Quantitative Forecasting.

The below are the components of time series:

Level: If the time series follows a straight line, then this would be the baseline value

Trend: The series' optional and frequently linear growing or decreasing tendency over time

Seasonality: The repeating patterns or behavior over the time

Noise: The optional unpredictability in the findings that the model cannot account for

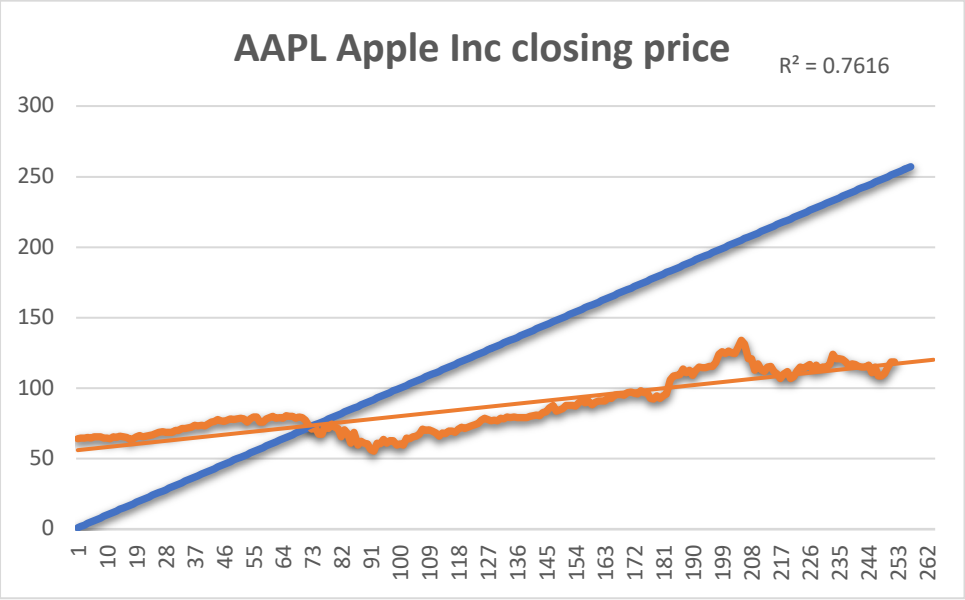
Regression analysis is a collection of statistical procedures for estimating connections between a dependent variable and one or more independent variables. It may be used to determine the strength of a relationship between variables and to predict how they will interact in the future. There are 2 types of regression analysis: Linear and Multiple. Linear regression estimates the relationship between one dependent variable and one independent variable. Multiple regression estimates the relationship between one dependent variable and more than one independent variables.

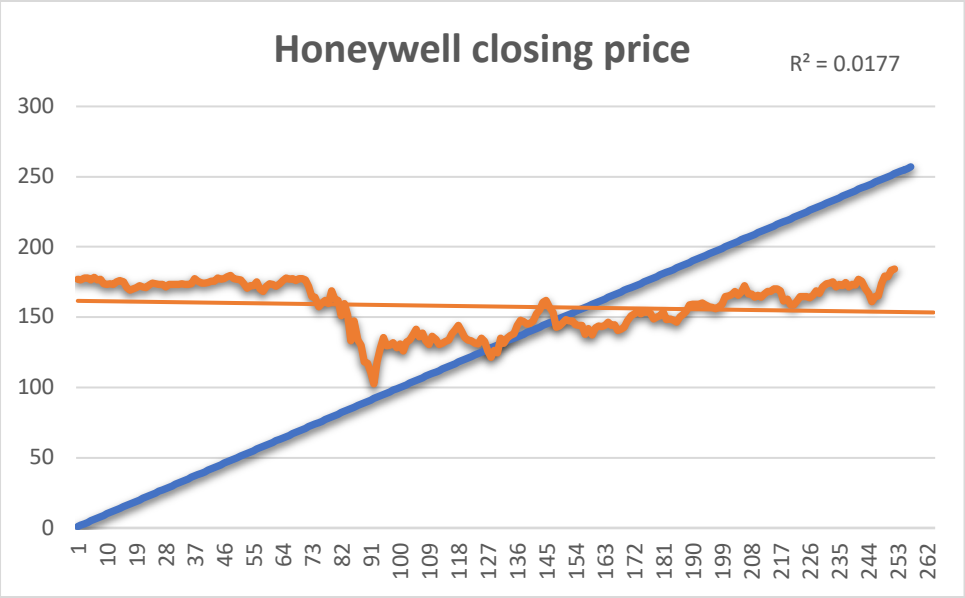
The project consists of Apple Inc (AAPL) and Honeywell International Inc (HON) historical stock prices for a one-year period, consisting of 252 trading days.

ANALYSIS

Part 1: Short-term Forecasting:

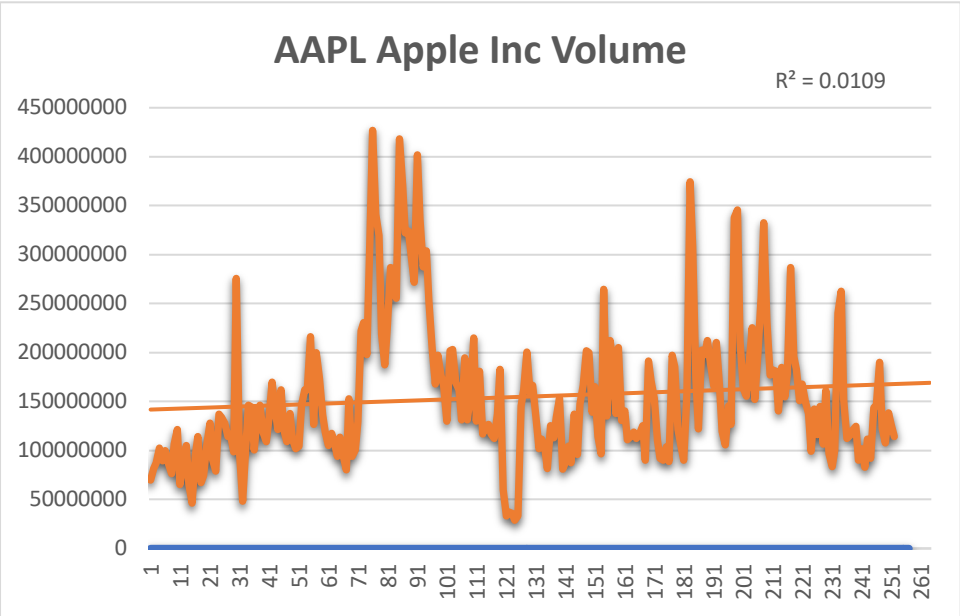
(i)Use a simple line plot of both time series to detect seasonal, irregular, or trend behaviors if any. Write a summary of your observations of both time series in your report.

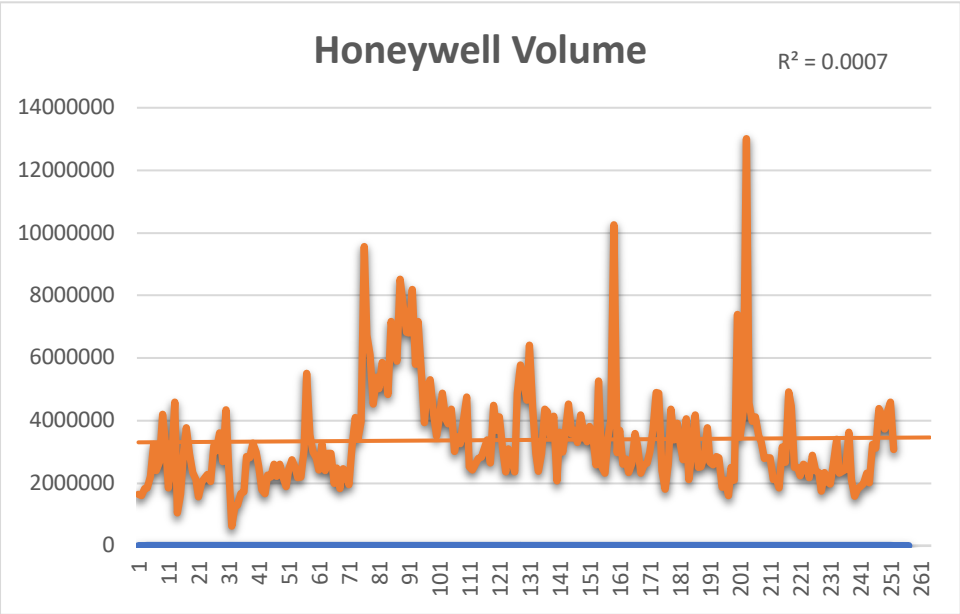




The above 2 plots show the stock prices over a period from period 1 to period 253. We can clearly notice that there is a difference between the trends of 2 stocks. The trend line for Apple Inc shows a positive correlation with the time whereas Honeywell Inc shows a negative correlation with the time period. For Apple Inc, we see a slight increase in the stock value from 1 to 64 and then we a dip in the stock values from 73 to 100. From 109, the stock has again started to increase until 253. For Honeywell Inc, we see a constant line from period

1 up to 64 and we see a dip in the stock price from 73 to 172. We see a slight increase from 181 period.
We can infer that Apple Inc sees a smaller decrease while Honeywell Inc see a rapid decrease in stock price. This can be a scenario of irregularity. At the end, Apple Inc shows an upward trend and Honeywell Inc shows a horizontal trend because of rapid decrease in stock price. As for seasonal, for the companies, from the beginning to 90 period and then to the end, the stock increases. This might create a seasonal component for the data.





Above 2 graphs shows the volume of Apple Inc and Honeywell Inc. For Apple Inc volume, we can see a roughly positive trend on the volume. There is an steep increase from period 81 to 91 and steep decrease from 121 to 131. Seasonal component cannot be derived here.. For Honeywell Inc volume, we can see a no correlation trend on the volume as it is a straight horizontal line. There is an steep increase from period 71 to 91 and steep decrease from 101

to 121. We see a very steep increase from period 201 to 211. Seasonal component cannot be derived here.

(ii) Perform exponential smoothing to forecast both prices for period 253. Use successive values of 0.16, 0,32, 0.60, and 0.78 for the smoothing parameter α. Next, calculate the MAPE (Mean Absolute Percentage Error) of each forecast; and based on the MAPEs, determine the value of α that has yielded the most accurate forecast for each stock. In your report, describe your results; and explain why in your opinion such values of α have yielded the most accurate forecasts for the two stocks.

Exponential smoothing is a univariate time series forecasting approach that may be extended to data with a systematic trend or seasonal component.

Here, we start by generating the forecasted value for different alpha value range. 1st forecasted value will be the actual stock value. The Mean Absolute Percentage Error (MAPE) is one of the most used KPIs to measure forecast accuracy. MAPE is the sum of the individual absolute errors divided by the demand (each period separately). It is the average of the percentage errors.

<u>Apple Inc:</u>

Below snapshot shows the exponential smoothing for each stock price for different smoothing values along with their MAPE values.

