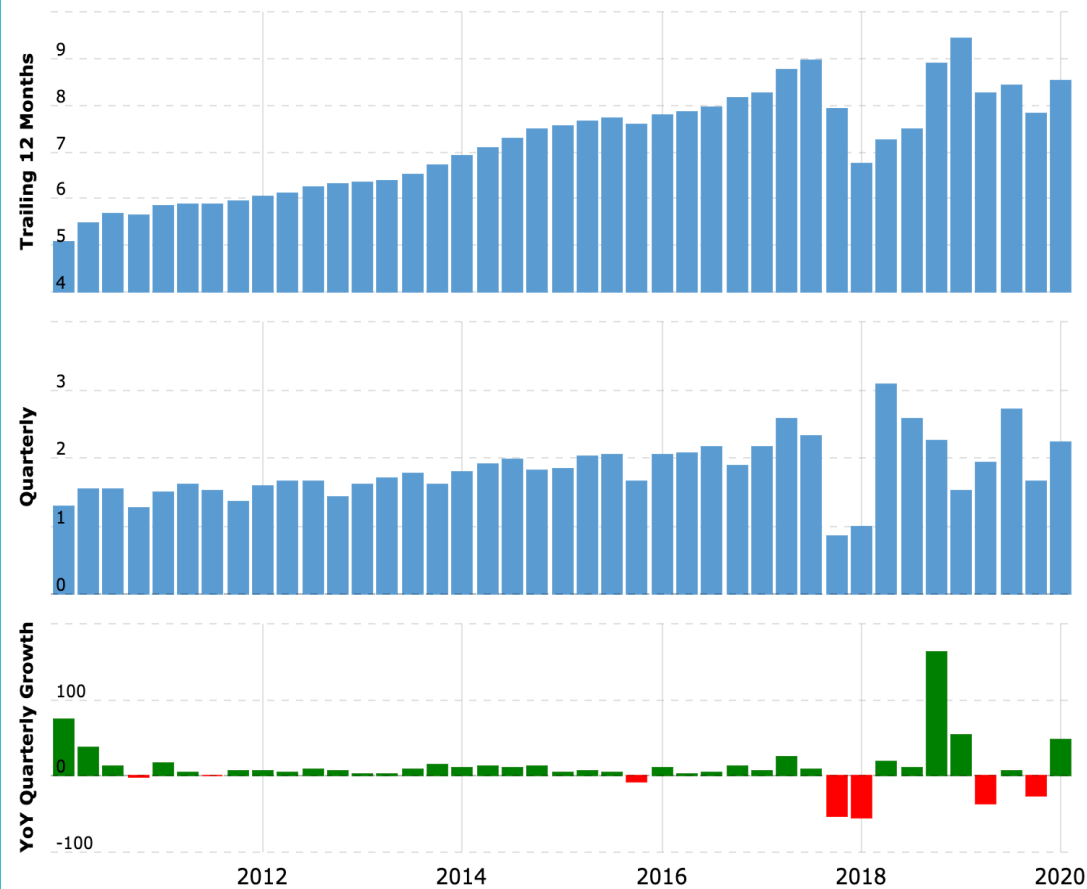


WFE Testing and Stock Model Selection

Yuru Li



Part I. Fundamental Research of 3M Company (1) EPS



The EPS of 3M company from 2010 to 2020 basically follows a healthy growth trend with a highest EPS of \$9.42 in 2019. For the record, 3M 2017 annual EPS was \$7.93, a 2.82% decline from 2016; 3M 2018 annual EPS was \$8.89, a 12.11% increase from 2017; 3M 2019 annual EPS was \$7.81, a 12.15% decline from 2018. As it shown in the graph, there is a dramatically decrease from Dec 2017 to Apr 2018, while the EPS bounce up at the end of 2018.

3M EPS for the twelve months ending March 31, 2020 was \$8.52, a 9.55% decline year-over-year, and 3M EPS for the quarter ending March 31, 2020 was \$2.22, a 47.02% increase year-over-year. Although the performance last year is not optimistic, the EPS shows a great growth in this quarter compared to last year.

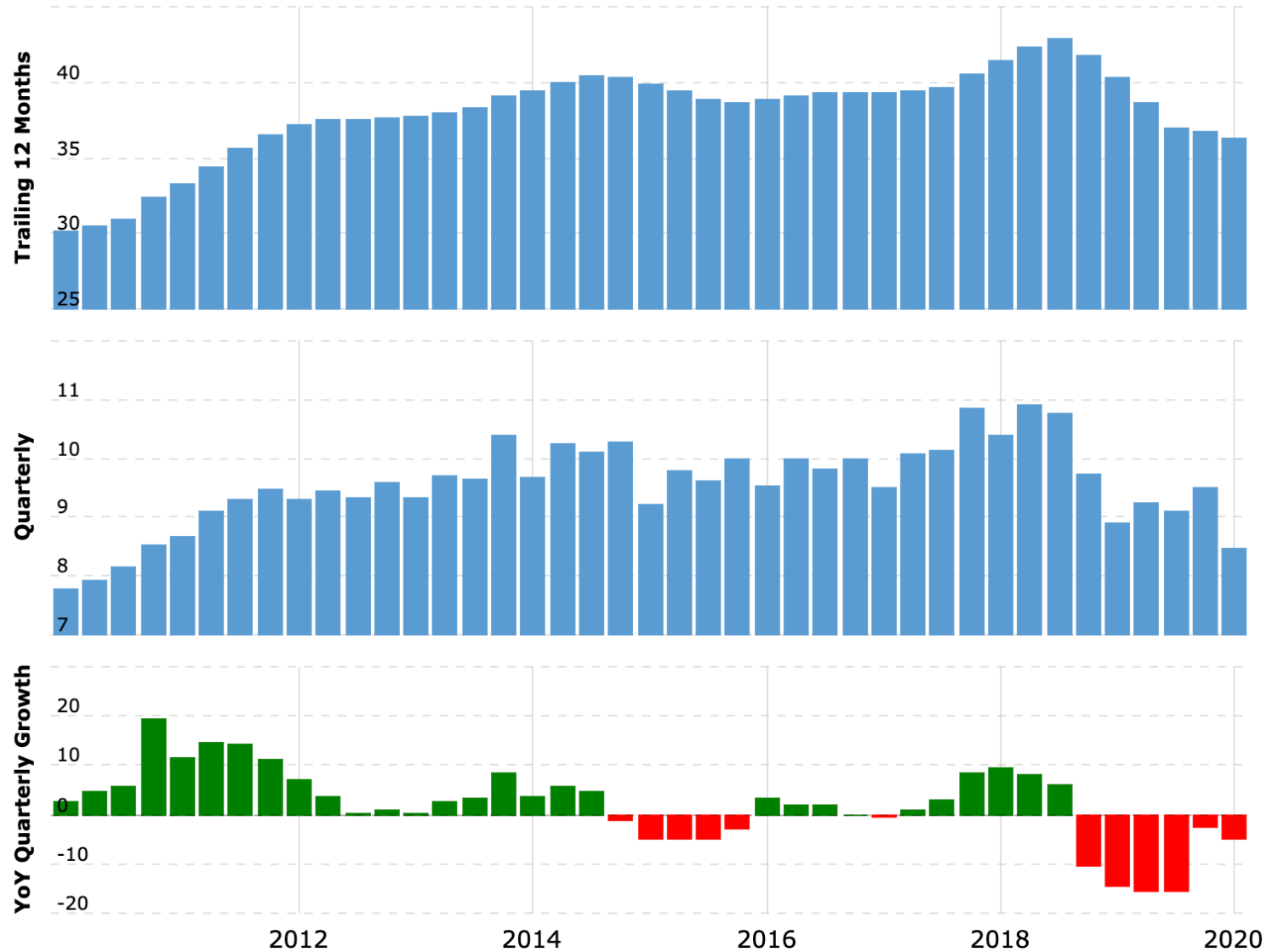


Part I. Fundamental Research of 3M Company (1) EPS

The EPS of Honeywell is about 4 times higher than 3M company. Honeywell annual revenue for 2017 was \$40.534B, a 3.13% increase from 2016; Honeywell annual revenue for 2018 was \$41.802B, a 3.13% increase from 2017; Honeywell annual revenue for 2019 was \$36.709B, a 12.18% decline from 2018.

