NATIONAL ECONOMICS UNIVERSITY

FACULTY OF MATHEMATICAL ECONOMICS

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GROUP ASSIGNMENT:

Independent Analysis and Forecast of Financial performance and Stock prices of Technology

Group 9 – DSEB 62

Instructor: MS Bui Duong Hai

Members:

No	ID	Full Name	Contribution for common section
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HA NOI, April 2023

CONTENTS

INTRODUCTION

The stock market is an essential part of any country's economy, and Vietnam's stock market has been gaining significant attention from both local and international investors in recent years. Technology and information play a crucial role in the development of the stock market, and Vietnam is no exception. With the rise of technology, access to information has become more accessible, and this has resulted in a significant impact on the stock market in Vietnam. This report aims to analyze focus on three prominent technology companies - VTC, CMG, and FPT in Vietnam's stock market . The report will use two different models, ARIMA and VAR, to analyze the individual stock prices and their relationship with the broader stock market index in Vietnam.

VTC is a technology company that specializes in digital content and communication services. The company has been in operation for over 20 years and is one of the leading players in the industry in Vietnam. The company went public in 2018, and its stock has been on a steady rise since then. Using the ARIMA model, we can see that the VTC stock price has been over the past nine years. The model also shows a positive trend in the future, indicating that the stock price is likely to continue to rise.

CMG is another technology company in Vietnam that focuses on providing software solutions for businesses. The company has been in operation for over 10 years and has shown steady growth over the years. Using the ARIMA model, we can see that the CMG stock price has been trending upwards over the past nine years, with some minor fluctuations. The model predicts that the stock price will remain stable in the future.

FPT is the largest technology company in Vietnam, with a diverse portfolio of products and services. The company has been in operation for over 30 years and has been relatively stable over the years. The model also predicts a positive trend in the future, indicating that the stock price is likely to continue to rise.

In addition to the individual analysis, we also used the VAR model to analyze the relationship between the stock prices of VTC, CMG, and FPT. The VAR model allows us to understand the interdependence between the individual stock prices.

INDIVIDUAL

I- Chu Đức Trung - FPT CORP. - FPT CORPORATION (FPT)

1. FPT

FPT Corporation is a leading technology company in Vietnam, providing a wide range of IT services, digital products, and solutions to clients worldwide. With over 30 years of experience in the industry, FPT has established itself as a trusted partner for businesses seeking innovative and reliable technology solutions. The company has a diversified portfolio of offerings, including software development, system integration, digital transformation, and cloud services, among others. FPT's strong market position and reputation have enabled the

company to achieve steady growth in revenue and profit in recent years, despite the challenges posed by the COVID-19 pandemic.

This part aims to provide an independent analysis and forecast of FPT's financial performance based on key metric net sales and stock price forecast. The report will utilize several forecasting models, and the accuracy of each model will be assessed using metrics such as RMSE, MAPE, and AIC, to determine which model provides the most reliable forecast for FPT's financial performance and stock prices.

1.1. Financial Analysis – Net Sales

This part analysis about the Vinamilk's net sales from the first quarter of 2009 to the fourth quarter of 2022 (57 observations).

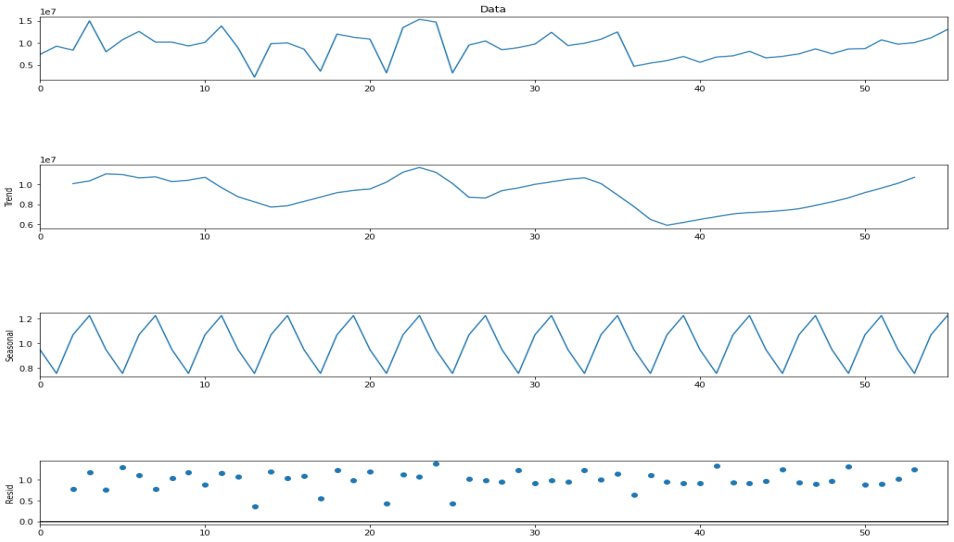


Figure 1. *Decompose the time series FPT Net Sales*

Figure 1 shows that FPT's net sales are seasonal. Here the trend is not really clear for the 14-year net sales data from 2009 to 2023. The objective of this section is to select an appropriate model for forecasting the company's quarterly net sales in 2023, based on the quarterly data from the past years.

8 different models use for forecasting in this part :

- Linear–Linear models:
  - **[1]** Only time trend
  - **[2]** Trend and seasonality in additive form
  - **[3]** Trend and seasonality in additive and multiplicative form
- Log-Linear models
  - **[4]** Only time trend
  - **[5]** Trend and seasonality in additive form:
  - **[6]** Trend and seasonality in additive and multiplicative form

• Holt-Winters models

[7] Additive form

[8] Multiplicative form

Model	Forecast 2023				Full Dataset		4 last obs (2022)	
	Q1	**Q2**	**Q3**	**Q4**	**RMSE**	**MAPE**	**RMSE**	**MAPE**
[1]	8388230	8363139	8338048	8312957	2860171.47	33.59%	2961033.96	**23.11%**
[2]	6534021	4859590	7664643	9228322	2314702.68	**27.87%**	4010037.11	36.30%
[3]	7236954	6914307	7132537	7458944	2595129.03	31.07%	3988853.5	33.99%
[4]	7278441	7245961	7213625	7181434	2646381.28	32.59%	3999043.34	33.42%
[5]	6568904	5241553	7541173	9351376	2344436.59	31.06%	3879351.10	35.31%
[6]	7148595	6865037	7079006	7404283	2622605.92	29.48%	4045194.24	34.57%
[7]	7172212	4689919	8181840	10283210	3430986.24	30.13%	3611947.09	31.90%
[8]	7445961	5036867	8241965	9858226	3328000.57	29.16%	3514286.91	31.02%

Table 1. *Result analysis FPT Net Sales*

Table 1 shows the results of 8 different models. In general, there is not too much difference in results between models. For 4 last observation in 2022, model **Linear–Linear model with only time trend [1]** is the best, MAPE = 23.11%. For full dataset, **Model Linear model with Trend and seasonality in additive form [2] i**s the best, MAPE = 27.87%. We can also find model results is better when comparing MAPE on the last 4 observations and MAPE on the Full dataset.

1.2.Stock price FPT forecasting using ARIMA

FPT is a highly respected technology company in Vietnam, with a strong track record of solid revenue growth and profitability.FPT's financials are also robust, with the company reporting strong profitability and a healthy balance sheet. These factors have made FPT a popular investment option for investors looking for stable and reliable long-term growth potential.