AAPL	α = 0.16	α = 0.32	α = 0.6	α = 0.78	Error_0.16	Error_0.32	Error_0.6	Error_0.78	Abs[Error_0.16	Abs[Error_0.32]	Abs[Error_0.6]	Abs[Error_0.78]	Error^2_0.16	Error^2_0.32	Error^2_0.6	Error^2_0.78	%age error_0.16	%age error_0.32	%age error_0.6	%age error_0.78	MAPE Abs(%age Error)-0.16	MAPE Abs(%age Error)-0.32
0.16	63.95	63.95	63.95	63.95	0.00	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00	0%	0%	0%	0%	0%	0%
0.32	63.9545	63.95454	63.95454	63.95454	0.51	0.51	0.51	0.51	0.506447	0.506447	0.506447	0.506447	0.26	0.26	0.26	0.26	1%	1%	1%	1%	1%	1%
0.6	64.03558	64.11661	64.25841	64.34957	0.37	0.29	0.14	0.05	0.36640248	0.28537096	0.1435658	0.05240534	0.13	0.08	0.02	0.00	1%	0%	0%	0%	1%	0%
0.78	64.0942	64.20793	64.34455	64.39045	0.92	0.81	0.67	0.63	0.92485108	0.81112525	0.67449932	0.62860217	0.86	0.66	0.45	0.40	1%	1%	1%	1%	1%	1%
	64.24218	64.46749	64.74925	64.88076	0.33	0.10	-0.18	-0.31	0.32698391	0.10167417	0.18009127	0.31159852	0.11	0.01	0.03	0.10	1%	0%	0%	0%	1%	0%
	64.29449	64.50002	64.6412	64.63771	1.04	0.84	0.70	0.70	1.04171848	0.83619044	0.69501549	0.69850033	1.09	0.70	0.48	0.49	2%	1%	1%	1%	2%	1%
	64.46117	64.7676	65.05821	65.18254	1.20	0.90	0.61	0.48	1.20446553	0.8980315	0.6074282	0.48309207	1.45	0.81	0.37	0.23	2%	1%	1%	1%	2%	1%
	64.65388	65.05497	65.42266	65.55935	0.81	0.41	0.04	-0.09	0.81262404	0.41153442	0.04384428	0.09284674	0.66	0.17	0.00	0.01	1%	1%	0%	0%	1%	1%
	64.7839	65.18666	65.44897	65.48693	-0.08	-0.48	-0.74	-0.78	0.0795268	0.4822876	0.74459329	0.78255728	0.01	0.23	0.55	0.61	0%	-1%	-1%	-1%	0%	1%
	64.77118	65.03233	65.00221	64.87654	-0.36	-0.62	-0.59	-0.46	0.35691052	0.61806357	0.58794532	0.4622706	0.13	0.38	0.35	0.21	-1%	-1%	-1%	-1%	1%	1%
	64.71407	64.83455	64.64945	64.51597	-0.36	-0.48	-0.29	-0.16	0.35634583	0.47682422	0.29171913	0.15824053	0.13	0.23	0.09	0.03	-1%	-1%	0%	0%	1%	1%
	64.65706	64.68197	64.47441	64.39254	0.83	0.80	1.01	1.09	0.8291105	0.80420053	1.01175335	1.09362808	0.69	0.65	1.02	1.20	1%	1%	2%	2%	1%	1%
	64.78972	64.93931	65.08147	65.24557	0.19	0.04	-0.11	-0.27	0.18509982	0.03550336	0.10665166	0.27075482	0.03	0.00	0.01	0.07	0%	0%	0%	0%	0%	0%
	64.81933	64.95067	65.01748	65.03438	1.03	0.90	0.83	0.81	1.02823385	0.89689228	0.83008934	0.81318394	1.06	0.80	0.69	0.66	2%	1%	1%	1%	2%	1%
	64.98385	65.23768	65.51553	65.66866	0.72	0.46	0.19	0.03	0.71866643	0.46483675	0.18698573	0.03385047	0.52	0.22	0.03	0.00	1%	1%	0%	0%	1%	1%
	65.09884	65.38643	65.62772	65.69507	-0.16	-0.44	-0.68	-0.75	0.1559942	0.44358501	0.68487971	0.7522269	0.02	0.20	0.47	0.57	0%	-1%	-1%	-1%	0%	1%
	65.07388	65.24448	65.21679	65.10833	-1.29	-1.46	-1.43	-1.32	1.28896012	1.45956281	1.43187688	1.32341492	1.66	2.13	2.05	1.75	-2%	-2%	-2%	-2%	2%	2%
	64.86764	64.77742	64.35767	64.07607	-0.52	-0.43	-0.01	0.27	0.5197495	0.42952571	0.00977375	0.27182572	0.27	0.18	0.00	0.07	-1%	-1%	0%	0%	1%	1%
	64.78448	64.63997	64.3518	64.28809	0.51	0.65	0.94	1.00	0.50746342	0.65197552	0.9401435	1.00385466	0.26	0.43	0.88	1.01	1%	1%	1%	2%	1%	1%
	64.86568	64.8486	64.91589	65.0711	1.69	1.70	1.64	1.48	1.68745427	1.70452835	1.6372424	1.48203302	2.85	2.91	2.68	2.20	3%	3%	2%	2%	3%	3%
	65.13567	65.39405	65.89823	66.22708	0.49	0.23	-0.28	-0.61	0.48571459	0.22733228	0.27685004	0.60569973	0.24	0.05	0.08	0.37	1%	0%	0%	-1%	1%	0%
	65.21338	65.4668	65.73212	65.75464	0.79	0.54	0.27	0.25	0.79151425	0.53809995	0.27277398	0.25026006	0.63	0.29	0.07	0.06	1%	1%	0%	0%	1%	1%
	65.34003	65.63899	65.89579	65.94984	1.23	0.93	0.67	0.62	1.22785997	0.92889597	0.67209759	0.61804521	1.51	0.86	0.45	0.38	2%	1%	1%	1%	2%	1%
	65.53648	65.93624	66.29905	66.43192	1.20	0.80	0.44	0.31	1.20103438	0.80128126	0.43847104	0.30560195	1.44	0.64	0.19	0.09	2%	1%	1%	0%	2%	1%
	65.72865	66.19265	66.56213	66.67029	1.92	1.45	1.08	0.97	1.91605788	1.45206025	1.08257741	0.97442143	3.67	2.11	1.17	0.95	3%	2%	2%	1%	3%	2%
	66.03522	66.65731	67.21168	67.43033	2.77	2.15	1.59	1.37	2.76741662	2.14532897	1.59095897	1.37230071	7.66	4.60	2.53	1.88	4%	3%	2%	2%	4%	3%
	66.47801	67.34381	68.16625	68.50073	2.46	1.59	0.77	0.44	2.45984596	1.5940397	0.77159959	0.43712216	6.05	2.54	0.60	0.19	4%	2%	1%	1%	4%	2%
	66.87158	67.8539	68.62921	68.84168	1.90	0.92	0.14	-0.07	1.9015516	0.919228	0.14392083	0.06855213	3.62	0.84	0.02	0.00	3%	1%	0%	0%	3%	1%
	67.17583	68.14806	68.71556	68.78821	1.67	0.69	0.13	0.05	1.66613635	0.69390804	0.12640133	0.05375153	2.78	0.48	0.02	0.00	2%	1%	0%	0%	2%	1%
	67.44241	68.37011	68.7914	68.83014	1.26	0.33	-0.09	-0.13	1.25697653	0.32927947	0.09201747	0.13075266	1.58	0.11	0.01	0.02	2%	0%	0%	0%	2%	0%
	67.64353	68.47548	68.73619	68.72815	2.18	1.34	1.08	1.09	2.17691529	1.34496504	1.08424801	1.09228941	4.74	1.81	1.18	1.19	3%	2%	2%	2%	3%	2%
	67.99183	68.90587	69.38674	69.58014	1.89	0.98	0.50	0.31	1.89498484	0.98095223	0.50007521	0.30667967	3.59	0.96	0.25	0.09	3%	1%	1%	0%	3%	1%
	68.29503	69.21977	69.68679	69.81935	2.98	2.05	1.59	1.45	2.97836127	2.05362151	1.58660408	1.45404353	8.87	4.22	2.52	2.11	4%	3%	2%	2%	4%	3%
	68.77157	69.87693	70.63875	70.9535	2.47	1.37	0.61	0.29	2.47478446	1.36942363	0.60760263	0.29285058	6.12	1.88	0.37	0.09	3%	2%	1%	0%	3%	2%
	69.16753	70.31514	71.00331	71.18193	2.50	1.35	0.67	0.49	2.50167795	1.35406707	0.66590005	0.48728613	6.26	1.83	0.44	0.24	3%	2%	1%	1%	3%	2%
	69.5678	70.74845	71.40285	71.56201	2.63	1.44	0.79	0.63	2.62506048	1.44441661	0.79001102	0.63085395	6.89	2.09	0.62	0.40	4%	2%	1%	1%	4%	2%
	69.98781	71.21066	71.87686	72.05408	3.85	2.63	1.96	1.79	3.8522298	2.62938229	1.96318341	1.78596687	14.84	6.91	3.85	3.19	5%	4%	3%	2%	5%	4%
	70.60417	72.05206	73.05477	73.44713	2.52	1.07	0.07	-0.32	2.51798503	1.07009196	0.06738536	0.32497529	6.34	1.15	0.00	0.11	3%	1%	0%	0%	3%	1%
	71.00705	72.39449	73.0952	73.19365	2.70	1.31	0.61	0.51	2.69777243	1.31032753	0.60961915	0.51117044	7.28	1.72	0.37	0.26	4%	2%	1%	1%	4%	2%
	71.43869	72.8138	73.46097	73.59236	1.92	0.54	-0.10	-0.23	1.91949484	0.54438872	0.10278634	0.2341765	3.68	0.30	0.01	0.05	3%	1%	0%	0%	3%	1%
	71.74581	72.988	73.3993	73.4097	2.79	1.55	1.14	1.13	2.79242967	1.55023833	1.13893946	1.12853517	7.80	2.40	1.30	1.27	4%	2%	2%	2%	4%	2%
	72.1926	73.48408	74.08266	74.28996	3.93	2.64	2.04	1.83	3.92889992	2.63742106	2.03883479	1.83153674	15.44	6.96	4.16	3.35	5%	3%	3%	2%	5%	3%
	72.82122	74.32805	75.30596	75.71856	3.47	1.97	0.99	0.58	3.47235693	1.96552732	0.98761491	0.57501908	12.06	3.86	0.98	0.33	5%	3%	1%	1%	5%	3%
	73.3768	74.95702	75.89853	76.16707	4.55	2.97	2.03	1.76	4.54673882	2.96651758	2.02500497	1.7564632	20.67	8.80	4.10	3.09	6%	4%	3%	2%	6%	4%
	74.10428	75.90631	77.11354	77.53712	2.77	0.97	-0.24	-0.67	2.76704561	0.96501695	0.24221301	0.6657931	7.66	0.93	0.06	0.44	4%	1%	0%	-1%	4%	1%

MAPE Abs(%age Error) - 0.6	MAPE Abs(%age Error)- 0.78
0%	0%
1%	1%
0%	0%
1%	1%
0%	0%
1%	1%
1%	1%
0%	0%
1%	1%
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1%	1%
0%	0%
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3%	2%
1%	1%
3%	2%
0%	1%
1%	1%

Below snapshot shows the forecasted value for 253rd period along with the average MAPE value.

Exponential Smoothing for AAPL		
Alpha	**253rd value**	**MAPE**
0.16	114.877658	4%
0.32	115.72869	2.58%
0.6	117.785278	2.03%
0.78	118.471426	1.96%

Here, we see that for **alpha = 0.78** we have the least MAPE value which tells us that the company has best forecast for 253rd value for **alpha =0.78**. This tells that the company rarely changes their pricing and can have a steady and predictable demand.

Honeywell Inc:

Below snapshot shows the exponential smoothing for each stock price for different smoothing values along with their MAPE values.