However, although the EPS of Honeywell is much higher than 3M, the YoY quarterly growth recently is less than 0, which means the EPS is decreasing. From the data we know that, Honeywell's revenue for the twelve months ending March 31, 2020 was \$36.288B, a 9.94% decline year-over-year. And its revenue for the quarter ending March 31, 2020 was \$8.463B, a 4.74% decline year-over-year.

Honeywell



Part I. Fundamental Research of 3M Company

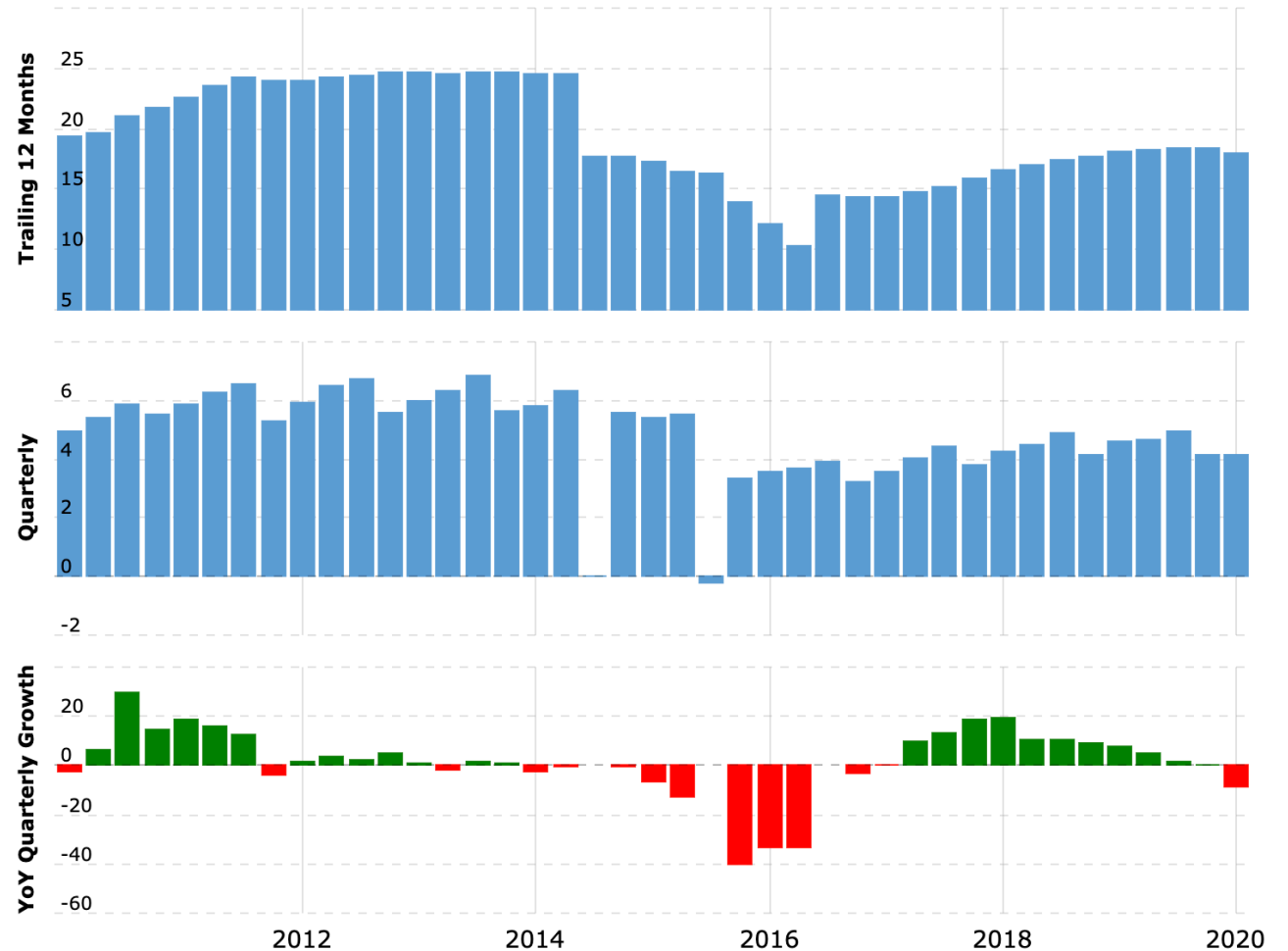
(1) EPS

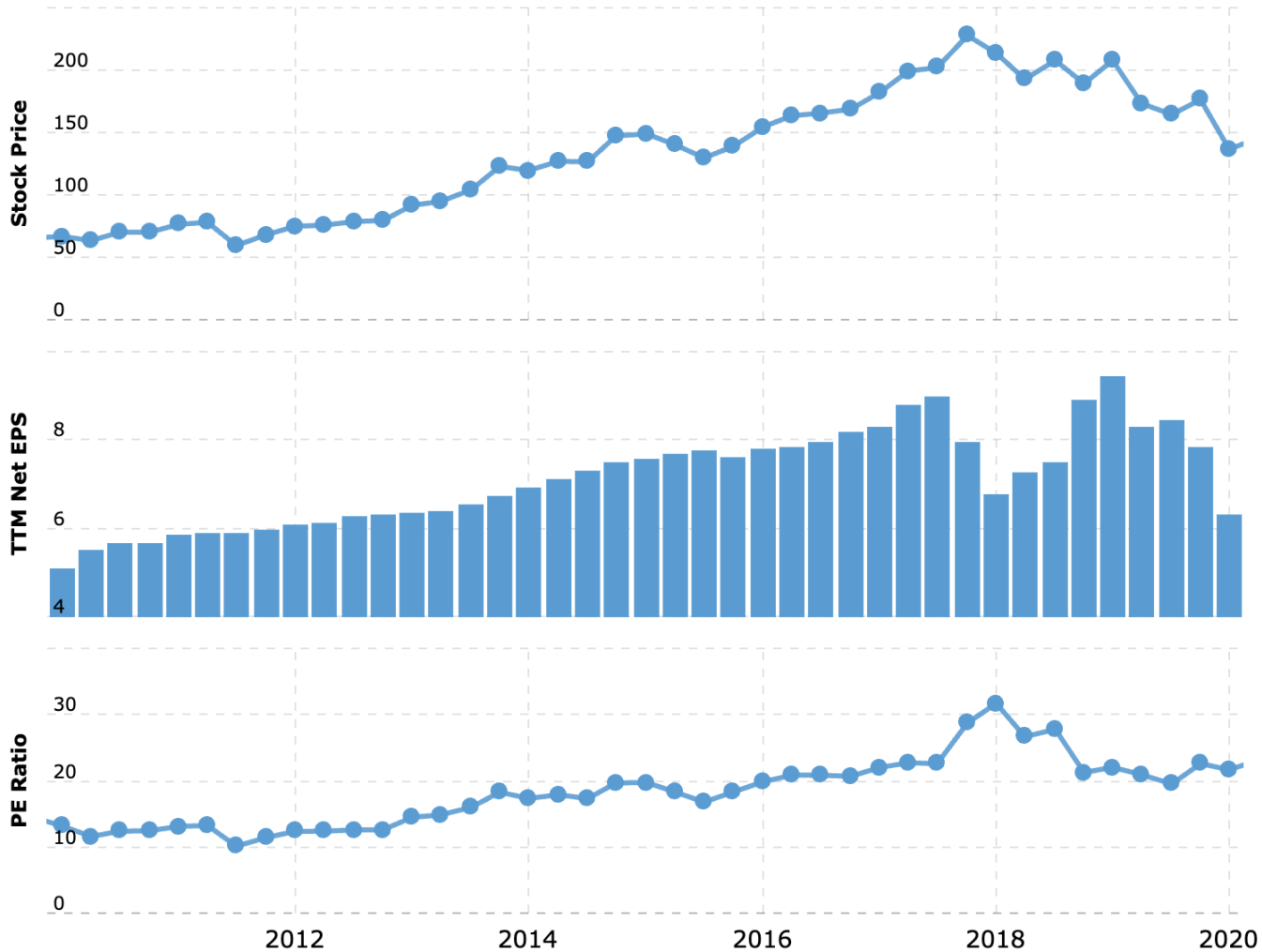
The EPS of Emerson encounter a cliff fall from \$24.54 to \$17.73 in Sep 2014, the revenue doesn't back to over \$20 level since then. The EPS of Emerson changed rapidly since 2014. Emerson Electric annual revenue for 2017 was \$15.264B, a 5.11% increase from 2016. The revenue had growth from Jun 2017 to Apr 2018, Emerson Electric annual revenue for 2018 was \$17.408B, a 14.05% increase from 2017. Then the growth trend has slowed down since Apr 2018, its annual revenue for 2019 was \$18.372B, a 5.54% increase from 2018.