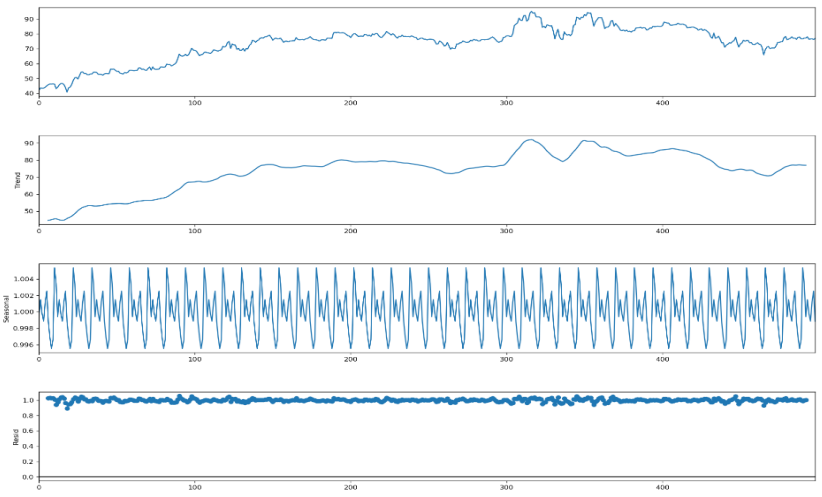


Figure 2. *Decompose the FPT stock price 2021-2022*

Figure 2 shows that FPT stock from 2021 to 2022 has an upward trend, with seasonality, and non-stationary. So, i will take difference of the fpt stock.

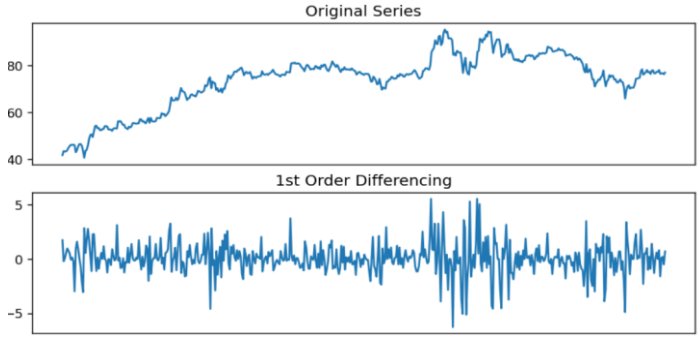


Figure 3. *Orginal and 1st Order Differencing of FPT stock price 2021-2022*

After take 1st Order Differencing, Figure 3 shows that 1st Order Differencing is stationary. Augmented Dickey-Fuller Test gives similar results to 1st Order Differencing

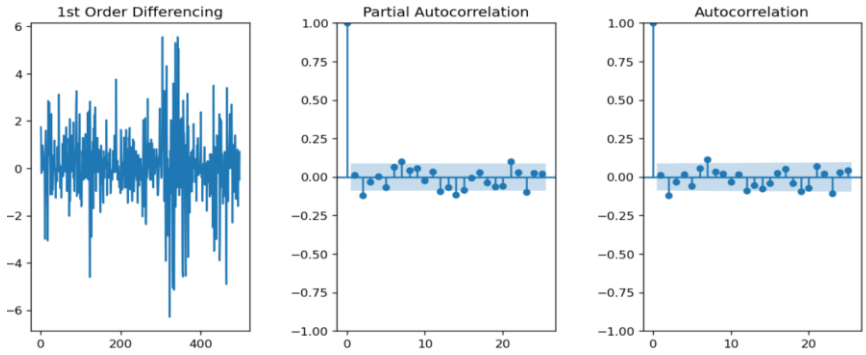


Figure 4. *1st Order Differencing and PACF, ACF of FPT stock price 2021-2022*

It is difficult to determine order AR, MA according to ACF and PACF to choose the best model. So I used AIC to find the best model, and the result is ARIMA (7,1,13) is the best model. I also test with ARIMA(4,1,5), ARIMA(2,1,2).

Model	Prob(Q)	RMSE	AIC	BIC

ARIMA(7,1,13)	0.96	2.32351	1773.690	1808.393
ARIMA(4,1,5)	0.84	2.34304	1774.717	1816.823
ARIMA(2,1,2)	0.95	2.36168	1786.036	1807.089

Table 2. *Evaluation of ARIMA models*

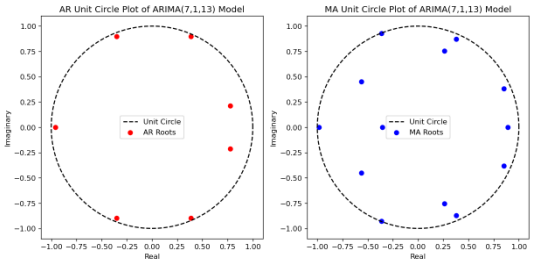


Figure 5. *ARIMA(7,1,13) Inverse roots*

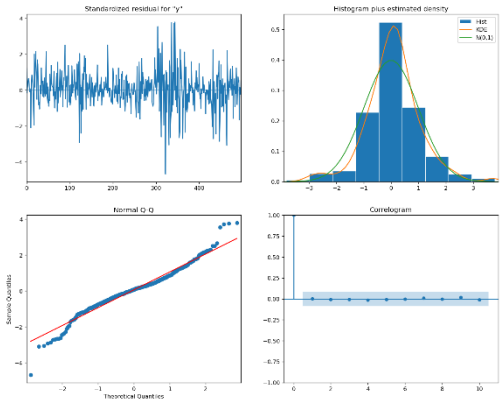


Figure 6. *Residuals checking for ARIMA(7,1,13)*

From figure 5 and figure 6, it can conclude that there is no serial correlation in the residuals of the model, and the reverse roots are inside the unit circle

II- Trần Thị Thu Trang - CMC CORPORATION (HOSE: CMG).

1. Introduction.

CMC CORPORATION (HOSE: CMG), formerly ADCOM Center, under the Institute of Microelectronics Technology, National Institute of Technology established 1991 - 1993, the center changed its name to CT TNHH HT&NT. On February 7, 2007, CMC equitized officially converted into a CMC Corporation with 13 founding shareholders who are key leaders of the company and of its member companies. CMG is also known as a large company in the information technology industry in Vietnam with 108 million shares outstanding. Currently, the main shareholders of CMC include Samsung SDS Asia Pacific Pte.Ltd, MVI Investment Co., Ltd and Geleximco Group with shares of 29.88%, 13.5% and 10.01% respectively.

The company is currently doing business in different fields and industries, but mainly related to information technology and application of information technology such as: Providing

science and technology services, hardware and software production, telecommunications network, educational consulting,....

2. Analysis of CMC's gross sales revenue.

a) Forecast for Gross Sales Revenue of CMG

To analyze the quarterly gross sales revenue of CMG, we will use 8 models using time series data of CMG's quarterly gross sales revenue since Q1 2009 until 2022Q4 to test.