HON	α = 0.16	α = 0.32	α = 0.6	α = 0.78	Error_0.16	Error_0.32	Error_0.6	Error_0.78	Abs(Error_0.16	Abs(Error_0.32)	Abs(Error_0.6)	Abs(Error_0.78)	Error^2_0.16	Error^2_0.32	Error^2_0.6	Error^2_0.78	%age error_0.16	%age error_0.32	%age error_0.6	%age error_0.78	MAPE Abs(%age Error)-0.16	MAPE Abs(%age Error)-0.32
0.16	177.03	177.03	177.03	177.03	0.00	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	0.00	0%	0%	0%	0%	0%	0%
0.32	177.0294	177.0294	177.0294	177.0294	-0.37	-0.37	-0.37	-0.37	0.371231	0.371231	0.371231	0.371231	0.14	0.14	0.14	0.14	0%	0%	0%	0%	0%	0%
0.6	176.97	176.9106	176.8066	176.7398	0.84	0.90	1.00	1.07	0.84093696	0.90033392	1.0042786	1.07110018	0.71	0.81	1.01	1.15	0%	1%	1%	1%	0%	1%
0.78	177.1045	177.1987	177.4092	177.5753	0.65	0.55	0.34	0.18	0.64779305	0.553633066	0.34311744	0.17704804	0.42	0.31	0.12	0.03	0%	0%	0%	0%	0%	0%
	177.2082	177.3758	177.6151	177.7134	-0.83	-1.00	-1.24	-1.34	0.83036484	0.998040515	1.23726402	1.335560431	0.69	1.00	1.53	1.78	0%	-1%	-1%	-1%	0%	1%
	177.0753	177.0565	176.8727	176.6716	1.36	1.38	1.57	1.77	1.36424553	1.38308445	1.56684639	1.767928705	1.86	1.91	2.46	3.13	1%	1%	1%	1%	1%	1%
	177.2936	177.4991	177.8128	178.0506	-0.77	-0.97	-1.29	-1.53	0.76852375	0.973992574	1.28775144	1.525545685	0.59	0.95	1.66	2.33	0%	-1%	-1%	-1%	0%	1%
	177.1706	177.1874	177.0402	176.8607	-0.33	-0.35	-0.20	-0.02	0.33138095	0.348135951	0.20092158	0.021441051	0.11	0.12	0.04	0.00	0%	0%	0%	0%	0%	0%
	177.1176	177.076	176.9196	176.844	-3.13	-3.08	-2.93	-2.85	3.125528	3.083900446	2.92753663	2.851885031	9.77	9.51	8.57	8.13	-2%	-2%	-2%	-2%	2%	2%
	176.6175	176.0891	175.1631	174.6195	-3.30	-2.77	-1.85	-1.30	3.30288852	2.774497304	1.84845965	1.304859707	10.91	7.70	3.42	1.70	-2%	-2%	-1%	-1%	2%	2%
	176.0891	175.2013	174.054	173.6017	-2.52	-1.63	-0.48	-0.03	2.51916136	1.631393166	0.48411886	0.031804136	6.35	2.66	0.23	0.00	-1%	-1%	0%	0%	1%	1%
	175.686	174.6792	173.7635	173.5769	-2.39	-1.38	-0.47	-0.28	2.39099854	1.384250353	0.46855054	0.28189991	5.72	1.92	0.22	0.08	-1%	-1%	0%	0%	1%	1%
	175.3034	174.2363	173.4824	173.357	-0.04	1.03	1.79	1.91	0.03504977	1.03209876	1.78596878	1.91137102	0.00	1.07	3.19	3.65	0%	1%	1%	1%	0%	1%
	175.2978	174.5666	174.554	174.8479	0.85	1.59	1.60	1.30	0.85416419	1.585433157	1.59799351	1.304107624	0.73	2.51	2.55	1.70	0%	1%	1%	1%	0%	1%
	175.4345	175.0739	175.5128	175.8651	-0.14	0.22	-0.21	-0.57	0.13664308	0.223953547	0.21494359	0.567237323	0.02	0.05	0.05	0.32	0%	0%	0%	0%	0%	0%
	175.4126	175.1456	175.3838	175.4226	-4.27	-4.00	-4.24	-4.28	4.26771919	4.000650588	4.23891644	4.277731211	18.21	16.01	17.97	18.30	-2%	-2%	-2%	-2%	2%	2%
	174.7298	173.8654	172.8405	172.086	-5.32	-4.46	-3.43	-2.68	5.32266212	4.4582204	3.43334458	2.678878866	28.33	19.88	11.79	7.18	-3%	-3%	-2%	-2%	3%	3%
	173.8782	172.4387	170.7805	169.9965	-3.82	-2.38	-0.73	0.06	3.82305618	2.383609872	0.72535783	0.058626649	14.62	5.68	0.53	0.00	-2%	-1%	0%	0%	2%	1%
	173.2665	171.676	170.3453	170.0422	-2.43	-0.84	0.50	0.80	2.42595219	0.835439713	0.49527187	0.798312863	5.89	0.70	0.25	0.64	-1%	0%	0%	0%	1%	0%
	172.8783	171.4086	170.6424	170.6649	-0.61	0.86	1.62	1.60	0.61418484	0.855515995	1.62172375	1.59924383	0.38	0.73	2.63	2.56	0%	0%	1%	1%	0%	0%
	172.7801	171.6824	171.6155	171.9123	-1.47	-0.37	-0.30	-0.60	1.46826227	0.370596123	0.3036575	0.600513357	2.16	0.14	0.09	0.36	-1%	0%	0%	0%	1%	0%
	172.5451	171.5638	171.4333	171.4439	-1.68	-0.69	-0.56	-0.57	1.6751583	0.693823364	0.563281	0.573930939	2.81	0.48	0.32	0.33	-1%	0%	0%	0%	1%	0%
	172.2771	171.3418	171.0953	170.9962	0.53	1.46	1.71	1.81	0.52697903	1.462312113	1.7087996	1.807847194	0.28	2.14	2.92	3.27	0%	1%	1%	1%	0%	1%
	172.3614	171.8097	172.1206	172.4064	1.80	2.35	2.04	1.75	1.79755138	2.349261237	2.03840884	1.752615383	3.23	5.52	4.16	3.07	1%	1%	1%	1%	1%	1%
	172.649	172.5615	173.3436	173.7734	1.11	1.19	0.41	-0.02	1.10740116	1.194955641	0.41282154	0.016966616	1.23	1.43	0.17	0.00	1%	1%	0%	0%	1%	1%
	172.8262	172.9439	173.5913	173.7602	0.36	0.24	-0.40	-0.57	0.36077397	0.243126836	0.40431439	0.573175655	0.13	0.06	0.16	0.33	0%	0%	0%	0%	0%	0%
	172.8839	173.0217	173.3487	173.3131	0.60	0.46	0.13	0.17	0.59759114	0.459867248	0.13281525	0.168442356	0.36	0.21	0.02	0.03	0%	0%	0%	0%	0%	0%
	172.9796	173.1688	173.4284	173.4445	-1.52	-1.71	-1.97	-1.99	1.52049944	1.709766271	1.9693499	1.985418682	2.31	2.92	3.88	3.94	-1%	-1%	-1%	-1%	1%	1%
	172.7363	172.6217	172.2468	171.8959	0.55	0.66	1.04	1.39	0.54890647	0.663484936	1.03838604	1.38933389	0.30	0.44	1.08	1.93	0%	0%	1%	1%	0%	0%
	172.8241	172.834	172.8698	172.9795	0.37	0.36	0.33	0.22	0.37271743	0.362805756	0.32699042	0.217289456	0.14	0.13	0.11	0.05	0%	0%	0%	0%	0%	0%
	172.8837	172.9501	173.066	173.149	0.33	0.27	0.15	0.07	0.33272064	0.266345914	0.15043417	0.06744168	0.11	0.07	0.02	0.00	0%	0%	0%	0%	0%	0%
	172.937	173.0353	173.1563	173.2016	0.16	0.06	-0.06	-0.10	0.16167234	0.063302222	0.05763933	0.10297583	0.03	0.00	0.00	0.01	0%	0%	0%	0%	0%	0%
	172.9628	173.0556	173.1217	173.1213	0.70	0.60	0.54	0.54	0.69542077	0.602661511	0.53656027	0.536961317	0.48	0.36	0.29	0.29	0%	0%	0%	0%	0%	0%
	173.0741	173.2485	173.4436	173.5401	0.19	0.02	-0.18	-0.27	0.19145344	0.017109827	0.17807589	0.27456851	0.04	0.00	0.03	0.08	0%	0%	0%	0%	0%	0%
	173.1047	173.2539	173.3368	173.326	0.10	-0.05	-0.13	-0.12	0.10187589	0.047310317	0.13017536	0.119350072	0.01	0.00	0.02	0.01	0%	0%	0%	0%	0%	0%
	173.121	173.2388	173.2587	173.2329	0.66	0.54	0.52	0.54	0.65501875	0.537271984	0.51737286	0.543185984	0.43	0.29	0.27	0.30	0%	0%	0%	0%	0%	0%
	173.2258	173.4107	173.5691	173.6566	4.27	4.09	3.93	3.84	4.27119375	4.086322949	3.92792714	3.840478917	18.24	16.70	15.43	14.75	2%	2%	2%	2%	2%	2%
	173.9092	174.7183	175.9259	176.6521	1.69	0.88	-0.32	-1.05	1.69296575	0.883862605	0.32366614	1.049931638	2.87	0.78	0.10	1.10	1%	1%	0%	-1%	1%	1%
	174.1801	175.0012	175.7317	175.8332	0.10	-0.72	-1.45	-1.56	0.09668223	0.724382428	1.45487546	1.55639396	0.01	0.52	2.12	2.42	0%	0%	-1%	-1%	0%	0%
	174.1956	174.7694	174.8587	174.6192	0.18	-0.39	-0.48	-0.24	0.17938807	0.394405051	0.48377518	0.244231671	0.03	0.16	0.23	0.06	0%	0%	0%	0%	0%	0%
	174.2243	174.6432	174.5685	174.4287	0.30	-0.12	-0.05	0.09	0.29794898	0.120932435	0.04624707	0.093532032	0.09	0.01	0.00	0.01	0%	0%	0%	0%	0%	0%
	174.272	174.6045	174.5407	174.5017	1.54	1.20	1.27	1.31	1.53642514	1.203913944	1.26764917	1.306725047	2.36	1.45	1.61	1.71	1%	1%	1%	1%	1%	1%
	174.5178	174.9897	175.3013	175.5209	0.91	0.44	0.12	-0.10	0.90767812	0.435742482	0.12414067	0.09543949	0.82	0.19	0.02	0.01	1%	0%	0%	0%	1%	0%
	174.663	175.1292	175.3758	175.4465	3.31	2.84	2.59	2.52	3.30528062	2.839135888	2.59248727	2.521834312	10.92	8.06	6.72	6.36	2%	2%	1%	1%	2%	2%
	175.1919	176.0377	176.9313	177.4135	1.97	1.13	0.23	-0.25	1.97136672	1.125543404	0.23192591	0.250265451	3.89	1.27	0.05	0.06	1%	1%	0%	0%	1%	1%
	175.5073	176.3979	177.0705	177.2183	1.93	1.04	0.37	0.22	1.93085105	1.040272515	0.36763336	0.219844601	3.73	1.08	0.14	0.05	1%	1%	0%	0%	1%	1%

MAPE Abs(%age Error) - 0.6	MAPE Abs(%age Error)- 0.78
0%	0%
0%	0%
1%	1%
0%	0%
1%	1%
1%	1%
1%	1%
0%	0%
2%	2%
1%	1%
0%	0%
0%	0%
1%	1%
1%	1%
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2%	2%
0%	1%
1%	1%
0%	0%
0%	0%
1%	1%
0%	0%
1%	1%

Below snapshot shows the forecasted value for 253rd period along with the average MAPE value.

Exponential Smoothing for HON		
Alpha	**253rd value**	**MAPE**
0.16	175.610463	3.01%
0.32	179.403837	2.42%
0.6	182.960007	1.98%
0.78	183.826219	1.88%

Here, we see that for **alpha = 0.78** we have the least MAPE value which tells us that the company has best forecast for 253rd value for **alpha=0.78**. This tells that the company rarely changes their pricing and can have a steady and predictable demand.

(iii) Use your exponential smoothing forecast of part (ii) with α=0.60 and perform an adjusted exponential smoothing to forecast both prices for period 253. Use successive values of 0.16, 0.36, 0.66, and 0.86 for the trend parameters β for both stocks. Next, calculate the MAPDs (Mean Absolute Percentage Deviation) of your forecasts and determine the values of β that have provided the most accurate forecasts for both stocks. In your report, describe your results and explain why, in your opinion, such values of β have yielded the most accurate forecasts.

The concept behind Trend-Adjusted Exponential Smoothing for forecasting is to use an exponential smoothing method for forecasting, but with a trend correction (when it exists). Otherwise, forecasts tend to lag when there is a trend that is not accounted for by exponential smoothing.

Here, we will be using 2 parameters: Smoothing parameter **alpha** and trend parameter **beta**.

For smoothing parameter **alpha=0.60**, I have calculated the trend values along with the forecasted value. The average distance between each data point and the mean is the **mean absolute deviation** of a dataset. It offers us an indication of how variable a dataset is. I have calculated the MAPD for each stock as shown below for both companies.