Emerson Electric's revenue for the twelve months ending March 31, 2020 was \$17.968B, a 0.51% decline year-over-year. The revenue for the quarter ending March 31, 2020 was \$4.162B, an 8.93% decline year-over-year.



EMERSON™

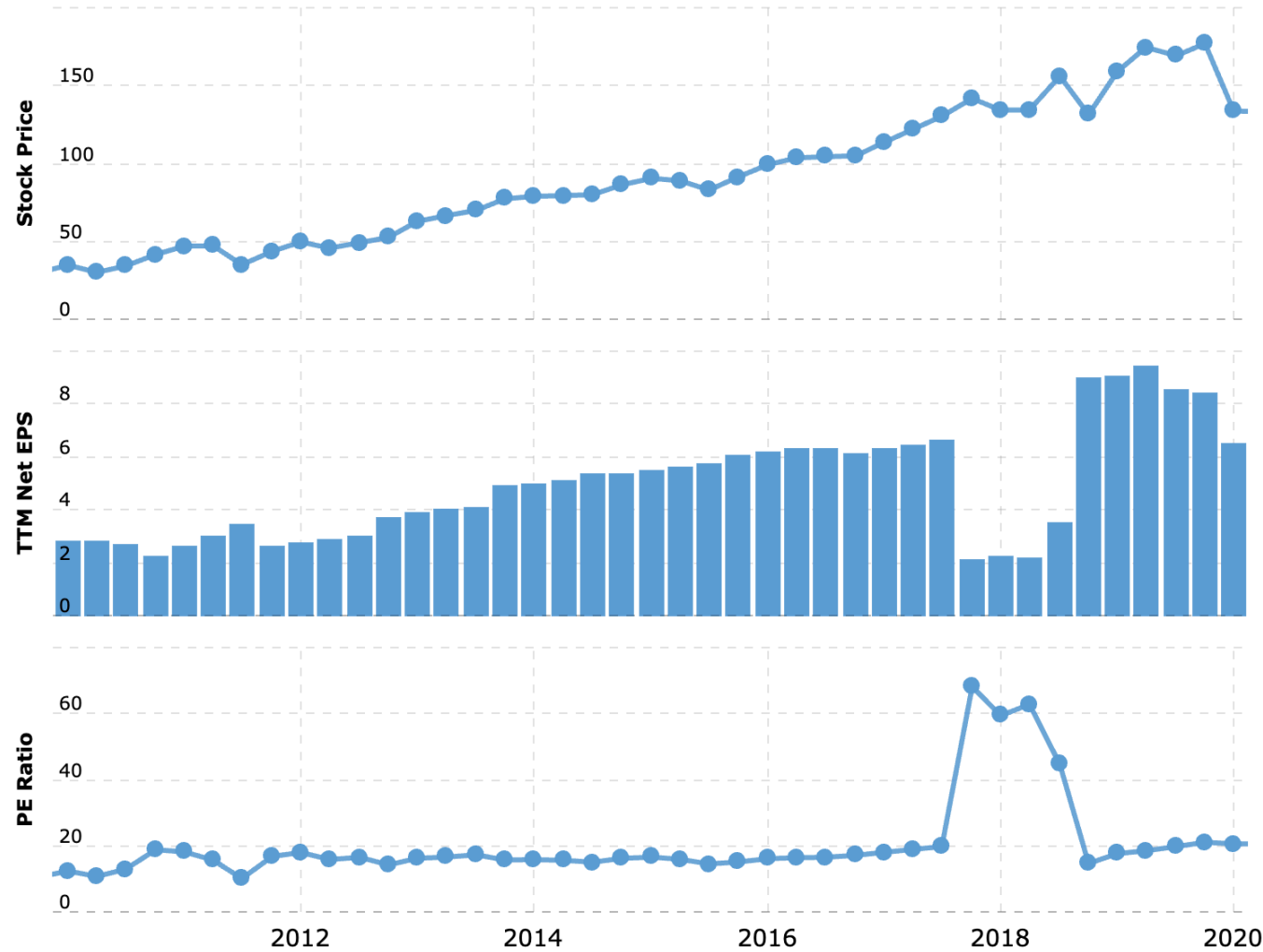




Part I. Fundamental Research of 3M Company (2) PE ratio

The price to earnings ratio is calculated by taking the latest closing price and dividing it by the most recent earnings per share (EPS) number. The PE ratio is a simple way to assess whether a stock is over or under valued and is the most widely used valuation measure.

