Assignment 2: Forecasting iPhone Quarter Revenue in 2022 Using Basic Forecasting Method

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I. Introduction

There are three basic forecasting techniques; qualitative approaches, time-series analysis, and clausal models. Qualitative methods are commonly used when quantitative data is scarce. Qualitative techniques include Delphi methods, jury of executive opinion, sales force composite, and consumer market survey. In time-series forecasting, prediction on future data is based solely on the past value of the variable. This technique focuses on pattern and pattern change. Basic time-series forecasting consist of moving average, exponential smoothing, trend projection, and time series decomposition. Clausal models such as regression and multiple regression analysis use information about relationship between dependent and independent variables to forecast future events.

A forecast is considered good if it has a small error and provides more than a single number. The chosen method should be easy to use and understand for everyone who uses it. It should include a mean value, standard deviation, and the accuracy range, the high and the low. Furthermore, a good forecast should incorporate qualitative methods such as expert views. Expert views are needed to justify forecasted values generated from the model to ensure the logic of the result.

Time-series data is a sequence of evenly spaced events. Time-series typically has four components: trend, seasonality, cycles, and random variations. Trend describes the movement that spans across seasonal periods. Seasonality represents demand fluctuation pattern above or below the trend line that repeats at regular intervals. Cycles represent the phenomena that occur across seasonal periods. Random variations are the remains after trend and seasonality are separated from time-series data. If a forecasting model can capture these components, its predicted future value is considered a good forecast.

II. Data and Analysis Result

Apple Inc. is one of the largest multinational companies that specialize in technology and its brand ranked as the world's valuable brand. Apple is responsible for the rise of smartphone with iPhone, which is also Apple's most profitable product. The first generation of iPhone was released in 2007; since then, Apple saw rapid sales growth and reached its highest point at 231 million in 2015. In the years after that, iPhone sales have stayed relatively stable.

This assignment focuses on forecasting the iPhone sales revenue in 2022. The quarterly data is obtained from www.statista.com from 2007 to 2021. The forecast employs time-series decomposition method. The first step in the decomposition is plotting the data. Next, decompose this time series into components; level, trend, seasonality, and noise or random variation. Level defined as the average value in the series and the other components have been explained in the introduction. All series have level and noise, while trend and seasonality are optional. Then, combine the components into either additive model or multiplicative model.

Additive model suggests that the components are added together. Mathematically, it presented by equation below