<u>Apple Inc:</u>

AAPL	α = 0.60	(β=0.16)	TREND(β=0.16)	Forecast ((β=0.16)	MAPD	(β=0.36)	TREND(β=0.36)	Forecast(β=0.36)	MAPD	(β=0.66)	TREND (β=0.66)	Forecast (β=0.66)	MAPD	(β=0.86)	TREND (β=0.86)	Forecast (β=0.86)	MAPD
0.6	63.95	0.16	0	63.95	0	0.36	0	63.95	0	0.66	0	63.95	0	0.86	0	63.95	0
	63.95454		0	63.95	0.506447		0	63.95	0.506447		0	63.95	0.506447		0	63.95	0.506447
	64.25841		0.04861891	64.31	0.094947		0.10939255	64.37	0.034173		0.200553012	64.46	0.056987		0.261326652	64.52	0.117761
	64.34455		0.0546222	64.40	0.619877		0.10102145	64.45	0.573478		0.125040081	64.47	0.549459		0.110665684	64.46	0.563834
	64.74925		0.11063459	64.86	0.290726		0.21034558	64.96	0.390437		0.309615358	65.06	0.489707		0.363534845	65.11	0.543626
	64.6412		0.07564429	64.72	0.619371		0.09572146	64.74	0.599294		0.033953078	64.68	0.661062		-0.04203222	64.60	0.737048
	65.05821		0.13026269	65.19	0.477166		0.21138508	65.27	0.396043		0.286770181	65.34	0.320658		0.352743483	65.41	0.254685
	65.42266		0.16773377	65.59	0.123889		0.26649094	65.69	0.222647		0.338043427	65.76	0.294199		0.362817037	65.79	0.318973
	65.44897		0.14510541	65.59	0.889699		0.18002457	65.63	0.924618		0.1322971	65.58	0.87689		0.073418033	65.52	0.818011
	65.00221		0.05040759	65.05	0.638353		-0.04561643	64.96	0.542329		-0.24987793	64.75	0.338067		-0.37393161	64.63	0.214014
	64.64945		-0.01410037	64.64	0.277619		-0.1561907	64.49	0.135528		-0.31778484	64.33	0.026066		-0.35573021	64.29	0.064011
	64.47441		-0.03984935	64.43	1.051603		-0.16297338	64.31	1.174727		-0.22356762	64.25	1.235321		-0.2003293	64.27	1.212083
	65.08147		0.06365487	65.15	0.170307		0.11423576	65.20	0.220887		0.324641336	65.41	0.431293		0.494018627	65.58	0.60067
	65.01748		0.04323153	65.06	0.786858		0.05007413	65.07	0.780015		0.068143997	65.09	0.761945		0.014130351	65.03	0.815959
	65.51553		0.11600306	65.63	0.070983		0.21134674	65.73	0.024361		0.351884336	65.87	0.164899		0.430304346	65.95	0.243319
	65.62772		0.1153932	65.74	0.800273		0.17565083	65.80	0.860531		0.193687025	65.82	0.878567		0.156727247	65.78	0.841607
	65.21679		0.03118184	65.25	1.463059		-0.03551748	65.18	1.396359		-0.20535878	65.01	1.226518		-0.33145611	64.89	1.100421
	64.35767		-0.11126744	64.25	0.101494		-0.3320166	64.03	0.322243		-0.63684523	63.72	0.627071		-0.78525233	63.57	0.775479
	64.3518		-0.09440293	64.26	1.034546		-0.21460175	64.14	1.154745		-0.22039778	64.13	1.160541		-0.11497858	64.24	1.055122
	64.91589		0.01095532	64.93	1.626287		0.06572587	64.98	1.571517		0.297361579	65.21	1.339881		0.469017044	65.38	1.168225
	65.89823		0.16637774	66.06	0.443228		0.39570892	66.29	0.672559		0.749450927	66.65	1.026301		0.910479464	66.81	1.18733
	65.73212		0.11317969	65.85	0.159594		0.1934541	65.93	0.07932		0.145180699	65.88	0.127593		-0.0153875	65.72	0.288161
	65.89579		0.12125725	66.02	0.55084		0.1827298	66.08	0.489368		0.157379935	66.05	0.514718		0.138597126	66.03	0.5335
	66.29905		0.16637746	66.47	0.272094		0.26212015	66.56	0.176351		0.319659825	66.62	0.118811		0.366205956	66.67	0.072265
	66.56213		0.18185028	66.74	0.900727		0.26246664	66.82	0.820111		0.282318871	66.84	0.800259		0.277519889	66.84	0.805058
	67.21168		0.25668167	67.47	1.334277		0.40181537	67.61	1.189144		0.524689073	67.74	1.06627		0.597462731	67.81	0.993496
	68.16625		0.36834466	68.53	0.403255		0.60080898	68.77	0.170791		0.808414035	68.97	0.036814		0.904579609	69.07	0.13298
	68.62921		0.38348308	69.01	0.239562		0.55118325	69.18	0.407262		0.580414208	69.21	0.436493		0.524786532	69.15	0.380866
	68.71556		0.33594218	69.05	0.209541		0.38384418	69.10	0.257443		0.254333481	68.97	0.127932		0.147733265	68.86	0.021332
	68.7914		0.29432596	69.09	0.386343		0.272296297	69.06	0.36498		0.136528312	68.93	0.228546		0.085905745	68.88	0.177923
	68.73619		0.23840013	68.97	0.845848		0.15482053	68.89	0.929427		0.009980709	68.75	1.074267		-0.03545421	68.70	1.119702
	69.38674		0.30434392	69.69	0.195731		0.333328271	69.72	0.166792		0.432755654	69.82	0.06732		0.554508386	69.94	0.054433
	69.68679		0.30365611	69.99	1.282948		0.32131718	70.01	1.265287		0.345166704	70.03	1.241437		0.33566998	70.02	1.250934
	70.63875		0.40738513	71.05	0.200218		0.54834947	71.19	0.059253		0.745651896	71.38	0.138049		0.865681504	71.50	0.258079
	71.00331		0.40053336	71.40	0.265367		0.48218583	71.49	0.183714		0.494132287	71.50	0.171768		0.434718369	71.44	0.231182
	71.40285		0.40037443	71.80	0.389637		0.45243334	71.86	0.337578		0.431701399	71.83	0.35831		0.404464999	71.81	0.385546
	71.87686		0.41215558	72.29	1.551028		0.46019972	72.34	1.502984		0.45962284	72.34	1.503561		0.464270787	72.34	1.498913
	73.05477		0.53467629	73.59	0.467291		0.71857544	73.77	0.65119		0.933692395	73.99	0.866307		1.078000549	74.13	1.010615
	73.0952		0.45559708	73.55	0.154022		0.47444352	73.57	0.135176		0.344140018	73.44	0.265479		0.185690924	73.28	0.423928
	73.46097		0.44122498	73.90	0.544011		0.43532159	73.90	0.538108		0.358416788	73.82	0.461203		0.340560208	73.80	0.443347
	73.3993		0.3607615	73.76	0.778178		0.25640397	73.66	0.882535		0.081158316	73.48	1.057781		-0.00535932	73.39	1.144299
	74.08266		0.41237785	74.50	1.626457		0.41010946	74.49	1.628725		0.478613855	74.56	1.560221		0.586942458	74.67	1.451892
	75.30596		0.54212553	75.85	0.445489		0.70285837	76.01	0.284757		0.970107286	76.28	0.017508		1.134210693	76.44	0.146596
	75.89853		0.55019648	76.45	1.474808		0.66315418	76.56	1.361851		0.720931983	76.62	1.304073		0.668398793	76.57	1.356606
	77.11354		0.65656552	77.77	0.898779		0.86181975	77.98	1.104033		1.047018841	78.16	1.289232		1.138478393	78.25	1.380691
	76.96821		0.52826259	77.50	0.954586		0.49924663	77.47	0.92557		0.260070052	77.23	0.686393		0.03440506	77.00	0.460728

Below snapshot shows the forecasted value for 253rd period along with the average MAPD value.

Adjusted Exponential Smoothing - AAPL		
Beta	**253rd value**	**MAPD**
0.16	118.42	1.95%
0.36	119.34	1.94%
0.66	119.70	1.97%
0.86	119.43	2.03%

Here, we see that for **beta=0.36**, we have the least MAPD value which indicates that we have the accurate forecast for 253rd value for **alpha=0.36**. MAPD value indicates how far are the data points from the mean value. Lower MAPD value indicated that the mean is more clustered and hence more accurate and predictable. Hence the forecast is more accurate.

<u>Honeywell Inc:</u>

HON	α = 0.60	(β=0.16)	TREND(β=0.16)	Forecast ((β=0.16)	MAPD	(β=0.36)	TREND(β=0.36)	Forecast(β=0.36)	MAPD	(β=0.66)	TREND (β=0.66)	Forecast (β=0.66)	MAPD	(β=0.86)	TREND (β=0.86)	Forecast (β=0.86)	MAPD
0.6	177.03	0.16	0	177.03	0	0.36	0	177.03	0	0.66	0	177.03	0	0.86	0	177.03	0
	177.0294		0	177.03	0.371231		0	177.03	0.371231		0	177.03	0.371231		0	177.03	0.371231
	176.8066		-0.03563818	176.77	1.039917		-0.0801859	176.73	1.084464		-0.14700748	176.66	1.151286		-0.1915552	176.62	1.195834
	177.4092		0.06647468	177.48	0.276643		0.1656052	177.57	0.177512		0.347711784	177.76	0.004594		0.49139003	177.90	0.148273
	177.6151		0.088778	177.70	1.326042		0.1801007	177.80	1.417365		0.254096513	177.87	1.491361		0.245843203	177.86	1.483107
	176.8727		-0.04420382	176.83	1.61105		-0.15198458	176.72	1.718831		-0.40356374	176.47	1.97041		-0.60401019	176.27	2.170857
	177.8128		0.11328604	177.93	1.401037		0.24116869	178.05	1.52892		0.483259499	178.30	1.771011		0.723931311	178.54	2.011683
	177.0402		-0.02846386	177.01	0.172458		-0.12380635	176.92	0.077115		-0.34564134	176.69	0.14472		-0.56312936	176.48	0.362208
	176.9196		-0.04319812	176.88	2.884339		-0.12263513	176.80	2.804902		-0.197083	176.72	2.730454		-0.18251364	176.74	2.745023
	175.1631		-0.31732993	174.85	1.53113		-0.71083439	174.45	1.137625		-1.22631273	173.94	0.622147		-1.53616081	173.63	0.312299
	174.054		-0.44400927	173.61	0.04011		-0.8542013	173.20	0.370082		-1.14893635	172.91	0.664817		-1.16886769	172.89	0.684749
	173.7635		-0.4194432	173.34	0.049107		-0.6512585	173.11	0.182708		-0.58234943	173.18	0.113799		-0.41344681	173.35	0.055104
	173.4824		-0.39731314	173.09	2.183282		-0.51801236	172.96	2.303981		-0.38354482	173.10	2.169514		-0.29965463	173.18	2.085623
	174.554		-0.16229003	174.39	1.760284		0.05424135	174.61	1.543752		0.576838399	175.13	1.021155		0.879608243	175.43	0.718385
	175.5128		0.01708375	175.53	0.232027		0.37988106	175.89	0.594825		0.828930487	176.34	1.043874		0.947709807	176.46	1.162653
	175.3838		-0.00628424	175.38	4.232632		0.19669606	175.58	4.435613		0.196718702	175.58	4.435635		0.021768478	175.41	4.260685
	172.8405		-0.41221474	172.43	3.02113		-0.78972047	172.05	2.643624		-1.61172655	171.23	1.821618		-2.1842333	170.66	1.249111
	170.7805		-0.67586146	170.10	0.049496		-1.24702353	169.53	0.521666		-1.90759148	168.87	1.182234		-2.07739846	168.70	1.352041
	170.3453		-0.63735798	169.71	1.13263		-0.95477235	169.39	1.450044		-0.9358228	169.41	1.431095		-0.66512043	169.68	1.160392
	170.6424		-0.4878346	170.15	2.109558		-0.50407558	170.14	2.125799		-0.12205209	170.52	1.743776		0.162443424	170.80	1.45928
	171.6155		-0.25409558	171.36	0.049562		0.02768396	171.64	0.331341		0.600704892	172.22	0.904362		0.859551533	172.48	1.163209
	171.4333		-0.24259141	171.19	0.32069		-0.04787229	171.39	0.515409		0.083991293	171.52	0.647272		-0.03635006	171.40	0.526931
	171.0953		-0.25785176	170.84	1.966651		-0.15230696	170.94	1.861107		-0.19450224	170.90	1.903302		-0.295742	170.80	2.004542
	172.1206		-0.05255072	172.07	2.09096		0.27162426	172.39	1.766785		0.610553881	172.73	1.427855		0.840336713	172.96	1.198072
	173.3436		0.15154465	173.50	0.261277		0.61413584	173.96	0.201314		1.01479822	174.36	0.601977		1.169466101	174.51	0.756645
	173.5913		0.16692837	173.76	0.571243		0.48221639	174.07	0.886531		0.508508723	174.10	0.912823		0.376741167	173.97	0.781056
	173.3487		0.10140565	173.45	0.03141		0.22128658	173.57	0.088471		0.012784469	173.36	0.120031		-0.15588246	173.19	0.288698
	173.4284		0.09793101	173.53	2.067281		0.1703115	173.60	2.139661		0.056941557	173.49	2.026291		0.046709122	173.48	2.016059
	172.2468		-0.10679554	172.14	1.145182		-0.31638022	171.93	1.354766		-0.76050243	171.49	1.798888		-1.00964527	171.24	2.048031
	172.8698		0.0099768	172.88	0.317014		0.02180805	172.89	0.305182		0.152630045	173.02	0.17436		0.394456858	173.26	0.067466
	173.066		0.0397716	173.11	0.110663		0.08458708	173.15	0.065847		0.18138242	173.25	0.030948		0.223951015	173.29	0.073517
	173.1563		0.04784982	173.20	0.105489		0.08662951	173.24	0.144269		0.121241953	173.28	0.178881		0.108977172	173.27	0.166617
	173.1217		0.03466047	173.16	0.5019		0.04299279	173.16	0.493567		0.018397088	173.14	0.518163		-0.01448509	173.11	0.551045
	173.4436		0.08062458	173.52	0.2587		0.1434124	173.59	0.321488		0.218732875	173.66	0.396809		0.274837185	173.72	0.452913
	173.3368		0.05062936	173.39	0.180805		0.05331955	173.39	0.183495		0.003851124	173.34	0.134026		-0.05340996	173.28	0.076765
	173.2587		0.03003183	173.29	0.487341		0.00600663	173.26	0.511366		-0.05024006	173.21	0.567613		-0.07464788	173.18	0.592021
	173.5691		0.07489453	173.64	3.853033		0.11559678	173.68	3.81233		0.187798031	173.76	3.740129		0.256513691	173.83	3.671413
	175.9259		0.43999241	176.37	0.763659		0.9224142	176.85	1.24608		1.619310479	177.55	1.942977		2.062722322	177.99	2.386388
	175.7317		0.33852168	176.07	1.793397		0.5204332	176.25	1.975309		0.42239377	176.15	1.877269		0.121769395	175.85	1.576645
	174.8587		0.14469016	175.00	0.628465		0.01882415	174.88	0.502599		-0.4325168	174.43	0.051258		-0.73366802	174.13	0.249893
	174.5685		0.07509732	174.64	0.121344		-0.09244798	174.48	0.046201		-0.33863068	174.23	0.292384		-0.35234152	174.22	0.306094
	174.5407		0.05864203	174.60	1.209007		-0.06915608	174.47	1.336805		-0.13344827	174.41	1.401097		-0.0731913	174.47	1.34084
	175.3013		0.17095363	175.47	0.046813		0.22955233	175.53	0.105412		0.456616659	175.76	0.332476		0.64386019	175.95	0.51972
	175.3758		0.15551855	175.53	2.436969		0.17372788	175.55	2.418759		0.204409369	175.58	2.388078		0.154197011	175.53	2.43829
	176.9313		0.37951436	177.31	0.147588		0.67116309	177.60	0.439237		1.096124143	178.03	0.864198		1.359311012	178.29	1.127385

Below snapshot shows the forecasted value for 253rd period along with the average MAPD value.