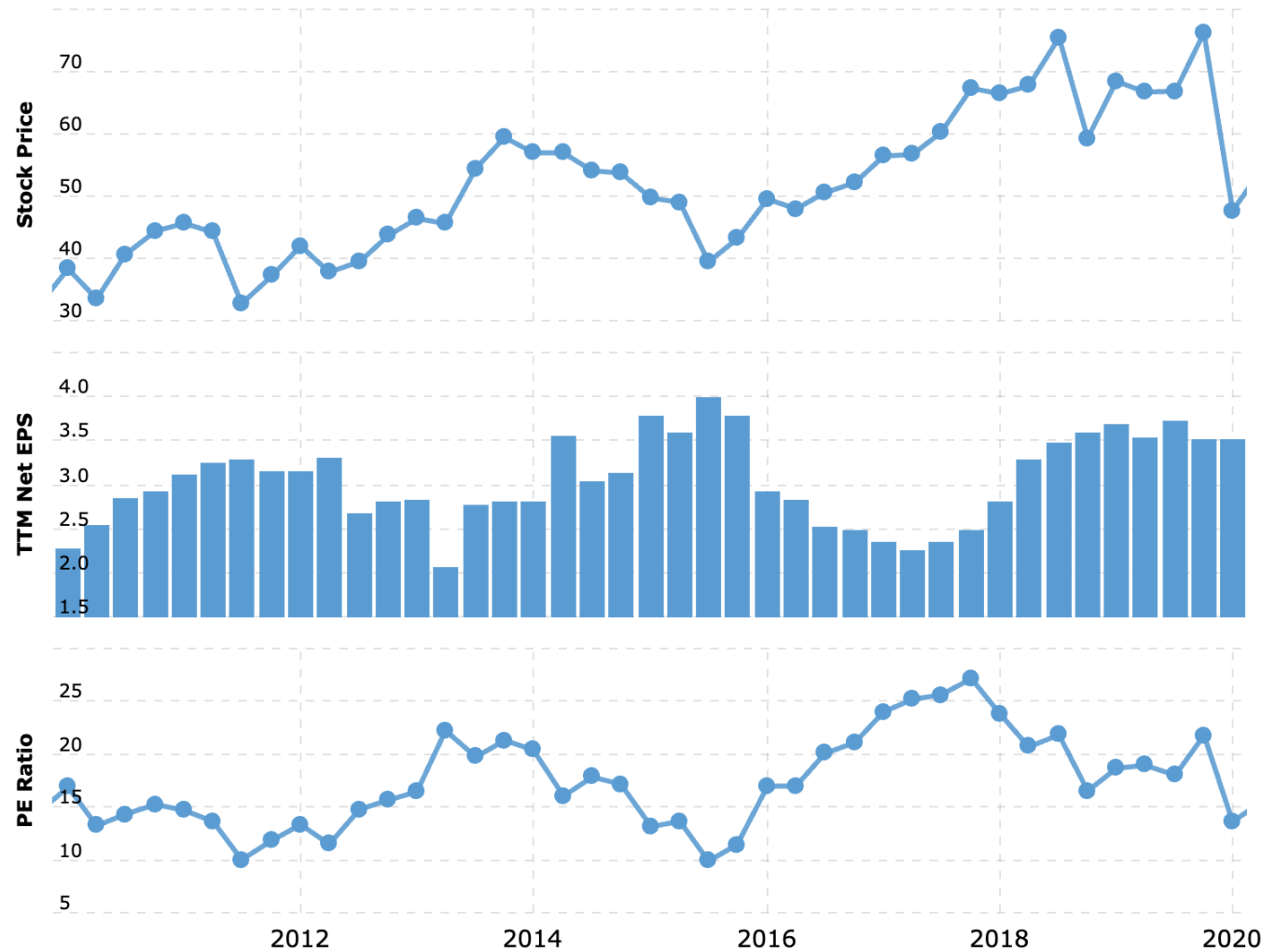
The PE ratio has been slightly increased from 2010 to 2020, with a sudden decrease from Dec 2017 to Apr 2018, the PE ratio goes high immediately. The PE ratio has back to 21.26 at the end of 2018.



Honeywell

Part I. Fundamental Research of 3M Company (2) PE ratio

With the net EPS decreased from \$6.66 to \$2.08 in the last quarter of 2017, the PE ratio increased 245% from 19.75 to 68.14, after a continuously high PE ratio in 2018, the ratio back to normal for 14.62 at the end of 2018. Honeywell PE ratio as of May 06, 2020 is 15.96.



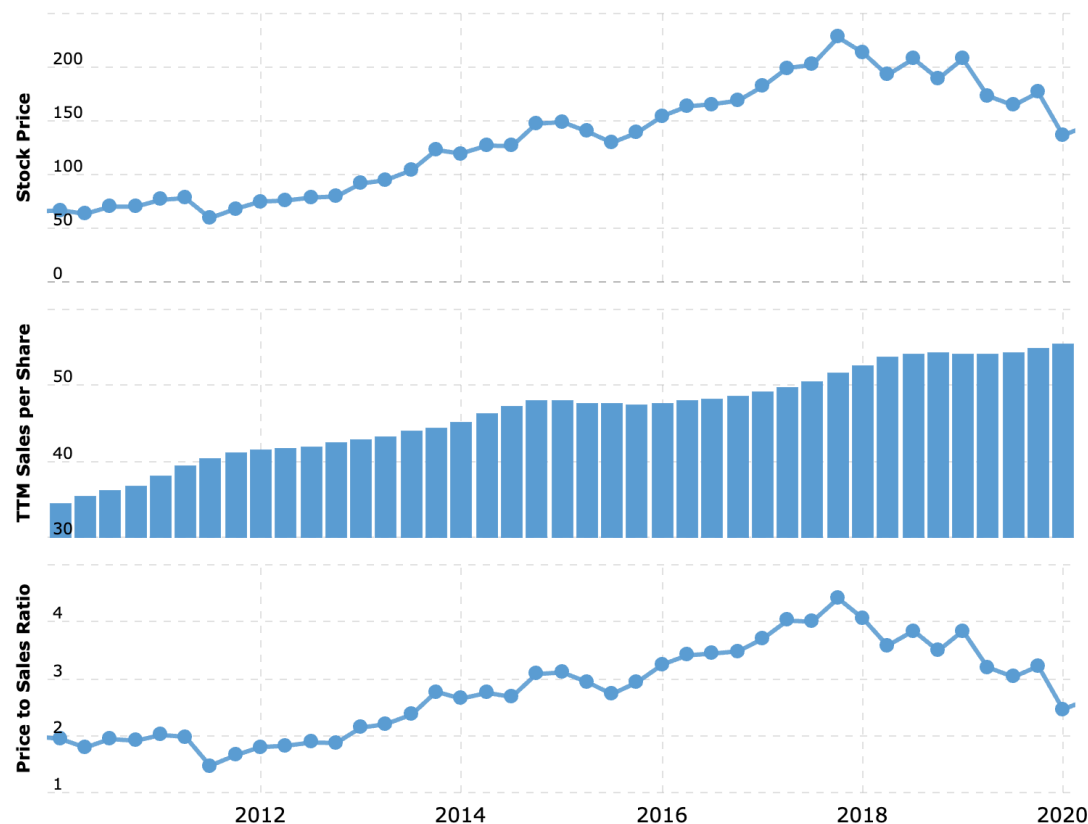
Part I. Fundamental Research of 3M Company (2) PE ratio

The PE ratio of Emerson company has the biggest variance among all the 3 companies, in another word, the value of the stock is not stable as the other 2 companies. The PE ratio has growth from 9.88 to 27.15 from Sep 2015 to Dec 2017, and then felled down to 13.61 this quarter. Emerson Electric PE ratio as of May 06, 2020 is 15.29.