Data from 2009Q1 to 2022Q4: t = 56	Forecast			
	2023: Q1: t = 57	2023: Q2: t = 58	2023: Q3: t = 59	2023: Q4: t = 60
1. LINEAR – LINEAR: $GSR_t = 727657 + 14278 * t + e_t$	1541503	1555781	1570059	1584337
2. LINEAR – LOG : $GSR_t = 545740 + 191319 * \ln(t) + e_t$	1319253	1322580	1325850	1329066
3. LOG – LINEAR: $GSR_t = \exp(13.445942 + 0.014653 * t + e_t)$	1593053	1616568	1640430	1664644
4. LOG – LOG $ln(GSR_t) = 13.2114 + 0.2119\, ln(t) + e_t$	1287384	1292137	1296826	1301453
5. LINEAR TREND + SEASONAL (ADDITIVE FORM) $GSR_t = 576035 + 13524 * t + 32127 * s_2 + 186775 * s_3 + 473507 * s_4 + e_t$	1346903	1392554	1560726	1860982
6. LINEAR TREND + SEASONAL (MULTIPLICATIVE FORM) $GSR_t = 439779 + 18570 * t + 116119 * s_2 + 208988 * s_3 + 935130 * s_4 - 3180 * t * s_2 - 1114 * t * s_3 - 15892 * t * s_4 + e_t$	1498269	1448518	1660101	1498449
7. HO LT-WINTES ANALYSIS (ADDITIVE FORM) : t = 56 + k $GSR^F_{T+k} = (1984722.7 + 43389.78 * k) + S_{appropriate}$	1831361	1831361	2076271	2386134
8. HO LT-WINTES ANALYSIS (MULTIPLICATIVE FORM) : t = 56 + k $GSR^F_{T+k} = (2176651 + 100178.1 * k * S_{appropriate}$	1990556	2004176	2325173	2683089

b) Compare among model.

	RMSE	**MAPE**	**RMSE** For last 4 obs	**MAPE** For last 4 obs
1. LINEAR – LINEAR	468381.9	21.81%	836135.4	39.81 %
2. LINEAR – LOG	493703	26.56%	821571	39.81 %

3. LOG – LINEAR	463439.6	17.98 %	893856.7	42.778 %
4. LOG – LOG	493290.1	22.833 %	887633.9	43.43 %
5. LINEAR TREND + SEASONAL (ADDITIVE FORM)	429491.4	19.45 %	806650.9	40.85%
6. LINEAR TREND + SEASONAL (MULTIPLICATIVE FORM)	417049.2	19.772%	813153.4	40.85%
7. HOLT-WINTES ANALYSIS (ADDITIVE FORM)	966781.2	64.414%	1467855	69.014%
8. HOLT-WINTES ANALYSIS (MULTIPLICATIVE FORM)	939495.5	60.478%	1470037	68.897 %

It can be seen that the difference between the MAPE of the whole data and the MAPE of the last 4 observations is not too large, it shows that found that the above model can be suitable for analyzing quarterly data of the company.

Compare the MAPE of the whole data between the models, the MAPE of model which is smaller, the model is better. It can be seen that the log-linear model is better than other models. MAPE of the last 4 observations between models, MAPE of 2 models is linear-log and linear-linear models is better than others.

3. Analyze CMG's closing price using the ARIMA model.

a) Plot: CMG trend : non-stationary.

Looking at the figure of ACF and PACF of the CMG's close price, it is easy to see that the sequence is a random step where ACF shows the correlation of continuous periods with each other. With Dickey-Fuller test, we have $|\tau_{stat}| = |-1.2154| < |\tau_{\alpha}|$, the test results make it even more clear that the CMG's close price is non-stationary.

Figure 1: Line plot of CMG's close price

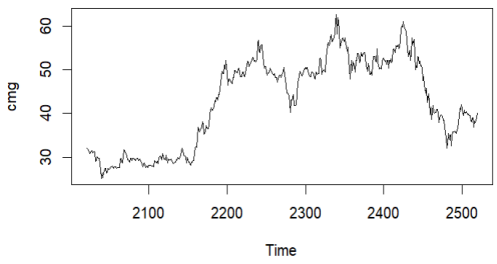
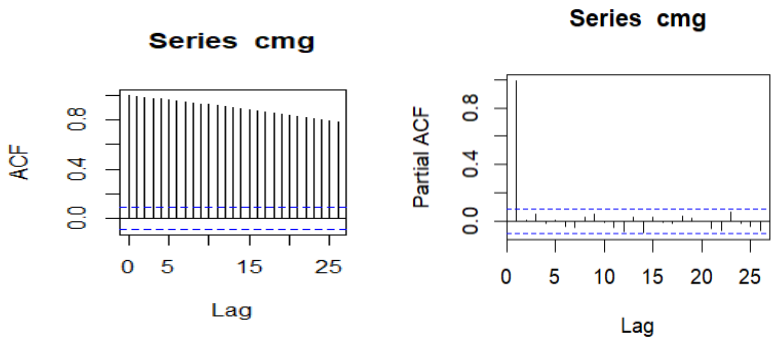


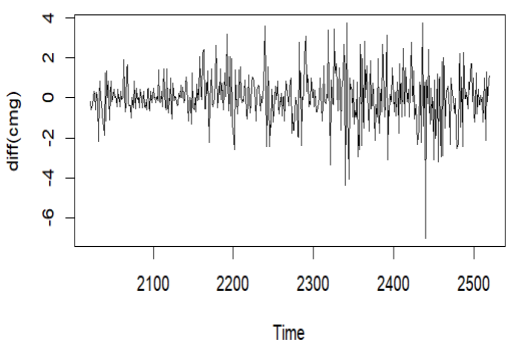
Figure 2: ACF and PACF of CMG's close price

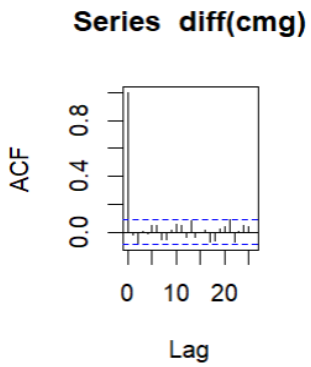


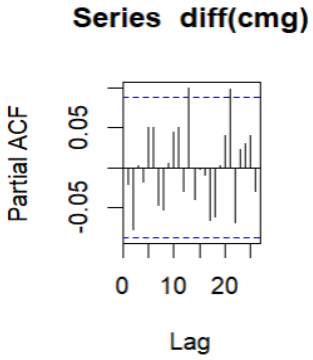
To check the stationary series, we will take the first difference of the series. It is clear from the ACF and PACF graphs of the first difference series that the series is stationary. Because Tau-test: $|\tau_{stat}| = |-17.1247| > |\tau_{0.05}| = |-2.87|$ so series (Δcmg_t) has not unit root, stationary.

Figure 3: line plot of difference series

Figure 4 : ACF and PACF of diffe rence series







b) Find order of ARMA of stationary series: Δcmg_t

Guest: AR(1), MA(3)

Model of $\Delta cpit$ is ARMA(1,3)

Model for CPI: ARIMA(1,1,3)

Original form: $\Delta cmg_t = \mu + \phi \Delta cmg_{t-1} + u_t + \theta_1 u_{t-1} + \theta_2 u_{t-2} + \theta_3 u_{t-3}$

Mean-adjusted form: $\Delta cmg_t - \mu^* = \phi(\Delta cmg_{t-1} - \mu^*) + u_t + \theta_1 u_{t-1} + \theta_2 u_{t-2} + \theta_3 u_{t-3}$

c) Estimate model ARIMA(1,1,3)

$$\Delta cmg_t - 0.0153 = 0.918(\Delta cmg_{t-1} - 0.0153) + u_t + (-0.9404)u_{t-1} + (-0.0593)u_{t-2} + 0.0833u_{t+3}$$

- Long-run mean is 0.0153
- AIC = 1614.32, BIC=1639.58

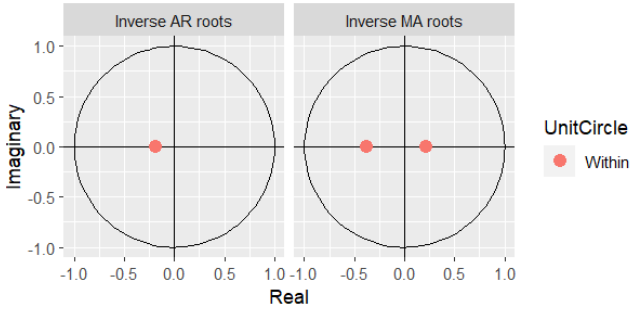
d) Check for goodness of model: Model ARIMA(1,1,2)