Adjusted Exponential Smoothing - HON		
Beta	**253rd value**	**MAPD**
0.16	184.56	0.47%
0.36	185.49	1.77%
0.66	185.37	1.74%
0.86	185.11	1.75%

Here, we see that for **beta=0.16**, we have the least MAPD value which indicates that we have the accurate forecast for 253rd value for **alpha=0.16**. MAPD value indicates how far are the data points from the mean value. Lower MAPD value indicated that the mean is more clustered and hence more accurate and predictable. Hence the forecast is more accurate.

Part 2: Long-term Forecasting

(i) For each stock, use a 5-period weighted moving averages to forecast its value during periods 1 through 100. Use the weights 0.4 (for the most recent period), 0.3 (for the period before the most recent), and 0.1 (for three, four and five periods ago). Next, use the observed value for period 101 as the base of a linear trend, and use that linear trend to forecast the values of both stocks for periods 101 through 257. Write a summary of your results in your report. Describe how accurate this method of forecasting has been by comparing the forecasted values for periods 253-257 with their actual "Close" values on those specific days (Hint: check the actual values on https://finance.yahoo.com).

To calculate the weighted moving average for each stock for 5 periods, I have used 0.4 for 6th period, 0.3 for 5th period, 0.1 for 4th, 3rd, 2nd periods. Subsequently increasing it for remaining periods until 101. From period 101 to 257, I have used the trend() function to forecast the values. From period 253 to 257, I have calculated the actual close value for both the companies from the website: https://www.wsj.com/market-data/quotes/HON/historical-prices and https://www.wsj.com/market-data/quotes/AAPL/historical-prices.

Below shows the table of actual closing values for AAPL and HON for the period 253 to 257.

Date	Period	AAPL Actual closing price	HON closing price
11/9/20	253	116.32	196.99
11/10/20	254	115.97	201.98
11/11/20	255	119.49	199.29
11/12/20	256	119.21	197.24
11/13/20	257	119.26	201.54

Apple Inc:

Below shows the weighted average forecasted value for Apple Inc from 1 to 100 period.

AAPL	Forecast 5 period weigted average
	NA
	NA
	NA
	NA
	NA
	64.6151306
	64.8934348
	65.2661361
	65.3787353
	65.0788031
	64.8238553
	64.6510229
	64.9603004
	64.9834135
	65.2572868
	65.5171465
	65.3187457
	64.6493082
	64.5239241
	64.8641735
	65.5164012
	65.5569684
	65.7076714
	66.1752699
	66.4833143
	66.898555
	67.7454963
	68.310942
	68.5090941
	68.7072449
	68.7837061
	69.1932877
	69.5323082
	70.2115816
	70.7212235
	71.1396559
	71.6185651
	72.6127714
	72.911717
	73.1887855
	73.3702256

Below shows the linear trend forecasted value from period 101 to 257 by using the observed value through this period.

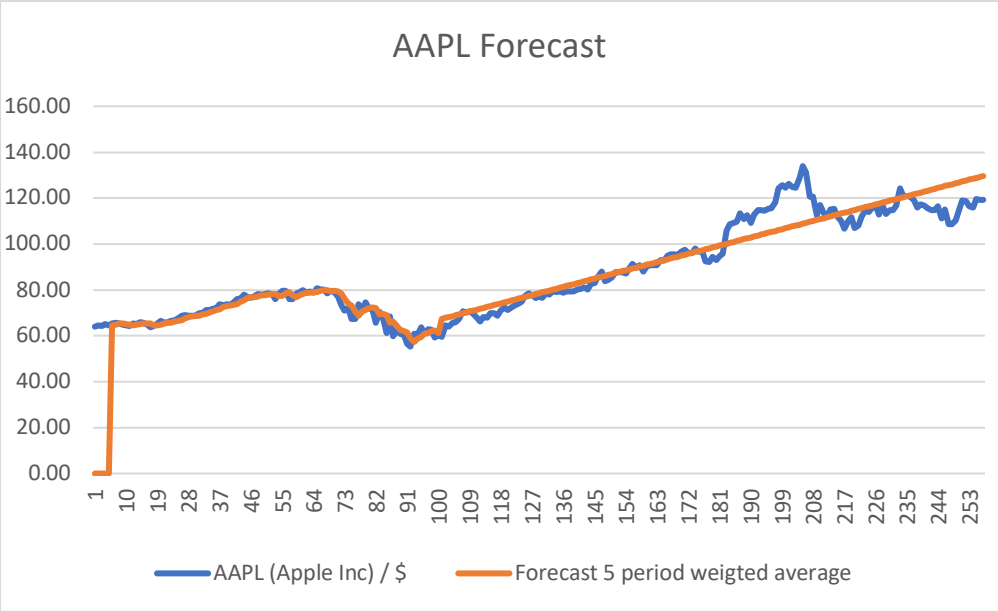
61.2994854
67.3849057
67.78379557
68.18268544
68.5815753
68.98046517
69.37935504
69.77824491
70.17713478
70.57602464
70.97491451
71.37380438
71.77269425
72.17158412
72.57047398
72.96936385
73.36825372
73.76714359
74.16603346
74.56492332
74.96381319
75.36270306
75.76159293
76.1604828
76.55937267
76.95826253
77.3571524
77.75604227
78.15493214
78.55382201
78.95271187
79.35160174

Here, we see that the trend is increasing over the period. The forecasted value is linearly increasing from period 101 to 257.

Below table shows the comparison of actual value with the forecasted value for the period 253 – 257.

Date	Period	AAPL Actual closing price	AAPL forecasted closing price
11/9/20	253	116.32	128.0161656
11/10/20	254	115.97	128.4150555
11/11/20	255	119.49	128.8139454
11/12/20	256	119.21	129.2128352
11/13/20	257	119.26	129.6117251

Here, we see that the forecasted value is higher for the period 253-257 when compared to the actual close values.



As seen from the graph above, the observed value and the forecasted 5 period weighted average value are trending almost similarly except we see a steep rise in observed value from period 190 to 199. Hence, we can see a good accuracy in the model.

<u>Honeywell Inc:</u>

Below shows the weighted average forecasted value for Honeywell Inc from 1 to 100 period.

HON	Forecast 5 period weigted average
	NA
	NA
	NA
	NA
	NA
	177.0266617
	177.5113038
	177.336
	176.9501893
	175.7828509
	174.7038666
	174.1579912
	173.8035661
	174.183516
	175.0592668
	175.1780673
	173.5188586
	171.7781511
	171.1036623
	170.9377365
	171.2185333
	171.2342407
	171.0575104
	171.8242781
	172.9494123
	173.2488569
	173.1850354
	173.4206648
	172.7383271
	172.7942903
	173.0770447
	173.0682098
	172.9985046
	173.3627471
	173.354898
	173.2596541
	173.4746581
	175.1446793
	175.5148177
	174.8393506
	174.7205563

Below shows the linear trend forecasted value from period 101 to 257 by using the observed value through this period.

129.7956508
130.0999532
130.4042557
130.7085581
131.0128605
131.317163
131.6214654
131.9257678
132.2300703
132.5343727
132.8386751
133.1429776
133.44728
133.7515824
134.0558849
134.3601873
134.6644897
134.9687921
135.2730946
135.577397
135.8816994
136.1860019
136.4903043
136.7946067
137.0989092
137.4032116
137.707514
138.0118165
138.3161189
138.6204213
138.9247237
139.2290262
139.5333286
139.837631
140.1419335
140.4462359
140.7505383
141.0548408
141.3591432

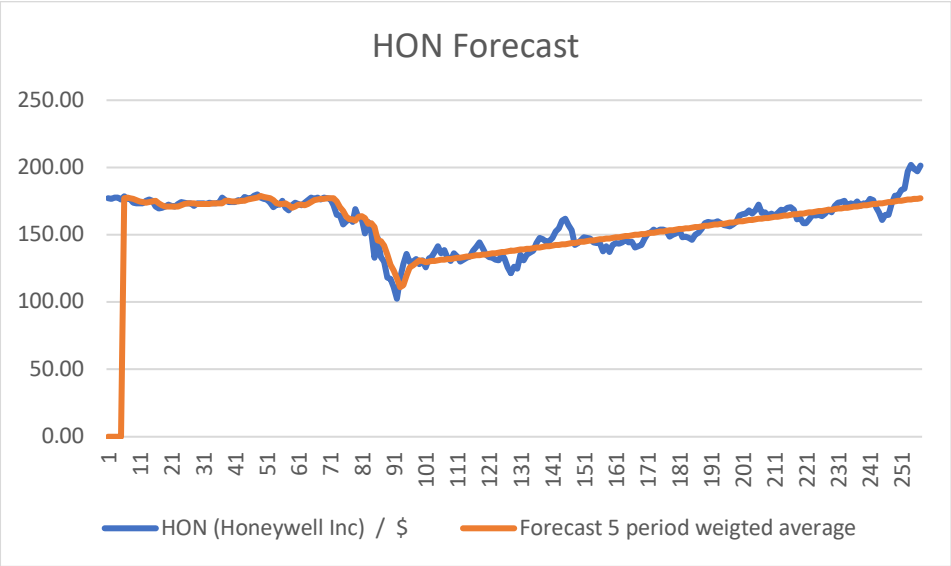
Here, we see that the trend is increasing over the period. The forecasted value is linearly increasing from period 101 to 257.

Below table shows the comparison of actual value with the forecasted value for the period 253 – 257.

Date	Period	HON closing price	HON forecasted closing price
11/9/20	253	196.99	176.0496204
11/10/20	254	201.98	176.3539228
11/11/20	255	199.29	176.6582252
11/12/20	256	197.24	176.9625276
11/13/20	257	201.54	177.2668301

Here, we see that the forecasted value is lower for the period 253-257 when compared to the actual close values.

As seen from the graph below, the observed value and the forecasted 5 period weighted average value are trending almost similarly except we see a rise in observed value from period 241 to 257 Hence, we can see a good accuracy in the model.



(ii) Calculate the MAPEs (Mean Absolute Percentage Error) of your forecasts in question (i) above and compare them with the values obtained for your forecasts in Part 1. For each stock, describe which method has yielded a most accurate forecast.

MAPE is calculated for each period for both the companies and is shown below.

<u>Apple Inc:</u>

AAPL	Forecast 5 period weigted average	MAPE
	NA	
	NA	
	NA	
	NA	
	NA	
	64.6151306	0.01103647
	64.8934348	0.01175956
	65.2661361	0.00306066
	65.3787353	0.01042216
	65.0788031	0.01031658
	64.8238553	0.00724277
	64.6510229	0.012753
	64.9603004	0.00022339
	64.9834135	0.01312351
	65.2572868	0.00677643
	65.5171465	0.00884325
	65.3187457	0.0240469
	64.6493082	0.00468415
	64.5239241	0.01176289
	64.8641735	0.02537758
	65.5164012	0.00159983
	65.5569684	0.00678631
	65.7076714	0.01292237
	66.1752699	0.00842477
	66.4833143	0.01716901
	66.898555	0.02767452
	67.7454963	0.01729608
	68.310942	0.0067205
	68.5090941	0.00483529
	68.7072449	0.00011438
	68.7837061	0.0148486
	69.1932877	0.00992362
	69.5323082	0.02442824
	70.2115816	0.01452385
	70.7212235	0.01322728
	71.1396559	0.0145888
	71.6185651	0.03008499
	72.6127714	0.00696619
	72.911717	0.01076052
	73.1887855	0.00230921
	73.3702256	0.01566999
	73.8894526	0.02932214

The net MAPE value is 3.8%. MAPE value lesser than 5 % is an indication that the forecast is acceptably accurate. Since 3.8% is lesser than 5%, we can consider that the forecasted value for Apple Inc is accurate.