$$y_t = seasonality + trend + level + noise$$

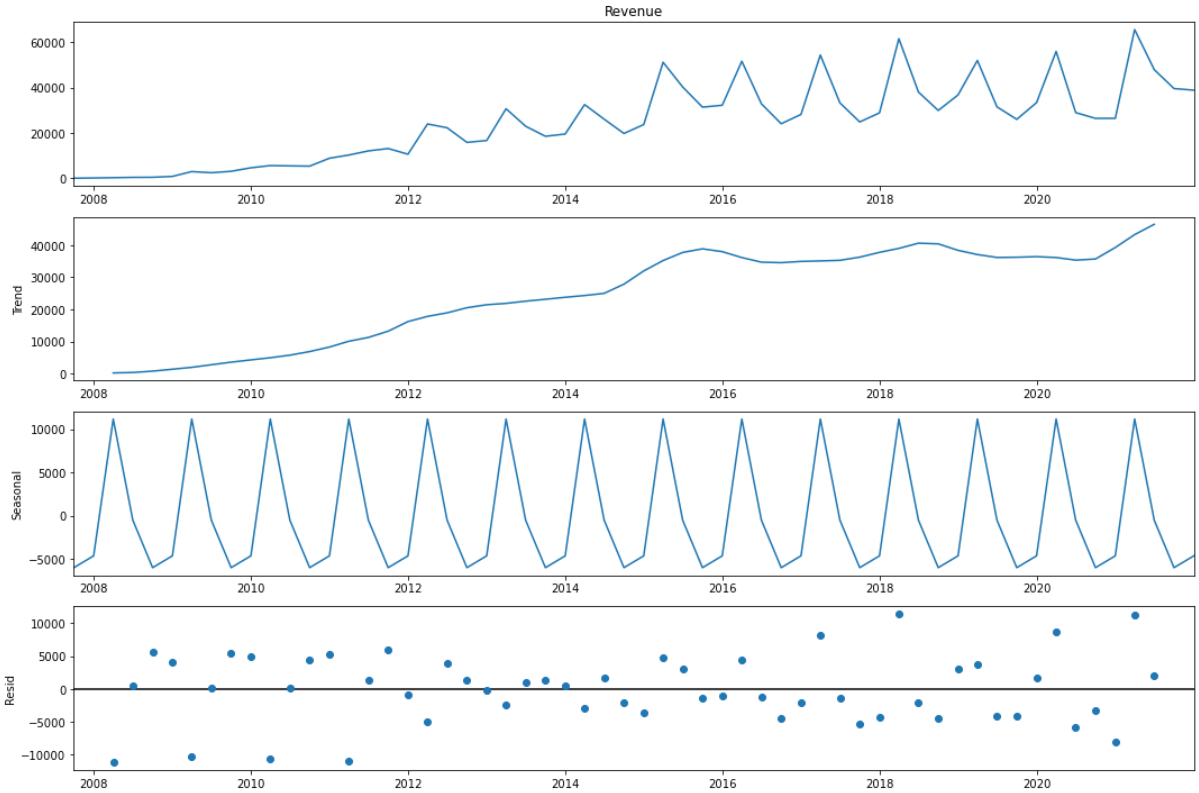
By visualization, if the increasing or decreasing pattern is similar throughout the series, it is additive model.

On the other hand, multiplicative model suggests that the components are multiplied together as follows:

$$y_t = seasonality \times trend \times level \times noise$$

By visualization, if the time-series has exponential growth with time, it can be considered as multiplicative model.

Below is the result of data plotting of iPhone quarter revenue from 2007 to 2021.



The graph above shows an increasing trend with seasonality. Hence, the model that is chosen for this data is Holt's Winter Additive. Next, the model decomposes the data into its elements; level (α), trend (β), and seasonality (γ). After running risk simulator, the value of α, β, and γ are 0.5338, 0.0265, and 1, respectively, with the lowest RMSE of 5118.769. RMSE is chosen as the criteria to evaluate the forecasting model because it puts more weight to large errors. Moreover, RMSE is the most popular error measure and used to the best-fitting time-series model. Other criteria measurements that can be used are MAD, MSE, and MAPE. For a clearer comparison in choosing the best-fitting model for this data, refer to the result below.

The Best Model: Holt-Winter's Additive	
Alpha	0.5338
Beta	0.0265
Gamma	1.0000
Seasons	4
Root Mean Squared Error (RMSE)	5118.7692
Mean Squared Error (MSE)	26201798.6327
Mean Absolute Deviation (MAD)	3450.3351
Mean Absolute Percentage Error (MAPE)	17.60%
	0.8285

Second Best Model: Seasonal Additive	
Alpha	0.5465
Gamma	1.0000
Seasons	4
Root Mean Squared Error (RMSE)	5174.2290
Mean Squared Error (MSE)	26772645.8401
Mean Absolute Deviation (MAD)	3421.1540
Mean Absolute Percentage Error (MAPE)	17.55%
	0.8392

Third Best Model: Holt-Winter's Multiplicative	
Alpha	0.1327
Beta	0.0549
Gamma	0.4774
Seasons	4
Root Mean Squared Error (RMSE)	5704.1380
Mean Squared Error (MSE)	32537190.4686
Mean Absolute Deviation (MAD)	4352.2498
Mean Absolute Percentage Error (MAPE)	25.20%
	0.7439

Fourth Best Model: Seasonal Multiplicative	
Alpha	0.2178
Gamma	0.6135
Seasons	4
Root Mean Squared Error (RMSE)	6066.3447
Mean Squared Error (MSE)	36800537.4731
Mean Absolute Deviation (MAD)	4502.6626
Mean Absolute Percentage Error (MAPE)	29.01%
	1.1127