Forecasting model ARIMA(1,1,2), we get the following results:

$$\Delta cmg_t - 0.0159 = -0.1874(\Delta cmg_{t-1} - 0.0159) + u_t + 0.1655u_{t-1} + (-0.0827)u_{t-2}$$

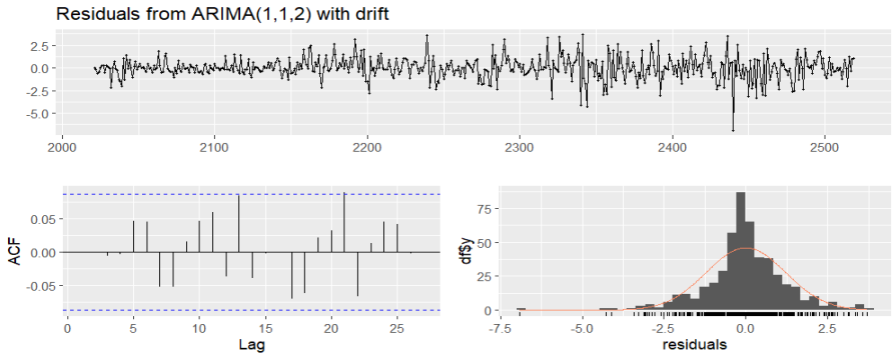
The above model gives AIC = 1612.61, BIC = 1633.66, slightly lower than ARIMA(1,1,3). Based on criteria AIC, BIC as well as theories economic, the ARIMA(1,1,2) model will preferred choice.

Stationary test for model:



Inverse roots: inside the unit circle: stationary

With model ARIMA(1,1,2) we use Ljung-Box test for check for the residuals of model. And we have result not reject H_0 is no serial correlation with P-value = 0.5119.



ACF: residual: white noise

Forecast equation:

$$\Delta cmg_t - 0.0159 = -0.1874(\Delta cmg_{t-1} - 0.0159) + u_t + 0.1655u_{t-1} + (-0.0827)u_{t-2}$$
$$\mu^* = 0.0159 \rightarrow \hat{\mu} = 0.0159\big(1 - (-0.1874)\big) = 0.0189$$
$$\rightarrow \Delta cmg_t = 0.0189 + (-0.1874)\Delta cmg_{t-1} + u_t + 0.1655u_{t-1} + (-0.0827)u_{t-2}$$

4. Forecast for the 10 first observaion in 2023.

Time	Real	Forecast
500	40.0000	39.90448
501	41.5000	39.85393
502	41.1000	39.88223
503	41.2000	39.89575
504	40.9500	39.91204
505	40.0000	39.92781
506	41.4000	39.94368
507	40.8500	39.95953
508	40.5000	39.97539
509	40.2500	39.99124

we can see that the forecast value will match the actual value close to about 90% in a short time. The forecast value has deviated by about 5% compared to the actual value, the ARIMA(1,1,2) model cannot predict the close price of CMG.

III- Nguyễn Ngọc Bảng Anh - VTC TELECOMMUNICATIONS JSC (VTC)

1. Introduction.

VTC Telecommunications JSC (vtctelecom) is a subordinate organization of Vietnam Posts and Telecommunications Group (VNPT). After more than 20 years of establishment, construction, and development, VTC Telecommunications JSC is proud to contribute effort to the construction and development of the largest telecommunications network in Vietnam: VNPT's telecommunications network. The company has experienced engineers and full facilities.

2. Financial series(Total assets):

This part analysis about the VTC TELECOMMUNICATIONS JSC total assets from the first quarter of 2009 to the fourth quarter of 2022 (52 observations).

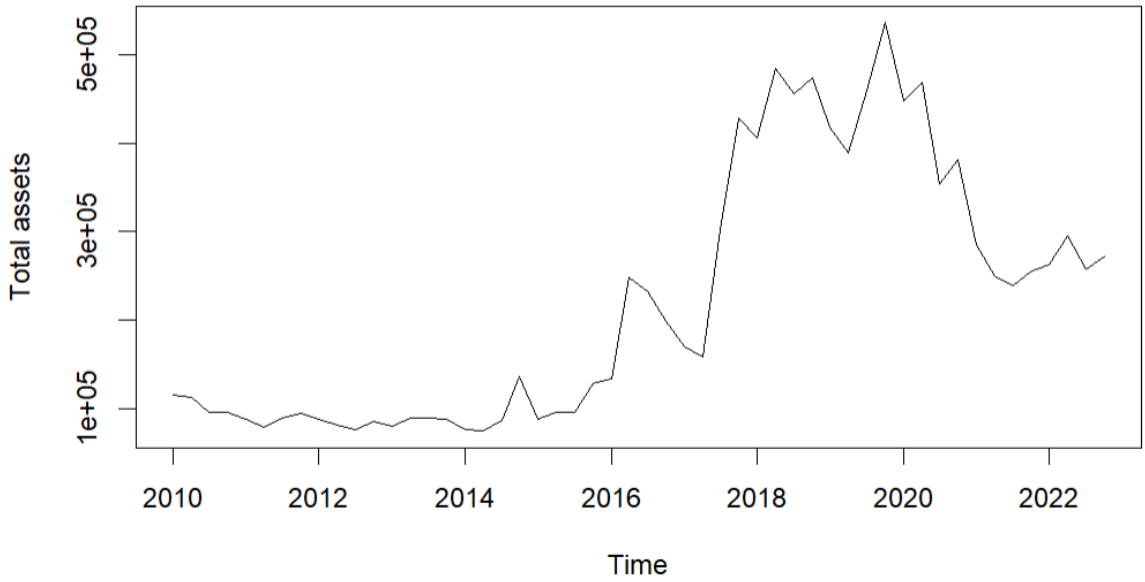


Figure 1: *Total assets of VTC*

Figure 1 is an overview graph of the total assets from the first quarter of 2010 to the fourth quarter of the year 2022.

There are 8 different models used for forecasting total assets of quarters in 2023:

Model	Quarter	2023 Forecast	RMSE, MAPE for whole data		RMSE, MAPE for 4 last observations	
			MAPE	RMSE	MAPE	RMSE
[1] Time Trend Regression (Linear-Linear)	1st	409087.6	42.94 %	97508.55	30.51%	120735.23
	2nd	416185.9				
	3rd	423284.2				
	4th	430382.5				
[2] Time Trend Regression (Log-Linear)	1st	476870.4	34.42 %	108937	37.42%	165031.35
	2nd	494845.1				
	3rd	513497.3				
	4th	532852.5				
[3] Linear Trend + Seasonality (Additive form) $Y_t = 27718.2 + 7071.4t + 5923.9 * s_{2t} + (-802.1) * s_{3t} + 18360.7 * s_{4t}$	1st	402502.4	43.07 %	97207.67	30.36%	120357.57
	2nd	415497.7				
	3rd	415843.1				
	4th	442077.3				