Part I. Fundamental Research of 3M Company (3) P/S ratio

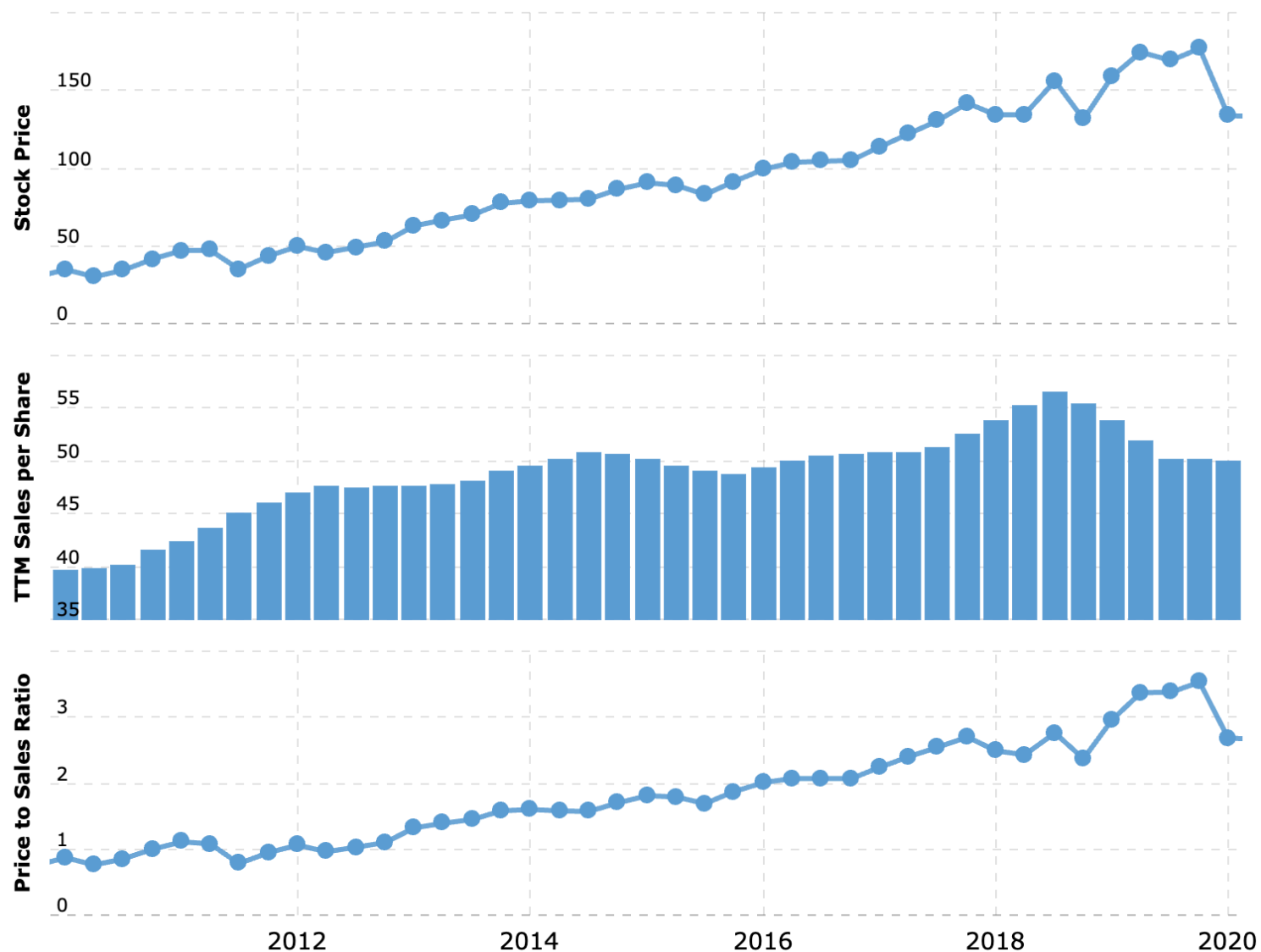
The price-to-sales ratio (Price/Sales or P/S) is calculated by taking a company's market capitalization (the number of outstanding shares multiplied by the share price) and divide it by the company's total sales or revenue over the past 12 months. The lower the P/S ratio, the more attractive the investment.

At the end of 2017, the stock price of 3M company is \$227.72, with a TTM sales per share of \$51.68. the P/S ratio reached a top ratio of 4.41 among 10 years. Recently the P/S ratio of 3M company is 2.46, back to the same level at it in 2014. The stock show attractiveness.



Part I. Fundamental Research of 3M Company (3) P/S ratio

From the graph we can see that, the variance of P/S ratio became larger recently, and it's still maintaining a general growth trend, which makes the stock shows lower attractiveness.



Honeywell

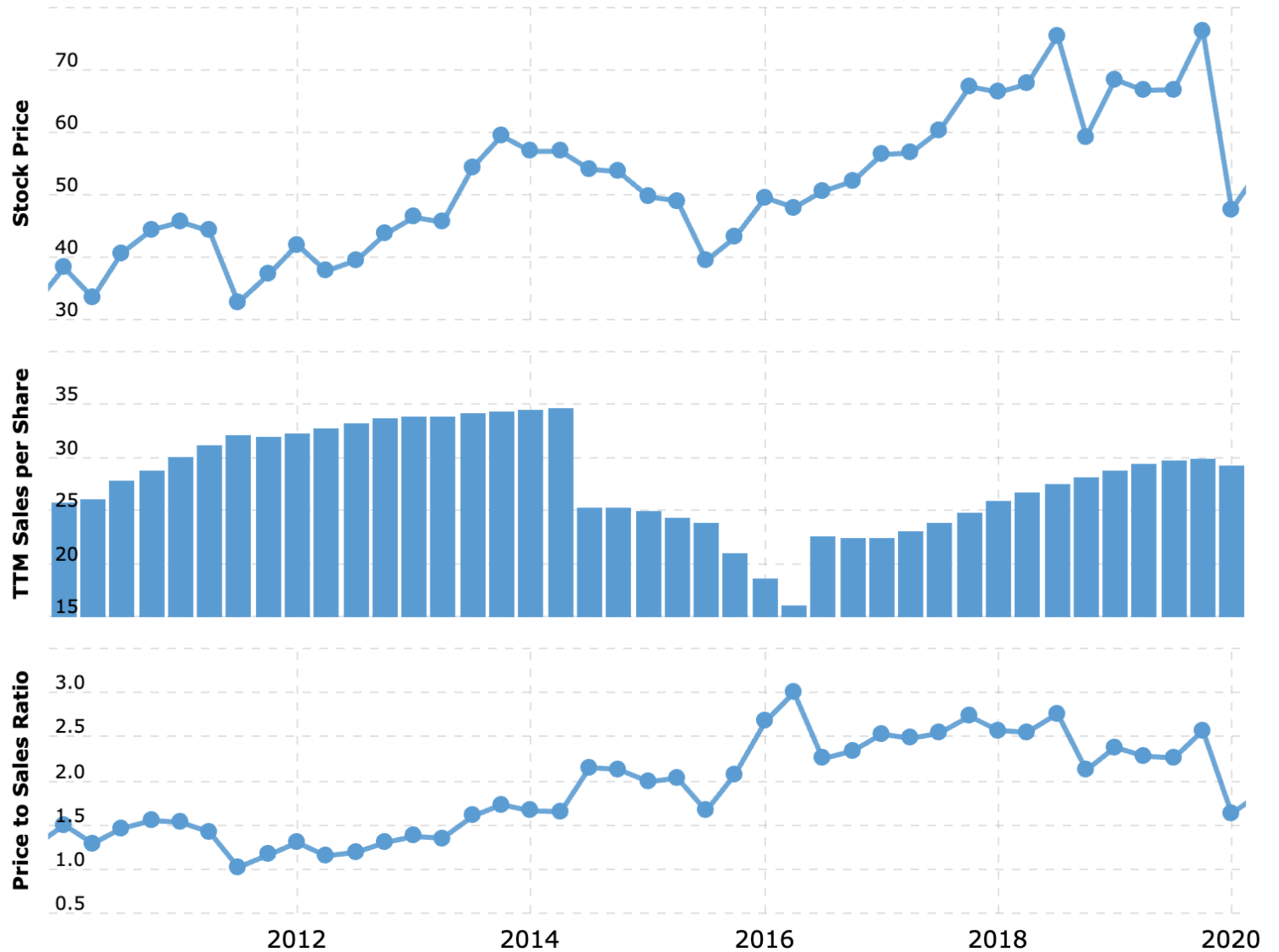
Part I. Fundamental Research of 3M Company

(3) P/S ratio

The stock price of Emerson decreased from \$76.26 to \$47.65 recently, the sales per share was slightly decreased from 29.73 to 29.15, which makes the P/S ratio decreased to 1.63 which is a much smaller rate compare to the other 2 companies. On the standard of P/S ratio, Emerson's stock shows the strongest attractive compares to 3M and Honeywell.