Fifth Best Model: Single Moving Average	
	4
Root Mean Squared Error (RMSE)	9805.6334
Mean Squared Error (MSE)	96150446.5104
Mean Absolute Deviation (MAD)	6973.9583
Mean Absolute Percentage Error (MAPE)	28.89%
	1.0383

Sixth Best Model: Double Exponential Smoothing	
Alpha	0.0521
Beta	1.0000
Root Mean Squared Error (RMSE)	9897.9041
Mean Squared Error (MSE)	97968505.2726
Mean Absolute Deviation (MAD)	7412.3906
Mean Absolute Percentage Error (MAPE)	37.02%
	1.1985

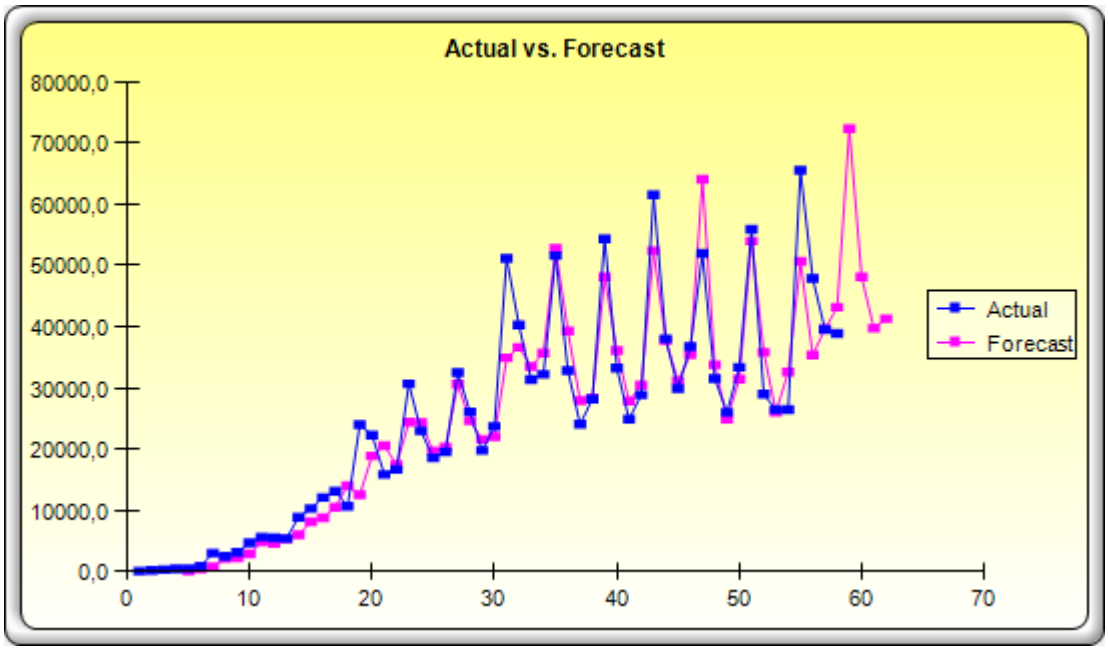
Seventh Best Model: Single Exponential Smoothing	
Alpha	0.2565
Root Mean Squared Error (RMSE)	10536.5678
Mean Squared Error (MSE)	111019261.1013
Mean Absolute Deviation (MAD)	7087.4364
Mean Absolute Percentage Error (MAPE)	34.59%
	1.0085

Eighth Best Model: Double Moving Average	
	4
Root Mean Squared Error (RMSE)	10825.4092
Mean Squared Error (MSE)	117189485.2959
Mean Absolute Deviation (MAD)	8121.8425
Mean Absolute Percentage Error (MAPE)	27.42%
	0.8480

The following table and graph represent the forecasted quarterly value for iPhone revenue using the chosen model.