[4] Linear Trend +Seasonality (Additive and Multiplicative form) $Y_t = 31003.9 + 6940 * t + (-2143.9) * s_{2t} + 5525.3 * s_{3t} + 6576.1 * s_{4t} + 315.4 * t * s_{2t} + (-224.6) * t * s_{3t} + 435 * t * s_{4t}$	1st	398823.9	42.87 %	97129.86	30.34%	120460.88
	2nd	420651.6				
	3rd	405876.2				
	4th	450580				
[5] Log-Linear Trend +Seasonality (Additive form) $ln\ln(Y_t) = 11.096 + 0.036t + 0.013s_{2t} + (-0.004)s_{3t} + 0.074s_{4t}$	1st	444186.6	34.16 %	108770.6	34.29%	146903.96
	2nd	466493.8				
	3rd	475441.9				
	4th	532852.5				
[6] Log-Linear Trend +Seasonality (Additive and Multiplicative form) $ln\ln(Y_t) = 11.108 + 0.036t + (-0.022) * s_{2t} + (-0.012) * s_{3t} + 0.068 * s_{4t} + 0.0014 * t * s_{2t} + 0.0003 * t * s_{3t} + 0.0002 * t * s_{4t}$	1st	449548.9	34.11 %	108714.5	35.88%	156175.38
	2nd	491688.2				
	3rd	485289.1				
	4th	542096.9				
[7] Holt-Winters (Additive form) $Y_{t+k} = 253246.502 + (-2764.345) * k + s_{coresponds}$ s1: 0.983, s2: 1.001, s3: 1.007, s4: 1.108	1st	243067	13.56 %	48460.24	3.67%	14829.31
	2nd	252518				
	3rd	245725.4				
	4th	261293.6				
[8] Holt-Winters (Multiplicative form) $Y_{t+k} = (247152.9 + (-2149.798)k) * s_{coresponds}$ s1: 0.992, s2: 1.007, s3: 0.995, s4: 1.102	1st	243043.1	13.28 %	46183.21	5.68%	20771.74
	2nd	244553.3				
	3rd	239500				
	4th	262886.2				

Table 1. *Result analysis VTC total assets*

The above models are forecasted with training sets from 2010 to 2021. We can see that the smallest MAPE (2022) falls into the Holt-winter additive model with MAPE = 3.67%; The smallest overall MAPE falls in the Holt-winter multiplicative model with MAPE = 13.28% and in the Holt-winter add MAPE model the overall MAPE is 13.56%. Therefore, these are the two best forecasting models for 2023.

3. Stock Price VTC forecasting using ARIMA:

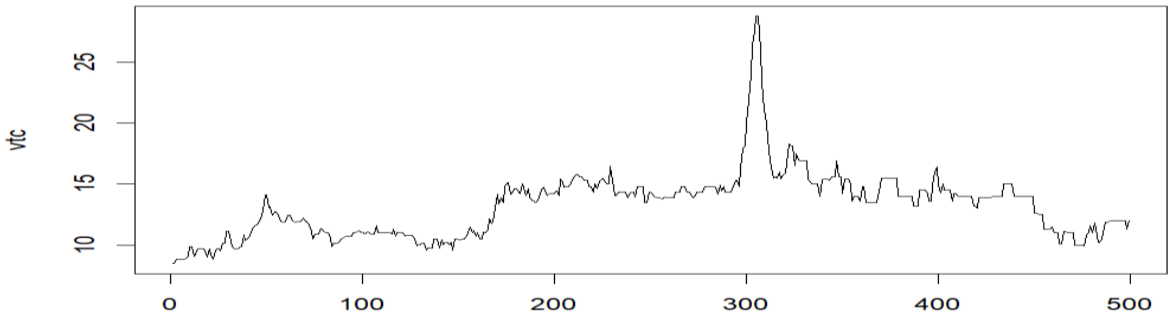


Figure 2: *Line graph of stock price VTC*

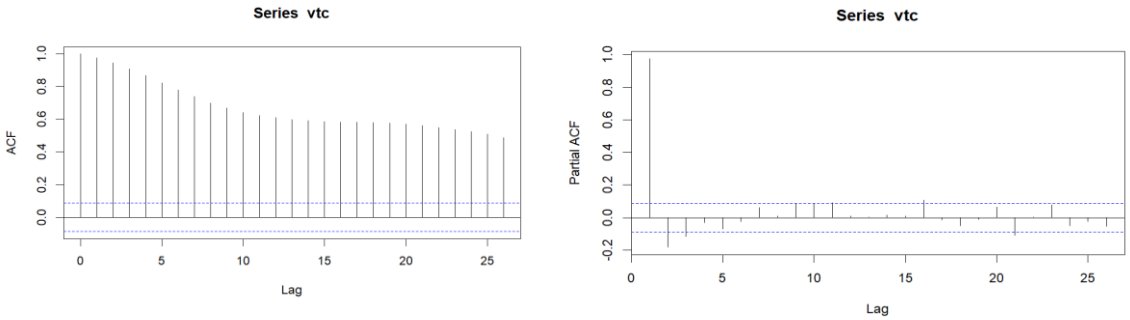


Figure 3: *PACF, ACF of VTC stock price in 2021-2022*

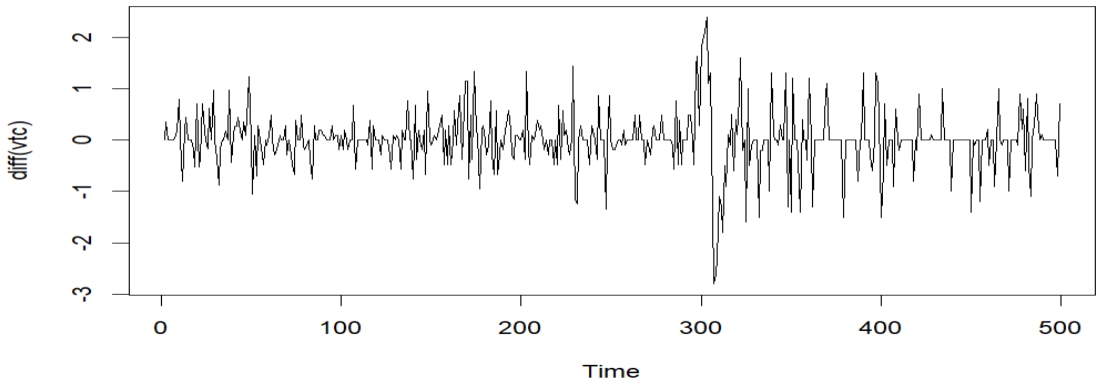


Figure 4: *1st Order Differencing*

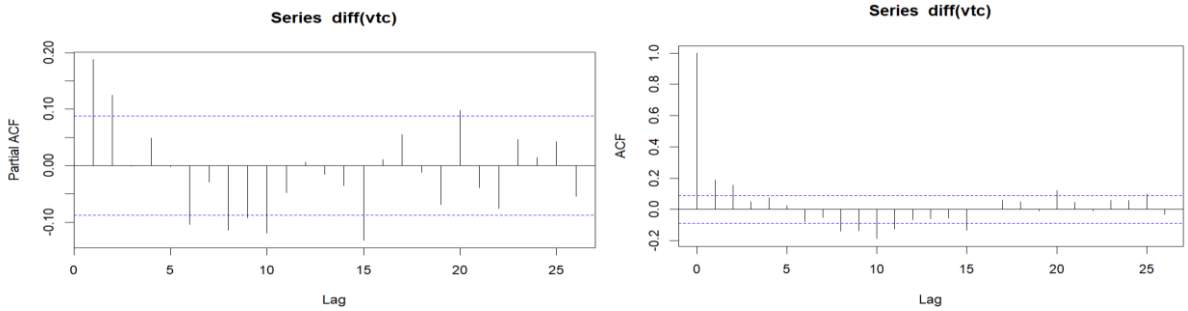


Figure 5: *PACF, ACF of difference series*

According to ACF and PACF choose the best model. So I used AIC to find the best model, and the result is ARIMA (1,1,9) is the best model with the smallest AIC = 809.79.