EMERSONTM



	MMM	HON	EMR
vars	1	1	1
n	2516	2516	2516
mean	130.013348036566	91.2608170727345	50.5767200747218
sd	48.7681388169981	42.2607085627316	10.95407406731
median	134.265938	86.1927605	49.2969815
trimmed	128.332361463257	88.6355206261172	49.9178202706058
mad	68.1881810148	56.284440471	11.507674332
min	56.705597	29.37854	30.980669
max	241.546799	182.243591	77.353622
range	184.841202	152.865051	46.372953
skew	0.11574117565423	0.404535344046837	0.461444714165195
kurtosis	-1.22129015966319	-0.945436455419273	-0.696244968550926
se	0.972256517571088	0.842522399541865	0.218383767850219

Part II. Descriptive Statistics

(1) Close Price

From the data over the 10 years since 2010, the 3M company has the overall highest stock price, with the mean of \$130.01 compare the \$91.26 for Honeywell and \$50.58 for Emerson. The 3M company has a medium price of \$134.27 which is higher than its mean price. While the other 2 companies have a median price lower than their mean price. From the 'sd' row and 'mad' row, the price of 3M companies seems has the most unstable trend.

The excess kurtosis of the 3 companies are all less than 0, which indicates all of the closing prices for the 3 companies are following a platykurtic distribution. All the skew value of these 3 companies are larger than 0, which means a positive skew, the distributions are all skew to the right, and EMR has the most obvious skewness of 0.46.

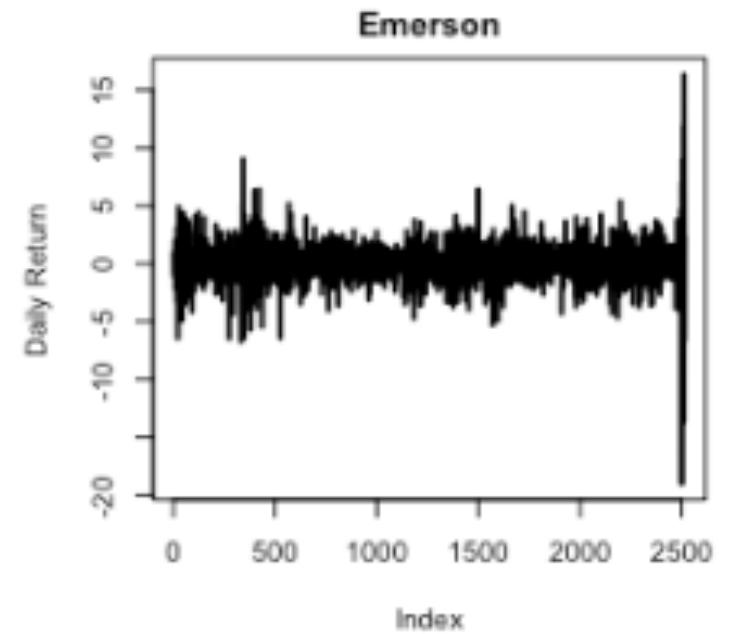
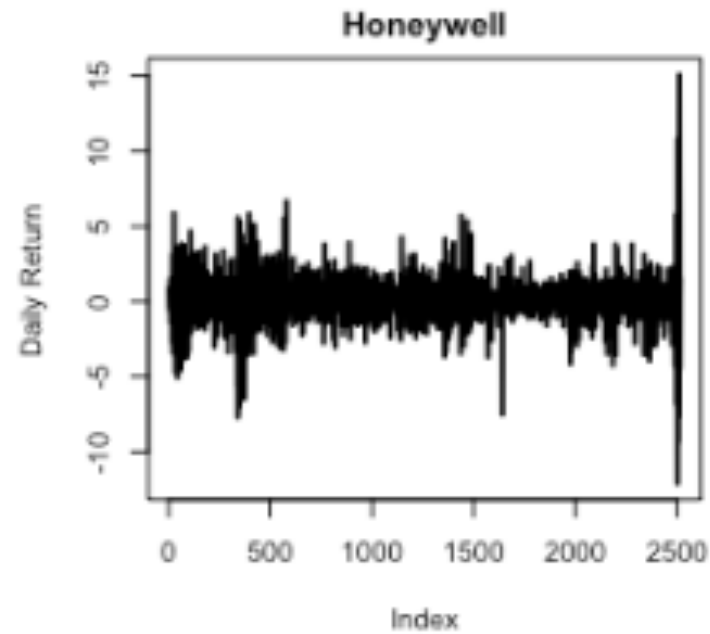
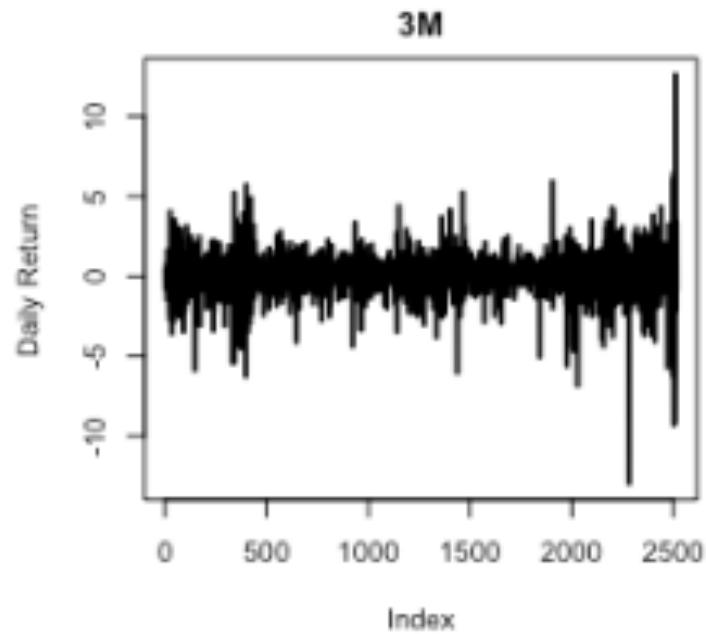
Part II. Descriptive Statistics

(2) Simple Return

The Honeywell company's simple return is the highest return among the 3 stocks with a mean rate of 0.0646 compare to 0.0386 for 3M and 0.0236 for EMR. The median return rate of MMM 0.07125 which is the highest among three stocks, we can conclude that there is a period of decreasing for 3M company in 10 year that cause this effect.

The kurtosis of the 3 companies are all over 10 which indicates that the return of these 3 companies follow a leptokurtic distribution. The skew of 3M and Emerson is less than 0 which show a strongly left skewness. Honeywell on the contrary shows a slightly right skewness.

	MMM	HON	EMR
vars	1	1	1
n	2516	2516	2516
mean	0.0386104590502672	0.0645977960122747	0.0236369791676553
sd	1.32633904270504	1.43158796701072	1.65489369277765
median	0.0712527965663867	0.0632557240987433	0.061768509516013
trimmed	0.0758683734431782	0.0688380654962234	0.0440819202248062
mad	0.875474111053069	0.941380232762125	1.14471039738465
min	-12.945042703131	-12.0868329883749	-18.9571905207144
max	12.5986235870377	15.0683620732875	16.3340248774147
range	25.5436662901687	27.1551950616624	35.291215398129
skew	-0.689290729430588	0.0659230986600842	-0.606132582734167
kurtosis	11.7812833108759	12.7922636886382	17.3105472897454
se	0.0264423004457472	0.0285405751616951	0.0329924663462766