0.07063656
0.07521504
3.8%

<u>Honeywell Inc:</u>

HON	Forecast 5 period weigted average	MAPE
	NA	
	NA	
	NA	
	NA	
	NA	
	177.0266617	0.0079181
	177.5113038	0.0055869
	177.336	0.0028091
	176.9501893	0.0170014
	175.7828509	0.0142412
	174.7038666	0.0065332
	174.1579912	0.0049799
	173.8035661	0.0083576
	174.183516	0.0111749
	175.0592668	0.001361
	175.1780673	0.0235657
	173.5188586	0.0242713
	171.7781511	0.0101322
	171.1036623	0.0015402
	170.9377365	0.0076999
	171.2185333	0.0005444
	171.2342407	0.0021318
	171.0575104	0.0101073
	171.8242781	0.0134056
	172.9494123	0.0046446
	173.2488569	0.0003572
	173.1850354	0.0017091
	173.4206648	0.0114407
	172.7383271	0.0031558
	172.7942903	0.0023241
	173.0770447	0.0008049
	173.0682098	0.0001758
	172.9985046	0.0037992
	173.3627471	0.0005609
	173.354898	0.0008561
	173.2596541	0.0029717
	173.4746581	0.0226617
	175.1446793	0.0026055
	175.5148177	0.0071038
	174.8393506	0.0026631
	174.7205563	0.0011364
	174.8589872	0.0054002

The net MAPE value is 2.8%. MAPE value lesser than 5 % is an indication that the forecast is acceptably accurate. Since 2.8% is lesser than 5%, we can consider that the forecasted value for Honeywell Inc is accurate.

0.0427705	
0.0462619	
2.8%	

Here, we see that for both Apple Inc and Honeywell Inc, the MAPE value is comparatively higher using trend-based forecasting when compared to exponential smoothing based forecasting.

In exponential smoothing based forecasting, we received a MAPE value of 1.96% and in trend- based forecasting, we received a MAPE value of 3.8% for Apple Inc. Similarly, for Honeywell Inc, we received a MAPE value of 1.88% in exponential smoothing based forecasting whereas we received a MAPE value of 2.8% in trend-based forecasting.

Hence, we can conclude that exponential smoothing based forecasting has yielded a better forecasted values when compared to trend-based forecasting.

Part 3: Regression

(i) For each stock, use simple regression of stock values versus the time periods to predict its values for periods 1 through 257. In your report, describe how the accuracy of this prediction has been compared to the methods used in Parts 1 and 2 of this project.

Below snapshot shows the predicted and residual values for each stock prices of Apple Inc and Honeywell Inc.

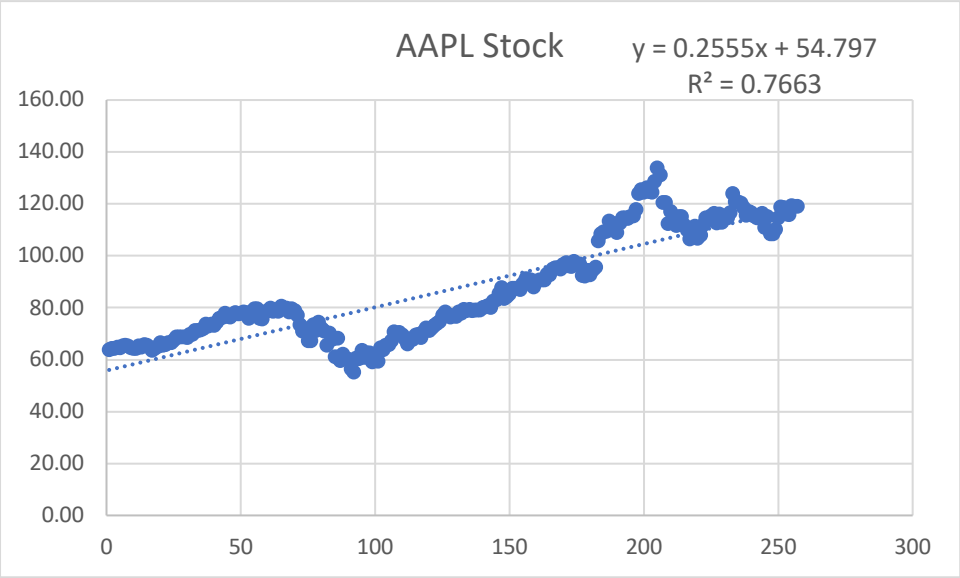
Predicted y AAPL	Residual AAPL	Predicted y HON	Residual HON
56.04	7.91	159.8993522	17.13
56.29	8.17	159.8883479	16.77
56.53	7.87	159.8773436	17.93
56.77	8.24	159.8663393	17.89
57.02	7.55	159.855335	16.52
57.26	8.07	159.8443307	18.60
57.51	8.16	159.8333264	16.69
57.75	7.72	159.8223221	17.02
57.99	6.71	159.8113178	14.18
58.24	6.18	159.8003135	13.51
58.48	5.88	159.7893092	13.78
58.73	6.76	159.7783049	13.52
58.97	6.01	159.7673006	15.50
59.21	6.63	159.7562963	16.40
59.46	6.25	159.745292	15.55
59.70	5.24	159.7342877	11.41
59.94	3.84	159.7232834	9.68
60.19	4.16	159.7122791	10.34
60.43	4.86	159.7012748	11.14
60.68	5.88	159.6902705	12.57
60.92	4.70	159.6792662	11.63
61.16	4.84	159.6682619	11.20
61.41	5.16	159.6572576	13.15
61.65	5.09	159.6462533	14.51
61.89	5.75	159.635249	14.12
62.14	6.66	159.6242447	13.56
62.38	6.56	159.6132404	13.87
62.63	6.15	159.6022361	11.86
62.87	5.97	159.5912318	13.69
63.11	5.59	159.5802274	13.62
63.36	6.46	159.5692231	13.65
63.60	6.29	159.5582188	13.54
63.84	7.43	159.5472145	14.11

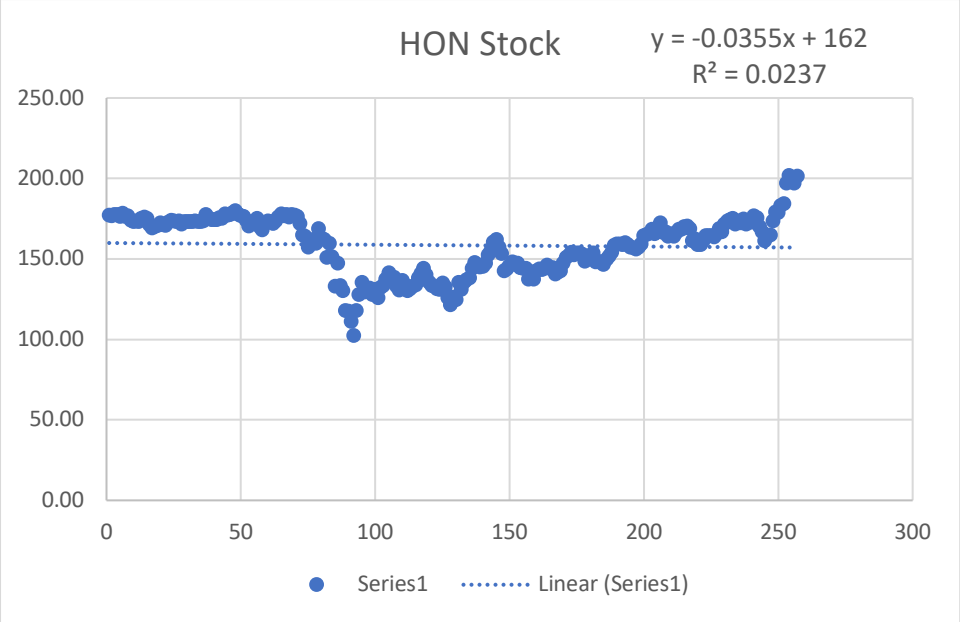
As per the below snapshot, I have calculated the slope, intercept, correlation, determination, residual mean and residual standard deviation for Apple Inc and Honeywell Inc. We see a correlation determination value of 77% for Apple Inc which states that stock price which is the dependent variable and time period which is independent variable are highly connected.

Any changes in the stock price are due to the changes that occur in the time period. We see a low correlation determination value of 0.2% for Honeywell Inc which states that stock price is not tightly connected to the time period. Any changes in stock price are not necessarily due to the changes in period. There can be other factors that affect the changes.

AAPL	Slope	0.243761718
	Intercept	55.79990484
	Correlation R	0.878696445
	Determination R2	0.7721
	Residual mean	0.00
	Resudual standard deviation	9.84
HON	Slope	-0.011004301
	Intercept	159.9103565
	Correlation R	-0.045462441
	Determination R2	0.0021
	Residual mean	0.00
	Residual standard deviation	17.9741

Below shows the scatterplot for Apple Inc and Honeywell Inc along with linear regression equation and determination value.





As inferred earlier, we see a strong correlation trend for Apple Inc whereas we see no correlation trend for Honeywell Inc.

The MAPE value of the predicted value for Apple Inc is 10% and for Honeywell Inc is 10% as generated in excel file. Since the value is greater than 5%, we say this forecasting method is not very accurate when compared to exponential smoothing and trend-based forecasting.

From all the 3 methods, we can conclude that exponential smoothing is the best forecasting method to opt for since it has generated the least MAPE value which gives accurate results.

(ii) Perform a residual analysis of your simple regression to verify whether regression is
appropriate to use for each of the given data. In particular, determine:
● Whether the residuals are independent
● Whether the residuals are homoscedastic.
● Whether the residuals are normally distributed by plotting a Normal probability plot of the residuals
● Whether the residuals are normally distributed by performing a Chi-squared test for Normality of the residuals.

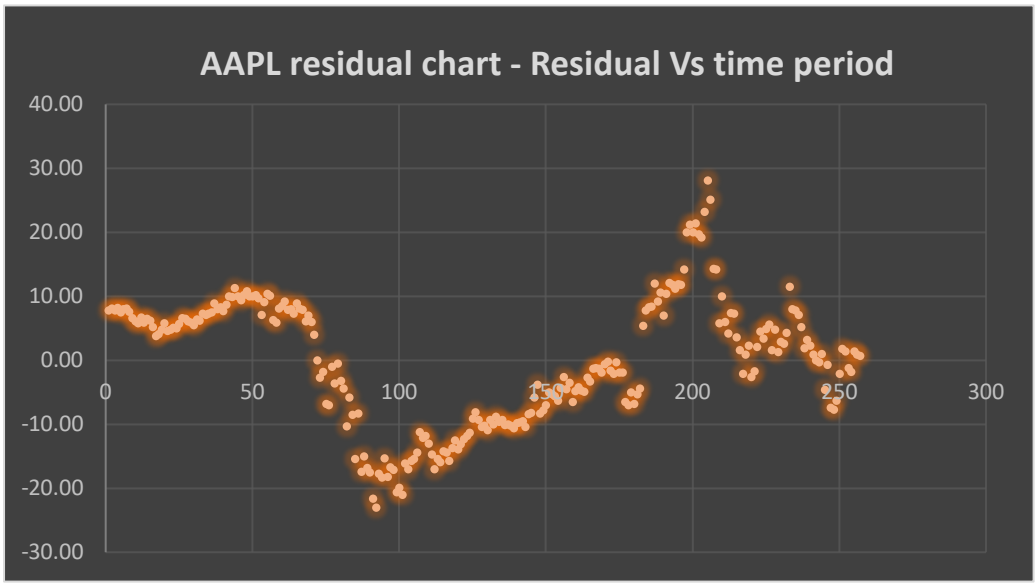
For the regression model to be a legitimate model, residuals must satisfy 4 conditions:

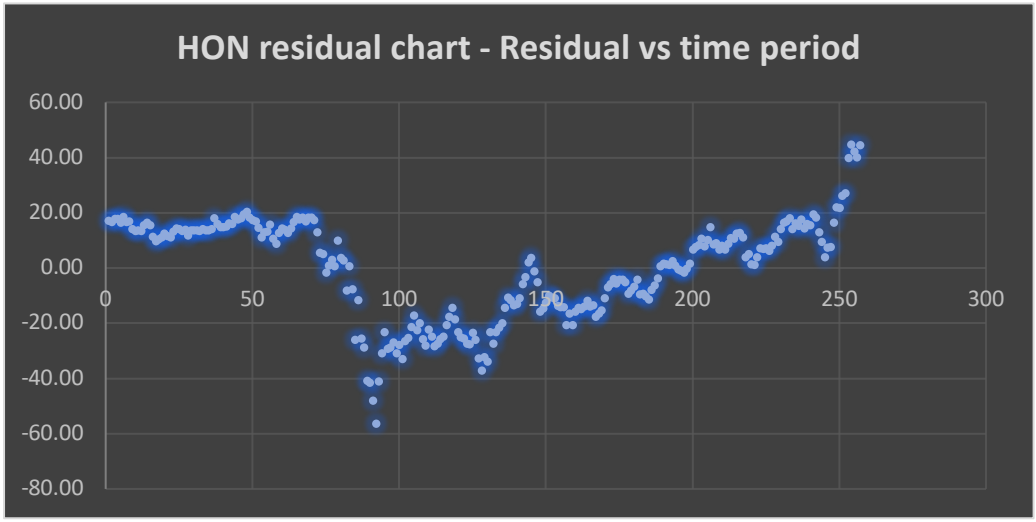
- Residuals must be normally distributed
- Residuals must have zero mean
- Residuals must have constant variance(homoscedastic)
- Residuals are independent

As per above, the residual mean is equal to 0 in both the cases i.e. for Apple Inc and for Honeywell Inc.