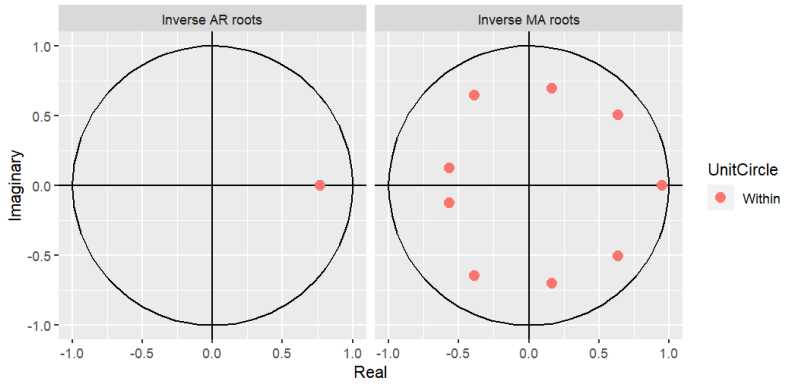


Figure 6: *Inverse roots of ARIMA(1,1,9)*

With model ARIMA(1,1,9) we use Ljung-Box test for check for the residuals of the model. And the result is no serial correlation with P-value = 0.3475.

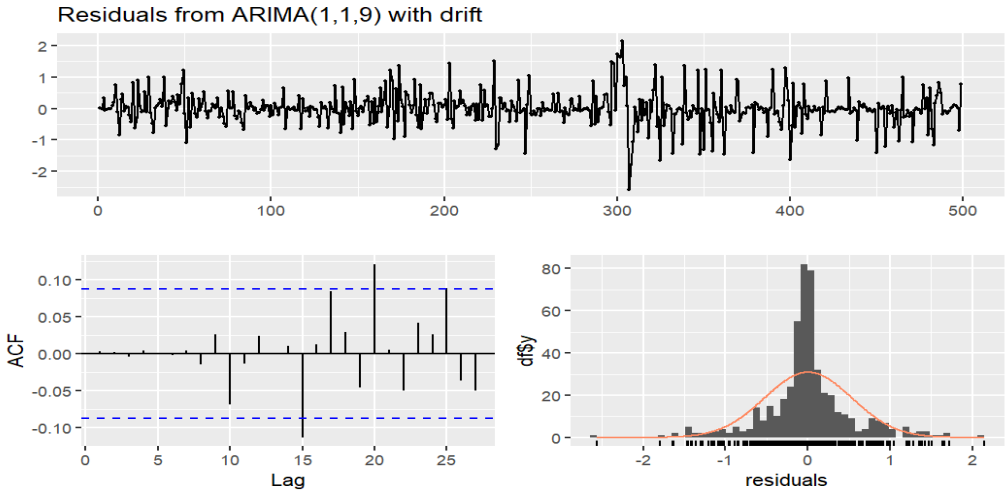


Figure 7: *Residuals check for ARIMA(1,1,9)*

The result of forecasting for the first 10 observations in 2023:

No.	Forecast price	Actual price
1	12.04	12
2	12.13	12
3	12.10	12
4	12.12	12
5	12.17	11.8
6	12.12	11.8

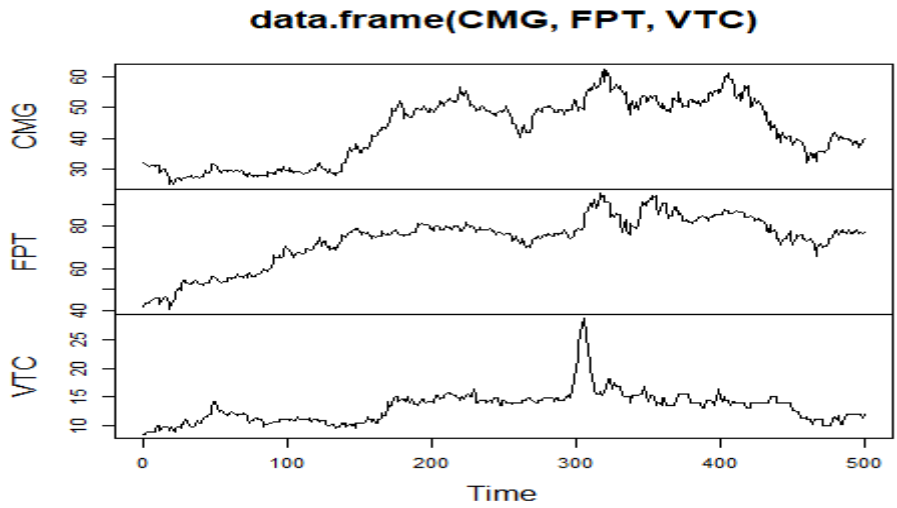
With RMSE and MAPE with results of 0.532 and 2.54% respectively, and MAPE of the next 10 values forecast is 1.99%. The ARIMA model (1,1,9) can be used for forecasting.

7	12.14	11.8
8	12.15	11.8
9	12.11	11.8
10	12.08	11.8

GROUP

I- Cointegration test.

Figure 1: Closing price series of CMG, FPT and VTC



Through the graph of variables CMG,FPT and VTC, both chains tend to be slow in mid-2021, when Covid-19 in Vietnam started raging. At the time t=300, around the beginning of 2022, the three chains tend to increase most clearly. In the following years due to the economic downturn, CMG, FPT and VTC cannot avoid the continuous devaluation and decrease. Only a real recovery will occur at the end of 2022. Precisely because the increase and decrease seems uniform, we hypothesize the following:

Cointegration test:

Cointegration is a statistical method used to test the correlation between two or more non-stationary time series in the long run or for a specified period.

1. Johansen test using "trace" criteria.

Table 1: Result of Johansen test using "trace" criteria.

	Test	10pct	5pct	1pct
r <= 2	2.70	6.5	8.18	11.65
r <= 1	15.78	15.66	17.95	23.52
r = 0	46.40	28.71	31.52	37.22

❖ $\begin{cases} H_0: r \leq 0\ , no\ cointegration \\ H_1: r > 0, more\ than\ 0\ cointegration \end{cases}$

In rank = 0, we can see the statistic is greater than the critical value at 10%, 5% and 1% so We can reject the null hepothesis of more than 0 cointegration.

❖ $\begin{cases} H_0: r \leq 1\ , no\ more\ than\ 1\ \ cointegration \\ H_1: r > 1, more\ than\ 1\ cointegration \end{cases}$

The next rank =1, we have 1 cointegrating vector because the statistic (15.78) smaller than the critical value at 5% (17.95).

Hence, we conclude that one cointegrating .

2. Unit root test for non-stationary series: CMG, FPT, VTC.

❖ CMG

```
Value of test-statistic is: -17.1367

Critical values for test statistics:
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62
```

❖ FPT

```
Value of test-statistic is: -17.5307

Critical values for test statistics:
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62
```

❖ VTC

```
Value of test-statistic is: -12.4748

Critical values for test statistics:
      1pct  5pct 10pct
tau1 -2.58 -1.95 -1.62
```

We can see the statistic value in 3 series is greater than all the critical value and p_value < 0.05 so all series is reject null hepothesis. All series are stationary.