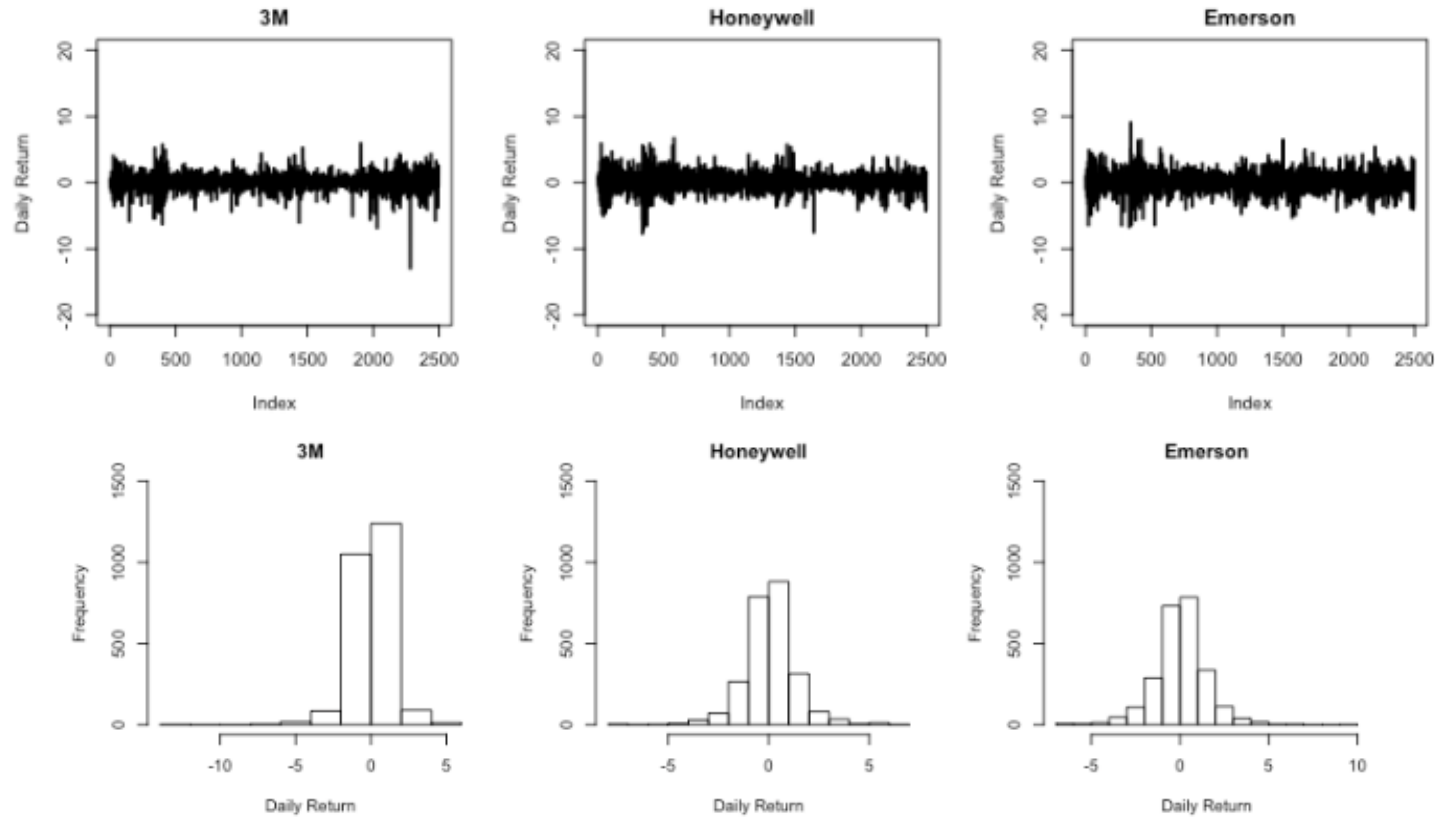


Part III. Stationary Check (1) Plots of Daily Return

The plots show the daily return of these 3 stocks.

All of the plots show a strong variance change near 2500 count.

It is due to the recent effect caused by coronavirus, to meet the requirement of stationary, we have to out count these data as outliers.

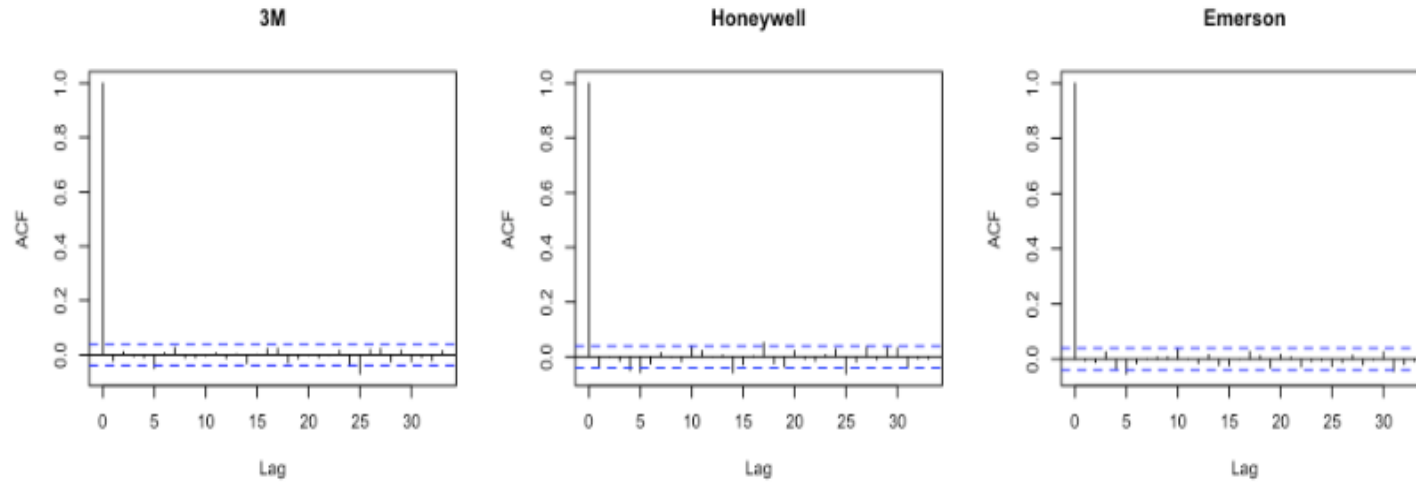


Part III. Stationary Check (1) Plots of Daily Return

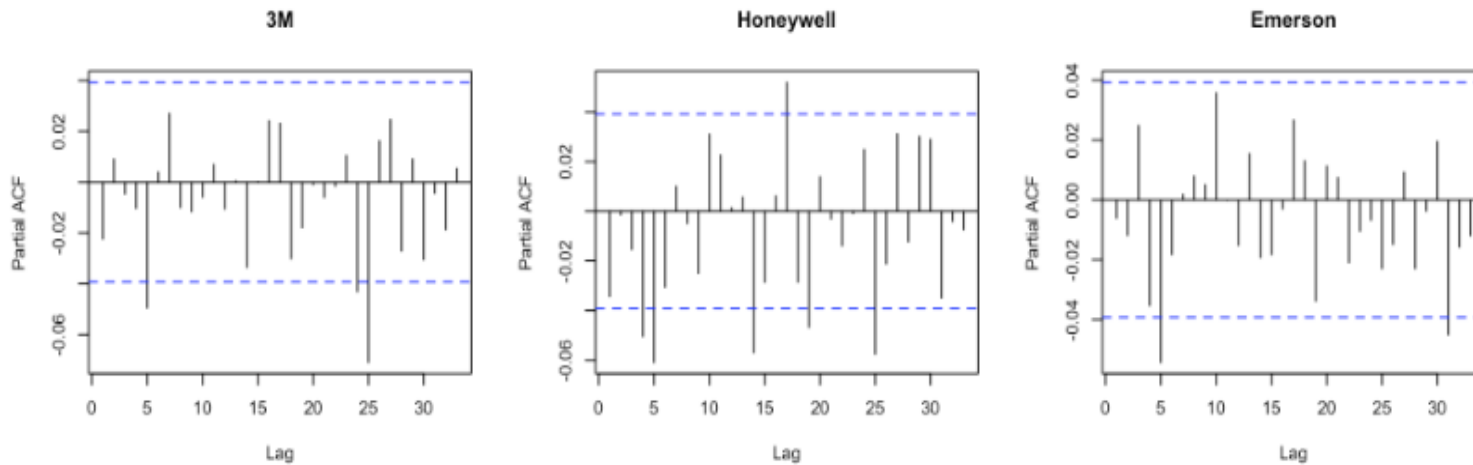
All the data of daily return generally follows normal distribution, which has a mean value close to 0 and basically constant variance.