<u>To check if the residual is independent</u>

In the below graph, I have plotted residual vs time period to check for independency.

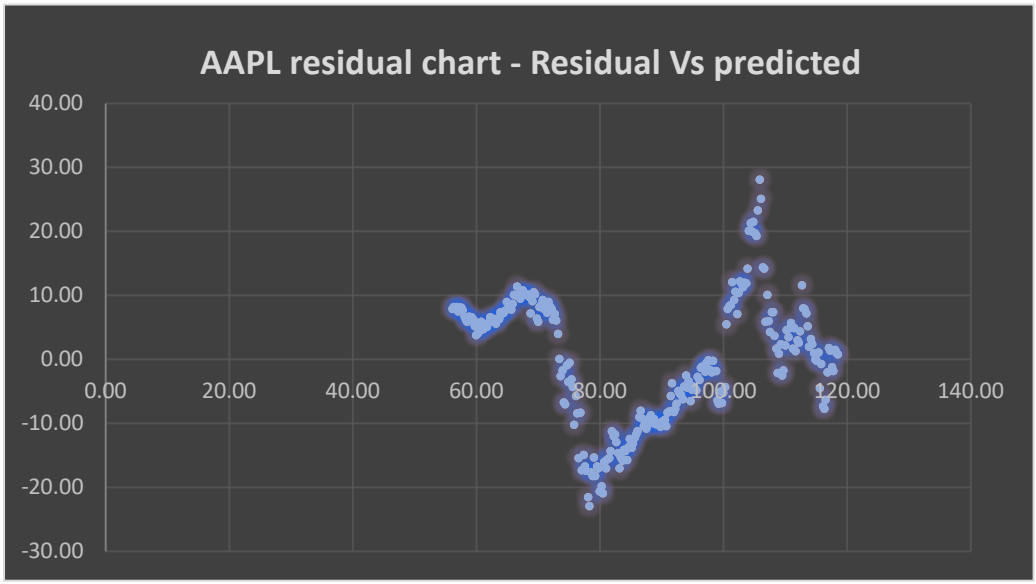


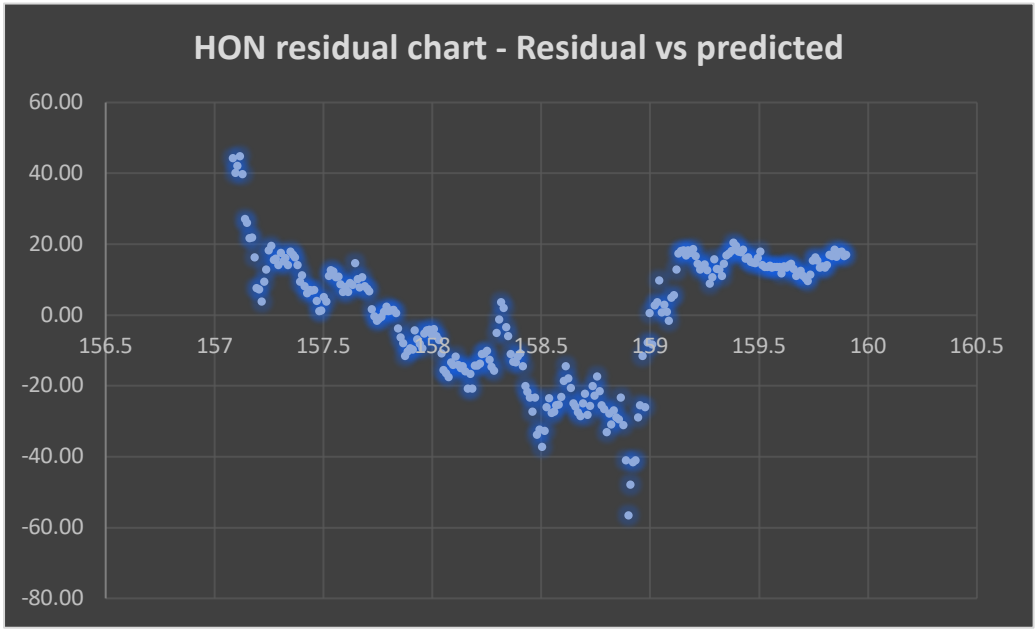


Here, we can infer that the residuals are not independent because it is follows some pattern. Residual is related to other variables and not just time period.

<u>To check if residual is homoscedastic</u>

The graph below checks if residuals have constant variance i.e. homoscedasticity. I have plotted residuals vs the predicted values.

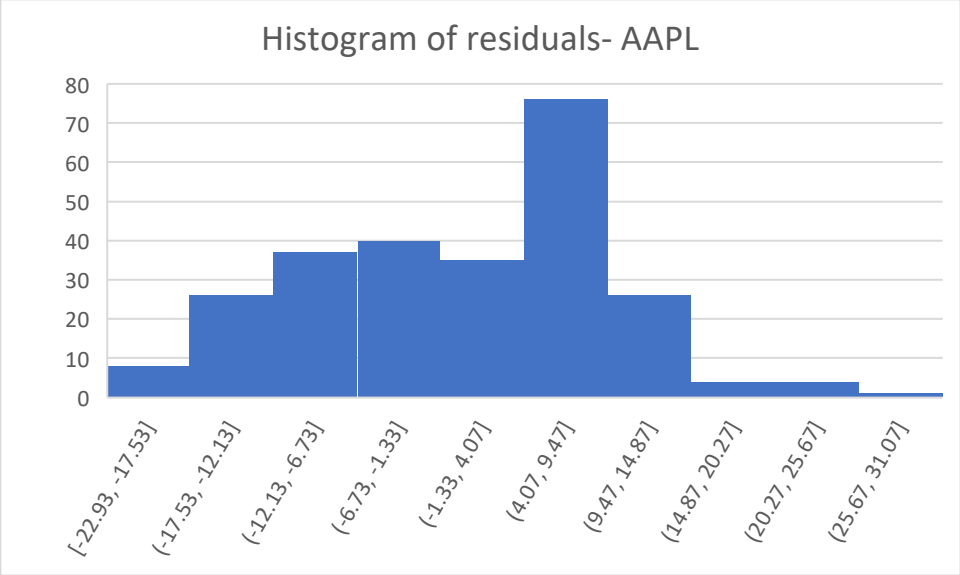


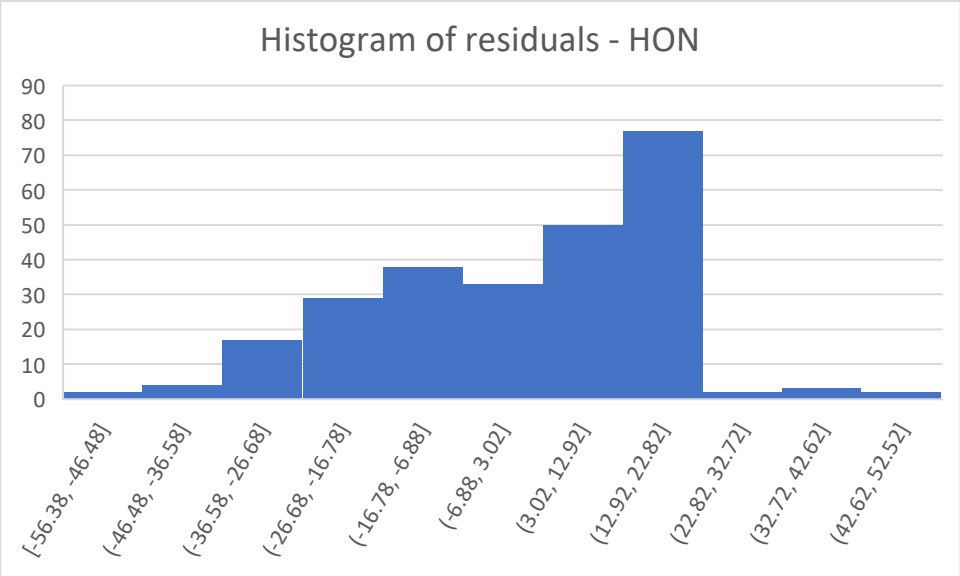


Here, we see that there is some pattern that exist in the residual vs predicted plot for both the companies and are scattered uniformly. Hence, we can say that the residuals are homoscedastic.

<u>To check if residuals are normally distributed</u>

First step is to create a histogram of the residuals to check the frequency of the data points for both the companies and to confirm if it follows a normal distribution curve.





From the above 2 histogram charts, we can infer that it necessarily is not following a normal distribution curve.

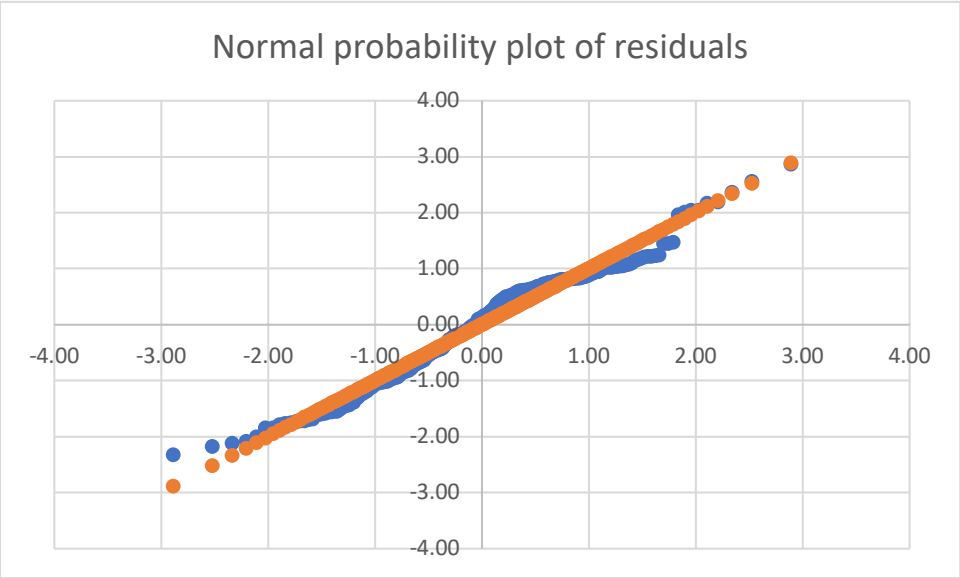
Second method is to create a normal probability plot to check if residuals are normally distributed

<u>Apple Inc:</u>

Here, to plot the graph, I must first calculate the standardized residuals, ranks, cumulative area, and standard z value. Below table shows the calculated value for the same.