3. Test for cointegration.

We estimated model by Rstudio: $CMG_t = \beta_0 + \beta_1 FPT_t + \beta_2 VTC_T + u_t$

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -15.59397    1.32994  -11.72   <2e-16 ***
FPT           0.55168    0.02201   25.07   <2e-16 ***
VTC           1.33372    0.09355   14.26   <2e-16 ***
---
Signif. codes:
0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.551 on 496 degrees of freedom
Multiple R-squared:  0.8014,    Adjusted R-squared:  0.8006
F-statistic:  1001 on 2 and 496 DF,  p-value: < 2.2e-16
```

$$CMG_t = -15.59397 + 0.5516 * FPT_t + 1.33372 * VTC_t + u_t$$

We used Dickey-Fuller test to chech residual for above model. Because $Tau - test$: $|\tau_{stat}| = |-4.1644| > |\tau_\alpha|\ at\ 1\%, 5\%\ and\ 10\%$, therefore we have reject null hypothesis. The residual of above model is stationary.

4. Error Correlation Model.

After check three tests above, we can confirm that the ECM model exists because all three data series are integrate with the same order (first difference) and their linear combination is stationary.

The ECM model shows that the change in CMG depends on the change in FPT, VTC and γ (that is coefficient of u_{t-1}. If γ is zero, then there will be no imbalance between the variables and in that case the long-run relationship will be determined by the cointegration relationship (no γ in here). But if $\gamma \neq 0$, then the relationship between CMG, FPT and VTC will ignore the external equilibrium. The ECM will tell us is the immediate effect of the FPT and VTC on the CMG.

ECM model:

$$\Delta Y_t = \alpha_1 + \alpha_2 \Delta X_{2t} + \cdots + \Delta X_{kt} + \gamma u_{t-1} + v_t$$