Part III. Stationary Check (2) Autocorrelation and Partial Autocorrelation

ACF Plots for the 3 Companies (Daily Return)



PACF Plots for the 3 Companies (Daily Return)



The above plots demonstrate low autocorrelations and partial autocorrelations among daily returns of all three securities. The ACF is often used to recognize the lag factor of MA time series modeling, while the PACF is used for lag factor of AR time series modeling. Since both of plots do not demonstrate apparent decays in both autocorrelations and partial autocorrelations, the returns are stationary and generate long-memory effect, violating the principle of weak form efficiency.

Augmented Dickey-Fuller Test alternative: stationary

Type 1: no drift no trend

	lag	ADF	p.value
[1,]	0	-51.5	0.01
[2,]	1	-35.8	0.01
[3,]	2	-29.4	0.01
[4,]	3	-26.5	0.01
[5,]	4	-24.8	0.01
[6,]	5	-22.8	0.01
[7,]	6	-20.4	0.01
[8,]	7	-18.8	0.01
[9,]	8	-18.0	0.01

Augmented Dickey-Fuller Test alternative: stationary

Type 1: no drift no trend

	lag	ADF	p.value
[1,]	0	-50.2	0.01
[2,]	1	-35.8	0.01
[3,]	2	-28.3	0.01
[4,]	3	-25.5	0.01
[5,]	4	-23.9	0.01
[6,]	5	-21.9	0.01
[7,]	6	-20.0	0.01
[8,]	7	-18.4	0.01
[9,]	8	-17.1	0.01

Augmented Dickey-Fuller Test alternative: stationary

Type 1: no drift no trend

	lag	ADF	p.value
[1,]	0	-51.0	0.01
[2,]	1	-35.3	0.01
[3,]	2	-28.9	0.01
[4,]	3	-25.2	0.01
[5,]	4	-23.6	0.01
[6,]	5	-21.2	0.01
[7,]	6	-18.9	0.01
[8,]	7	-17.8	0.01
[9,]	8	-17.0	0.01

The Augmented Dickey Fuller Test (ADF) is unit root test for stationarity. By performing ADF test on return data using the aTSA package in R, I got the following result:

For all the daily returns, the result indicates a p value that less than 0.01 which reject the null hypothesis that there is a unit root. We accept the alternative hypothesis that the data is stationary.

Part III. Stationary Check (3) Augmented Dickey-Fuller Test

Part III. Stationary Check

(4) Phillips-Perron Test

Phillips-Perron test for the null hypothesis of a unit root of a univariate time series.

For all the daily returns, the result indicates a p value that less than 0.01 which reject the null hypothesis that there is a unit root. We accept the alternative hypothesis that the data is stationary.

```
Phillips-Perron Unit Root Test
alternative: stationary
```

```
Type 1: no drift no trend
lag Z_rho p.value
      8 -2410      0.01
```

```
Phillips-Perron Unit Root Test
alternative: stationary
```

```
Type 1: no drift no trend
lag Z_rho p.value
      8 -2512      0.01
```

```
Phillips-Perron Unit Root Test
alternative: stationary
```

```
Type 1: no drift no trend
lag Z_rho p.value
      8 -2413      0.01
```

```
KPSS Unit Root Test
alternative: nonstationary
```

```
Type 1: no drift no trend
lag stat p.value
11 2.02 0.0299
```

```
KPSS Unit Root Test
alternative: nonstationary
```

```
Type 1: no drift no trend
lag stat p.value
11 0.522 0.1
```

```
KPSS Unit Root Test
alternative: nonstationary
```

```
Type 1: no drift no trend
lag stat p.value
11 3.81 0.01
```

Part III. Stationary Check

(5) KPSS Test

The Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test figures out if a time series is stationary around a mean or linear trend or is non-stationary due to a unit root.

For all the daily returns, the result indicates a p value that larger than 0.01, which do not reject the null hypothesis that the data is stationary.

MMM: $W = 0.92677$, $p\text{-value} < 2.2e-16$

HON: $W = 0.94885$, $p\text{-value} < 2.2e-16$

EMR: $W = 0.96919$, $p\text{-value} < 2.2e-16$

- The result of Shapiro – Wilk test all have a p-value less than 0.01 for each return data, which reject the null hypothesis that the data is normal distributed.

Part III. Stationary Check

(6) Shapiro-Wilk Test

Part III. Stationary Check

(7) Linear Model Construction for Checking Stationary

For further validation for data, I constructed a linear model to test if there is any correlation between return and the lag value.

Liner Model Result for Return vs. Lag Value (coefficient value of lag)

MMM	HON	EMR
-0.0009078	0.00010809	-0.006506

The coefficient of lag value is -0.0009078, 0.00010809, and -0.006506 for 3M, Honeywell, and Emerson respectively, all of them are not significantly different from 0. We consider there is no linear relationship between return and log value for all the 3 model, which support the assumption that the data is stational.

Part IV. Modeling (1) ARIMA

From the last part of the passage, the daily return is tested to be stationary, so we can set $d=0$, and build ARMA model.

AIC for the three ARMA models

MMM	HON	EMR
7096.8	7533.37	8041.05

According to the auto.arima result for 3M company's return data, the best p and q value is $p=2$ and $q=2$, which brings an AIC of 7096.8. Similarly, for Honey well, the best value is $p=3$, and $q=3$, which brings an AIC of 7533.37. For Emerson, the best value is $p=0$ and $q=0$, it's a white noise, which brings an AIC of 8041.05. it is likely to be overfitted.

F ratio of the ANOVA tests for the prediction result

MMM	HON	EMR
1.837	0.195	0.056

Part IV. Modeling

(1) ARIMA

The F ratio of the ANOVA test for the 3 prediction results are 1.837, 0.1965, and 0.056 for 3M, Honeywell, and Emerson, respectively. The p value of these 3 ANOVA tests are 0.176, 0.659, 0.813, respectively, which do not reject the null hypothesis that the means are equal. This represents a good prediction.

Part IV. Modeling

(2) Linear States-Space Model

State space modelling is a popular technique for forecasting and smoothing time series data. I used 90% of the daily return data to build the states-space model, predicted the following 10% of the data, and finally use ANOVA to test the mean of the predicted result and the real result. The results are list in the form below:

	MMM	HON	EMR
F ratio	14.02	2.541	4.84
P Value	0.000202	0.112	0.0283

At the significant level of 0.01, the p value for MMM is less than 0.01, we reject the null hypothesis that the mean is equal, which means, the States-Space Model doesn't predict well for data of 3M company. The p value for Honeywell and Emerson is larger than 0.01, we do not reject the hypothesis that the means are equal, which means the model can effectively predict the daily return.

Part IV. Modeling

(3) VARMA Model

VARMA model further concludes the effect between the stocks based on ARIMA model. I apply VARMA(1,1) model to the daily return data, predict the following return, and compare the prediction to the testing dataset. Finally, I used ANOVA to compare the result to see how well the model predict the data.

Firstly, all the p values are larger than 0.01, we do not reject the null hypothesis that the means are equal, which means the models fits good. The F ratio is calculated by MSC/MSE, the smaller the error is, the larger the F ratio will be.

	MMM	HON	EMR
F ratio	2.029	0.216	0.07
P value	0.155	0.642	0.792

	MMM	HON	EMR
ARIMA	1.837	0.195	0.056
VARMA	2.029	0.216	0.07

Conclusion

The comparison between ARIMA model and VARMA model presents that all of the F ratio of ARIMA model are smaller than VARMA model's, which support the conclusion that VARMA model here is the best fit.