Period	Actual	Forecast Fit
1	5.00	
2	118.00	
3	241.00	
4	378.00	
5	419.00	5.00
6	806.00	344.87
7	2940.00	726.42
8	2427.00	2088.81
9	3060.00	2137.84
10	4606.00	2826.64
11	5578.00	4803.18
12	5445.00	4577.25
13	5334.00	5242.68
14	8822.00	5937.26
15	10239.00	8100.96
16	12053.00	8730.74
17	13102.00	10463.91
18	10604.00	13975.66
19	23950.00	12518.29
20	22276.00	18859.79
21	15821.00	20523.91
22	16645.00	17411.10
23	30660.00	24378.21
24	22955.00	24293.81
25	18514.00	19627.24
26	19510.00	20309.28
27	32498.00	30587.05
28	26064.00	24597.91
29	19751.00	21554.57
30	23678.00	22025.40
31	51182.00	34921.13
32	40282.00	36633.81
33	31368.00	33510.75
34	32209.00	35686.46
35	51635.00	52855.67
36	32857.00	39311.34
37	24048.00	27907.52
38	28160.00	28332.13
39	54378.00	48152.21
40	33249.00	36083.01
41	24846.00	27812.41
42	28846.00	30436.31

43	61576.00	52465.32
44	38032.00	37737.14
45	29906.00	31143.73
46	36755.00	35425.03
47	51982.00	64135.83
48	31501.00	33779.79
49	25986.00	24895.10
50	33362.00	31446.49
51	55957.00	54022.49
52	28962.00	35828.36
53	26418.00	26038.26
54	26444.00	32557.10
55	65597.00	50705.09
56	47938.00	35357.83
57	39570.00	39634.46
58	38868.00	43190.78
Forecast59		72413.00
Forecast60		48154.22
Forecast61		39758.55
Forecast62		41303.02



III. Conclusion

After plotting the data and observing the graph, it is clearly seen that the data has an increasing trend and seasonality. Hence, it is determined that the best-fitting model to forecast iPhone revenue in 2022 is Holt Winter's Additive with parameters α, β, and γ are 0.5338, 0.0265, and 1, respectively. The model has the lowest RMSE value, the criteria measurement used to evaluate the models, compared to the same model with different values of parameters or to other basic forecasting models. The forecasted value for Q1, Q2, Q3, and Q4 of 2022 are 72413.00, 48154.22, 39758.55, and 41303.02, respectively.

Appendix

Period	Year	Revenue
1	2007-Q3	5
2	2007-Q4	118
3	2008-Q1	241
4	2008-Q2	378
5	2008-Q3	419
6	2008-Q4	806
7	2009-Q1	2940
8	2009-Q2	2427
9	2009-Q3	3060
10	2009-Q4	4606
11	2010-Q1	5578
12	2010-Q2	5445
13	2010-Q3	5334
14	2010-Q4	8822
15	2011-Q1	10239
16	2011-Q2	12053
17	2011-Q3	13102
18	2011-Q4	10604
19	2012-Q1	23950
20	2012-Q2	22276
21	2012-Q3	15821
22	2012-Q4	16645
23	2013-Q1	30660
24	2013-Q2	22955
25	2013-Q3	18514
26	2013-Q4	19510
27	2014-Q1	32498
28	2014-Q2	26064
29	2014-Q3	19751
30	2014-Q4	23678
31	2015-Q1	51182
32	2015-Q2	40282
33	2015-Q3	31368
34	2015-Q4	32209
35	2016-Q1	51635
36	2016-Q2	32857
37	2016-Q3	24048
38	2016-Q4	28160

39	2017-Q1	54378
40	2017-Q2	33249
41	2017-Q3	24846
42	2017-Q4	28846
43	2018-Q1	61576
44	2018-Q2	38032
45	2018-Q3	29906
46	2018-Q4	36755
47	2019-Q1	51982
48	2019-Q2	31501
49	2019-Q3	25986
50	2019-Q4	33362
51	2020-Q1	55957
52	2020-Q2	28962
53	2020-Q3	26418
54	2020-Q4	26444
55	2021-Q1	65597
56	2021-Q2	47938
57	2021-Q3	39570
58	2021-Q4	38868