AQ	AR	AS	AT	AU	AV
AAPL	Residual AAPL	Standardized residuals- AAPL	Ranks I - AAPL	Cummulative area - (I-0.5/)n	Standard z value
	-23.01	-2.19	1	0.001945525	-2.89
	-21.56	-2.06	2	0.005836576	-2.52
	-21.11	-2.01	3	0.009727626	-2.34
	-20.73	-1.98	4	0.013618677	-2.21
	-19.99	-1.91	5	0.017509728	-2.11
	-18.31	-1.75	6	0.021400778	-2.03
	-18.28	-1.74	7	0.025291829	-1.95
	-17.72	-1.69	8	0.029182879	-1.89
	-17.47	-1.67	9	0.03307393	-1.84
	-17.34	-1.65	10	0.036964981	-1.79
	-17.28	-1.65	11	0.040856031	-1.74
	-17.19	-1.64	12	0.044747082	-1.70
	-17.17	-1.64	13	0.048638132	-1.66
	-16.79	-1.60	14	0.052529183	-1.62
	-16.75	-1.60	15	0.056420233	-1.59
	-16.18	-1.54	16	0.060311284	-1.55
	-16.15	-1.54	17	0.064202335	-1.52
	-16.04	-1.53	18	0.068093385	-1.49
	-15.80	-1.51	19	0.071984436	-1.46
	-15.63	-1.49	20	0.075875486	-1.43
	-15.59	-1.49	21	0.079766537	-1.41
	-15.38	-1.47	22	0.083657588	-1.38
	-15.35	-1.46	23	0.087548638	-1.36
	-14.97	-1.43	24	0.091439689	-1.33
	-14.92	-1.42	25	0.095330739	-1.31
	-14.66	-1.40	26	0.09922179	-1.29
	-14.55	-1.39	27	0.10311284	-1.26
	-14.45	-1.38	28	0.107003891	-1.24
	-14.22	-1.36	29	0.110894942	-1.22
	-14.04	-1.34	30	0.114785992	-1.20
	-13.47	-1.28	31	0.118677043	-1.18
	-13.21	-1.26	32	0.122568093	-1.16
	-12.80	-1.22	33	0.126459144	-1.14

Based on the above table, I have plotted the normal probability plot to check if residuals are normally distributed



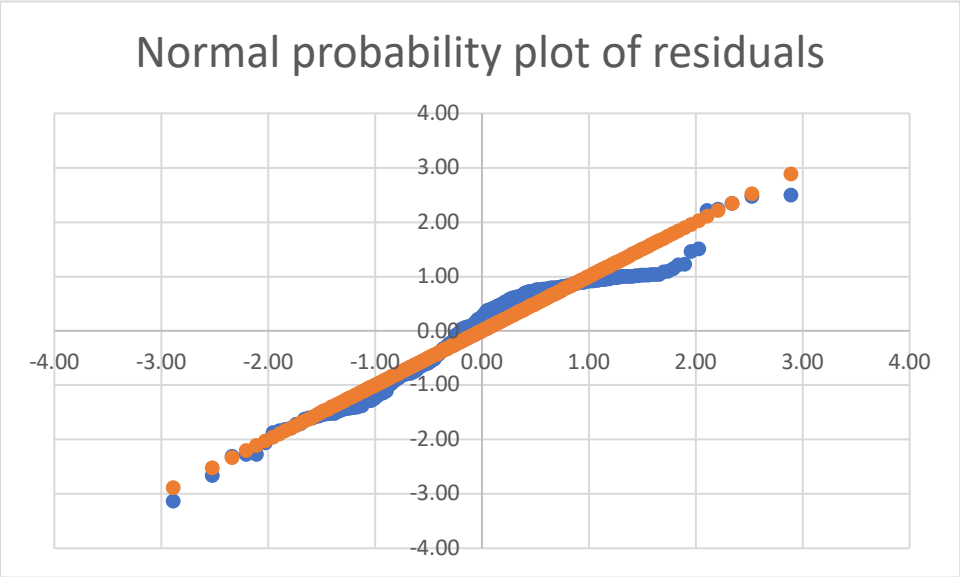
Here, we see that the z value and standardized residual value are close enough to each other, and almost fits the line. Hence, we can conclude that they can be normally distributed.

<u>Honeywell Inc:</u>

Here, to plot the graph, I must first calculate the standardized residuals, ranks, cumulative area and standard z value. Below table shows the calculated value for the same.

HON	Residual HON	Standardized residuals- HON	Ranks I - HON	Cummulative area - (I-0.5/)n	Standard z value
	-56.22	-3.32	1	0.001945525	-2.89
	-47.72	-2.82	2	0.005836576	-2.52
	-41.38	-2.44	3	0.009727626	-2.34
	-40.77	-2.41	4	0.013618677	-2.21
	-40.73	-2.40	5	0.017509728	-2.11
	-36.07	-2.13	6	0.021400778	-2.03
	-32.68	-1.93	7	0.025291829	-1.95
	-32.61	-1.92	8	0.029182879	-1.89
	-31.55	-1.86	9	0.03307393	-1.84
	-31.09	-1.83	10	0.036964981	-1.79
	-30.69	-1.81	11	0.040856031	-1.74
	-30.45	-1.80	12	0.044747082	-1.70
	-29.02	-1.71	13	0.048638132	-1.66
	-28.78	-1.70	14	0.052529183	-1.62
	-28.51	-1.68	15	0.056420233	-1.59
	-27.73	-1.64	16	0.060311284	-1.55
	-27.51	-1.62	17	0.064202335	-1.52
	-27.35	-1.61	18	0.068093385	-1.49
	-26.68	-1.57	19	0.071984436	-1.46
	-26.52	-1.57	20	0.075875486	-1.43
	-26.46	-1.56	21	0.079766537	-1.41
	-26.31	-1.55	22	0.083657588	-1.38
	-26.11	-1.54	23	0.087548638	-1.36
	-26.11	-1.54	24	0.091439689	-1.33
	-25.87	-1.53	25	0.095330739	-1.31
	-25.39	-1.50	26	0.09922179	-1.29
	-25.07	-1.48	27	0.10311284	-1.26
	-25.01	-1.48	28	0.107003891	-1.24
	-24.98	-1.47	29	0.110894942	-1.22
	-24.85	-1.47	30	0.114785992	-1.20
	-24.54	-1.45	31	0.118677043	-1.18
	-24.25	-1.43	32	0.122568093	-1.16
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Based on the above table, I have plotted the normal probability plot to check if residuals are normally distributed.



Here, we see that the z value and standardized residual value are close enough to each other, but the standardized residual value is not following a normal distribution here as there is some deviation when compared to z value. Hence, we can conclude that they are not normally distributed.

<u>Chi-squared test for Normality of the residuals</u>

HO =The residuals are normally distributed

H1 = The residuals are not normally distributed

Confidence level is set to 0.05.

I have used 9 cell values to perform the calculation because I have received number of cells value as 9. Cell start will be the minimum value and cell end will be sum of cell start value and cell length value. Probability is calculated using normdist() function. Expected frequency is calculated by multiplying probability with sample size. Observed frequency is calculated using countif() function where we check the occurrences of start and end values. Finally, we calculate the chi-square value using formula (expected frequency – observed frequency) ^2/expected frequency.

<u>Apple Inc:</u>

Using the residual values, I have calculated the below parameters to calculate the chi-square value.

Sample Size	**257**
Minimum	**-22.934464**
Maximum	**28.177841**
Range	**51.1123049**
Cell length	**5.67548881**
Number of cells	**9.00579784**
Mean	**0.00**
Standard deviation	**9.84413351**

						Chi Square	
	Cell Start	**Cell End**	**Probability**	**Expected Frequency E**	**Observed Frequency O**	**(E-O)^2/E**	
1st cell	-22.9344639	-17.2589751	0.02987232	7.677185225	10.00	0.70279254	
2nd cell	-17.2589751	-11.5834863	0.07987803	20.52865326	27.00	2.03999396	
3rd cell	-11.5834863	-5.9079974	0.15454198	39.71728931	39.00	0.01295416	
4th cell	-5.9079974	-0.2325086	0.2163765	55.60876013	43.00	2.85891704	
5th cell	-0.2325086	5.4429802	0.21926132	56.35015971	40.00	4.74404552	
6th cell	5.4429802	11.1184690	0.16080666	41.32731212	78.00	32.542306	
7th cell	11.1184690	16.7939578	0.08534845	21.93455243	11.00	5.45096314	
8th cell	16.7939578	22.4694466	0.03277602	8.423437777	6.00	0.69722729	
9th cell	22.4694466	28.1778410	0.00912705	2.345651836	3.00	0.18253839	
			sum	sum	sum	sum	df
			0.98798833	**253.9130018**	**257.00**	**49.231738**	**8**

P value	**5.73948E-08**

Here, we see that **p value = 0.0000000573948** is less than the **alpha value 0.05**.

Conclusion
Since P value is lesser than significance level (0.05), we have an evidence to reject null hypothesis

Honeywell Inc:

Sample Size	257
Minimum	-56.3777888
Maximum	44.86473602
Range	101.2425248
Cell length	11.24192733
Number of cells	9.005797836
Mean	0.00
Standard deviation	17.97406208

						Chi Square	
	Cell Start	Cell End	Probability	Expected Frequency E	Observed Frequency O	(E-O)^2/E	
1st cell	-56.377789	-45.135861	0.0051621	1.326661687	2.00	0.34174838	
2nd cell	-45.135861	-33.893934	0.0236501	6.078083205	4.00	0.71049205	
3rd cell	-33.893934	-22.652007	0.0741209	19.04906156	33.00	10.2172321	
4th cell	-22.652007	-11.410079	0.1589892	40.86021529	35.00	0.84047827	
5th cell	-11.410079	-0.168152	0.2334910	60.00719726	35.00	10.4214152	
6th cell	-0.168152	11.073775	0.2348171	60.34798946	52.00	1.15478459	
7th cell	11.073775	22.315703	0.1617138	41.56045084	89.00	54.1502986	
8th cell	22.315703	33.557630	0.0762507	19.59642582	2.00	15.8005447	
9th cell	33.557630	44.864736	0.0246719	6.340678632	5.00	0.28347426	
			sum	sum	sum	sum	df
			0.9928668	255.1667638	257.00	93.9204681	8

P value	7.42157E-17

Here, we see that **p value = 0.00000000000000000742157** which is less than the **alpha value 0.05**

Conclusion
Since P value is lesser than significance level (0.05), we have evidence to reject null hypothesis

Hence, we can conclude that the residuals are not normally distributed.

Subjective Question

Question: Suppose that you have decided to form a portfolio *Π* (Pi) consisting of the above two stock types (denote a share value of AAPL by *X* and that of HON by *Y*). You are however undecided as to what percentage of your investment should be allocated to the AAPL shares and what percentage should be allocated to HON shares. Let these percentages be denoted by P and Q respectively (Obviously, P + Q=100%). In your opinion, what are good values to select for P and Q?

Based on the regression analysis, we can conclude that the Apple Inc shows a better fitness of the regression. We can also conclude that the normal probability plot of residual for Apple Inc shows a better fit to the residual line when compared to Honeywell Inc. Hence, according to me, I would invest **60% to Apple Inc** and **40% to Honeywell Inc.**

CONCLUSION

In this project, we have captured how to use time series forecasting method to check for accuracy of the data model and use regression analysis to capture the data. I have learnt how to use MAPE and MAPD to calculate the accuracy of the predictions. We have used exponential smoothing forecasting methods, adjusted exponential smoothing forecasting methods, trend-based forecasting methods, weighted average forecasting method and regression analysis method to capture the accuracy of predictions. Based on the calculations, we concluded that exponential smoothing forecasting method is better fit than trend-based forecasting as it yielded less MAPE value. The MAPE value of the predicted value for both the companies are greater than other 2 forecasting methods. We have seen how to check if regression model is a legitimate model based on the criteria which residuals must satisfy. We concluded that the residuals are homoscedastic, they are independent, they are not normally distributed. We have inferred the same using chi square test. Based on all the findings, we can conclude that Apple Inc is a better company to invest the stocks when compared to Honeywell Inc.

BIBLIOGRAPHY

Breiman, L., Friedman, J., Stone, C. J., & Olshen, R. A. (1984). Classification and regression trees. CRC press.

Guidotti, R., Monreale, A., Ruggieri, S., Turini, F., Giannotti, F., & Pedreschi, D. (2018). A survey of methods for explaining black box models. ACM computing surveys (CSUR), 51(5), 1–42.

Mujkanovic, F. (2019). Explaining the predictions of any time series classifier (Unpublished master's thesis). Hasso Plattner Institut.

Taieb, S. B., Bontempi, G., Atiya, A. F., & Sorjamaa, A. (2012). A review and comparison of strategies for multi-step ahead time series forecasting based on the nn5 forecasting competition. Expert systems with applications, 39(8), 7067–7083.

Hyndman, R.J. (2004), 'The interaction between trend and seasonality', International Journal of Forecasting, 20, 561–563.

Huot, G., K. Chiu and J. Higginson (1986), 'Analysis of revisions in the seasonal adjustment of data using X-11-ARIMA model-based filters', International Journal of Forecasting, 2, 217–229.

APPENDIX

The excel file used for the calculation is given below. These files are attached in Canvas.

ALY6050_MOD3Project_ VidyanandaS.xlsx