```
Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)     -0.009099   0.048848  -0.186 0.852305
diff(FPT)        0.352897   0.033775  10.448  < 2e-16 ***
diff(VTC)        0.078071   0.087951   0.888 0.375153
resid.CMG[1:498] -0.036835   0.010821  -3.404 0.000718 ***
---
```

⇨ $\Delta CMG_t = -0.0091 + 0.353 * \Delta FPT_t + 0.078 * \Delta VTC_t - 0.0368 u_{t-1} + e_t$

We can see that $\gamma = -0.036835$ is less than 0 and note that $\gamma \epsilon (-1; 0)$, so relationship between FPT, VTC and CMG will deviate from the equilibrium. At the same time, the immediate impact of FPT and VTC on CMG is the imbalance of the previous period.

II- Vector Autoregressie Model (VAR).

1. Granger causality test:

Granger causality test is a statistical hypothesis test for determining whether one-time series is useful in forecasting another.

VTC, FPT, CMG: Non-stationary.

$\Delta VTC_t, \Delta FPT_t, \Delta CMG_t$: Stationary.

Time series	P-value of F-test	Result
$\Delta VTC, \Delta FPT$ with order = 1	0.2222	No Granger's causality
$\Delta VTC, \Delta FPT$ with order = 2	0.3595	No Granger's causality
$\Delta VTC, \Delta CMG$ with order = 1	0.0334	**Have Granger's causality**
$\Delta FPT, \Delta VTC$ with order = 1	0.1004	No Granger's causality
$\Delta FPT, \Delta VTC$ with order = 2	0.0082	**Have Granger's causality**
$\Delta FPT, \Delta CMG$ with order = 1	0.1692	No Granger's causality
$\Delta FPT, \Delta CMG$ with order = 2	0.3528	No Granger's causality
$\Delta CMG, \Delta FPT$ with order = 1	0.684	No Granger's causality

$\Delta CMG, \Delta FPT$ with order = 2	0.7568	No Granger's causality
$\Delta CMG, \Delta VTC$ with order = 1	0.8205	No Granger's causality
$\Delta CMG, \Delta VTC$ with order = 2	0.0312	**Have Granger's causality**

This table shows the result of 11 Granger's causality tests with the specifies the number of lags (1, 2).

From the table, we can see that:

- VTC and FPT do not exhibit Granger causality in either direction, regardless of the order of the test.
- VTC and CMG exhibit Granger causality with order 1.
- FPT and VTC exhibit Granger causality with order 2.
- FPT and CMG, CMG and FPT, CMG and VTC do not exhibit Granger causality in either direction, regardless of the order of the test.
- CMG and VTC exhibit Granger causality with order 2.

These results suggest that there is a causal relationship between VTC and CMG, and between FPT and VTC, but not between FPT and CMG, or between CMG and FPT or VTC.

Data	**500**	**501**	**502**	**503**	**504**	**505**	**506**	**507**	**508**	**509**
VTC	**12.02**	**12.07**	**12.1**	**12.11**	**12.12**	**12.13**	**12.14**	**12.15**	**12.15**	**12.16**
CMG	**39.61**	**39.68**	**39.73**	**39.74**	**39.76**	**39.78**	**39.79**	**39.81**	**39.83**	**39.84**
FPT	**76.9**	**77.01**	**77.07**	**77.13**	**77.21**	**77.27**	**77.34**	**77.41**	**77.48**	**77.55**

Predicted stock by VAR(2)

2. Forecast with VAR, compare VAR and ARIMA's forecast.

	RMSE		**MAPE**	
	ARIMA	**VAR(2)**	**ARIMA**	**VAR(2)**
VTC	**0.26325**	**0.2709**	**1.9931%**	**0.02%**
CMG	**1.2081**	**1.1774**	**1,9657%**	**0.0255%**
FPT	**3.5362**	**3.1754**	**4.34%**	**3.93%**

Comparison of ARIMA and VAR(2)

Looking at the table, we can see that for all three stocks, the VAR(2) model outperformed the ARIMA model in terms of both RMSE and MAPE. This suggests that the VAR(2) model is a better fit for these stocks' time series data.

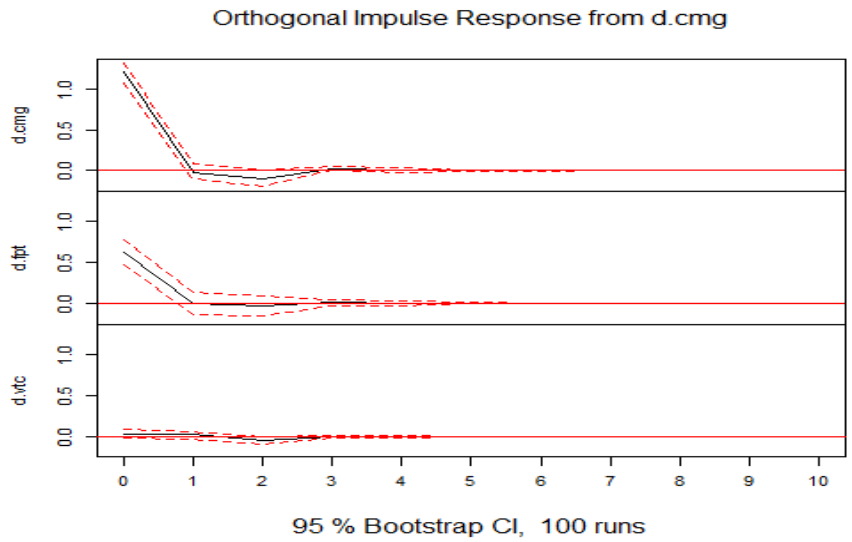
Additionally, we can see that for all three stocks, the MAPE values are relatively low, indicating that the models are making accurate predictions. However, the MAPE values for the VAR(2) model are significantly lower than those for the ARIMA model, suggesting that the VAR(2) model is making more accurate predictions.

3. Impulse response function.

We use VAR(2)'s forecast for Impulse Repsonse Function.

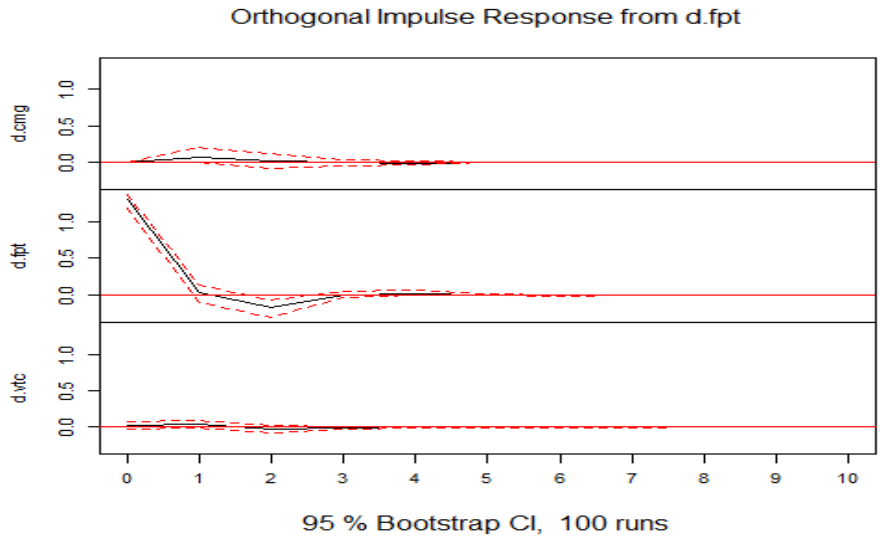
The Impulse Response plots describe under, looking at the response function of the CMG differential variable, we can clearly see the strong impact of shock on the volatility of CMG and FPT. The effects of the shock are significant before 1 time period as confidence intervals were well above zero, and after 1 period fades to negative, and back to 0 at 3 time periods. While VTC has almost too much influence in the short term with a value of approximately 0.

Figure 2: Impulse reponse for difference of CMG



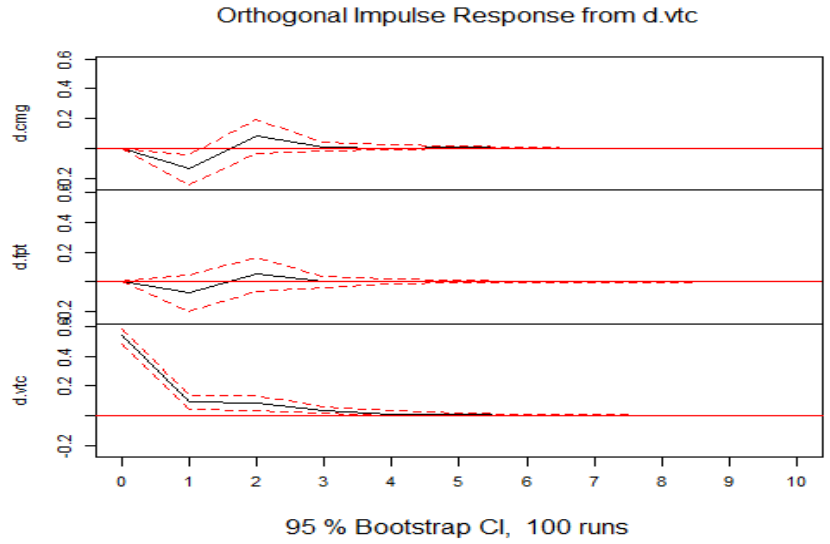
With the inpulse response function of FPT, the same thing happens when the impact of shock CMG and VTC on FPT is almost zero. While FPT is strongly influenced by its own shock, the effect goes down for 1 period and then goes negative and returns to 0 at 3 periods.

Figure 3: Impulse reponse for difference of FPT



With VTC's inpulse response function, similar to FPT, VTC is strongly influenced by its own shock. While the impact of CMG and FPT shocks on VTC is approximately 0, it ranges from -0.2 to 0.2.

Figure 4: Impulse reponse for difference of VTC



4. Variance Decomposition (FEDV).

After using the VAR model for 2 variables CMG and CTR, we will perform analysis of variance and give the following results:

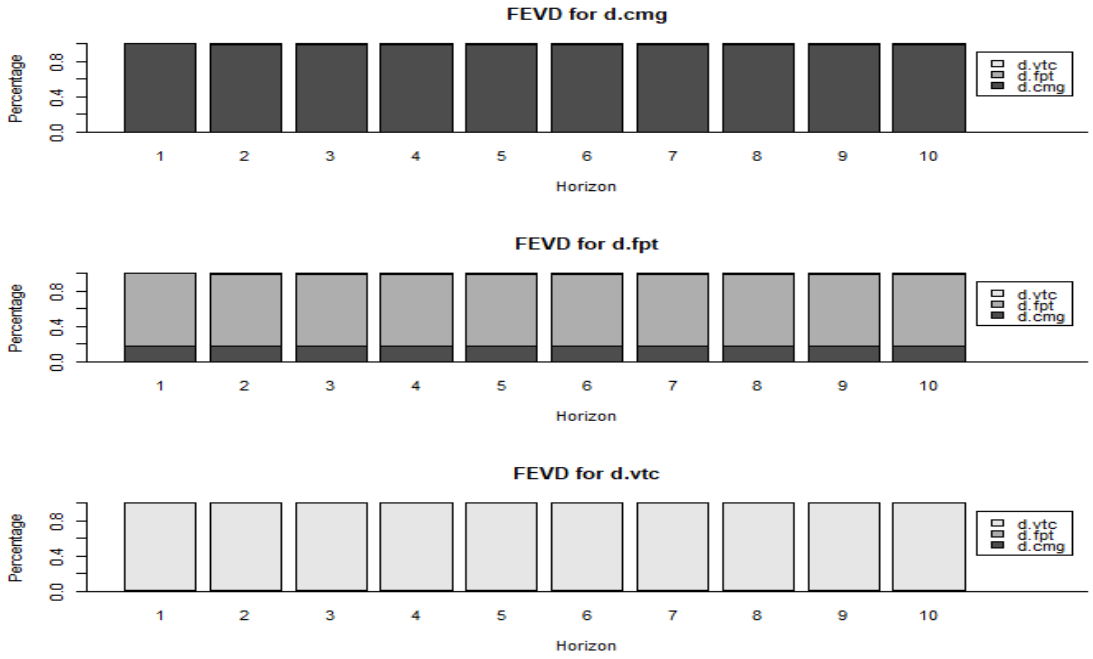


Figure 3: FEVD for difference of 3 series

The variance decomposition graph of 3 different variables CMG, FPT and VTC shows that there is almost only its own explanation in the previous to present periods. The impact of the remaining variables is insignificant. . The self-explanatory even though all three variables on the same IT industry group further clarify the independence of the three companies as each company develops in a different direction.

CONCLUSION

Overall, the Vietnamese stock market presents opportunities for both local and international investors, particularly in the technology sector. VTC, CMG, and FPT are established players in this industry, with potential for further growth. While the market is subject to fluctuations, the analysis of these companies using both the ARIMA and VAR models provides insights into their past and potential future performance.

The individual analysis using the ARIMA model demonstrated that these companies have shown steady growth over the past few years, with positive trends predicted for the future. The VAR model analysis revealed a relationship between the individual stock prices of these companies and, emphasizing the importance of considering the market's overall performance when making investment decisions.

Overall, the Vietnamese stock market presents potential opportunities for both local and international investors, particularly in the technology sector. The analysis of these companies provides insights into their past and potential future performance, giving investors a better understanding of the market's dynamics. As the market continues to evolve, keeping a close eye on technology and information trends will remain essential in making informed investment decisions.