BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE PILANI
29 November 2023

FIN F414: Financial Risk Analytics and Management
Under the Supervision of
Dr. Nagaraju Thota

BITS Pilani
Pilani | Dubai | Goa | Hyderabad

A report on estimation of BETA using the CAPM model and analysis of returns of underlying equity using ARIMA, GARCH, and EGARCH MODEL and VaR Analysis.

By
Group 2
Submitted for
Financial Risk Analytics and Management

Group Details

Name	ID
Raghunendra	2021A8PS1542H
Kartik Sharma	2021A4PS3085H
Rashmit Chauhan	2020B3A81182H

Firm Details

S. no	Name of the Firm
1.	VAIBHAVGBL
2.	RICOAUTO
3.	SOMICONVEY
4.	TAJGVK
5.	SELAN
6.	TNPL

ABSTRACT

The aim of the assignment is to compare the returns obtained by implementing the **CAPM, ARIMA, GARCH, and EGARCH** models for the above-mentioned firms. To achieve this goal, the **stock's closing prices** have been taken for the above-mentioned study period and then adjusted with the **risk-free rat**e to get the **excess returns.**

After this, **Value at Risk (VaR)** analysis was performed for a portfolio of the above stocks.

ACKNOWLEDGEMENT

I want to sincerely thank Dr. Thota Nagaraju for letting me work under him on this project and for giving us his precious time when we needed it to offer us the direction we needed.

His advice turned out to be quite helpful for the project. I want to express my gratitude to him for giving me this amazing chance to apply the information we have learned in class to actual data and get practical experience. I owe him for all of his assistance and advice throughout the course and on this project.

TABLE OF CONTENTS

Section 1: Company Introduction

Nature of Business

Ownership Distribution

Commencement of Business

Overall Greatness of the Company

Vaibhav Global Limited

1.1 INTRODUCTION

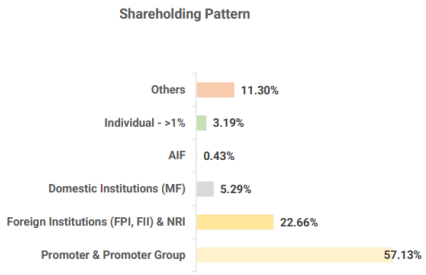
1.1.1 Nature of Business

Vaibhav Global Limited (VGL), previously identified as Vaibhav Gems, is a globally operating manufacturer and retailer of lifestyle accessories and fashion jewellery. Its purchasing channels are utilized to distribute its products. The corporate headquarters are located in Jaipur, India.

1.1.2 Ownership Distribution

Shareholding Pattern: As on 30th September 2023

Key Shareholders	Holding as on 30th-Sep-23
Nalanda India Fund Limited	10.16%
Motilal Oswal Flexi Cap Fund	5.26%
Malabar India Fund Limited	5.38%
Vanguard	1.46%
Taiyo Greater India Fund	2.10%
Vijay Kedia	1.98%
Ashish Kacholia	1.21%
Government Pension Fund Global	0.32%



As of September 2023, for Vaibhav Global LTD, the total promoter shareholding is 57.13%, and domestic Institutions is 5.29%. Foreign shareholding accounts for 22.66% and also consists of FIIs/FPI/QFIs. Individual shareholders account for only 3.19%.

1.1.3 Commencement of Business

In 1980, Vaibhav Enterprises was established as VGL. During the holiday season of 2005, VGL inaugurated its initial retail location in Alaska. As of 2007, the company had accumulated a grand total of 19 retail establishments across various vacation destinations, including the Caribbean, Alaska, and Mexico. VGL underwent a shift from high-street retail to deep-discounted teleshopping in the wake of the aftermath of the 2009 global financial crisis. The rebranding of VGL occurred in 2013 under the name "Vaibhav Global Limited."

1.1.4 Overall Greatness of the Company

- VGL is currently one of the leading exporters of studded jewellery and colored gemstones from India.
- The company was ranked 65th in Fortune India's Next 500 list.
- VGL has been shortlisted for the ICSI National Corporate Governance Award for the third time in succession in recognition of its implementation of sound corporate governance practices.

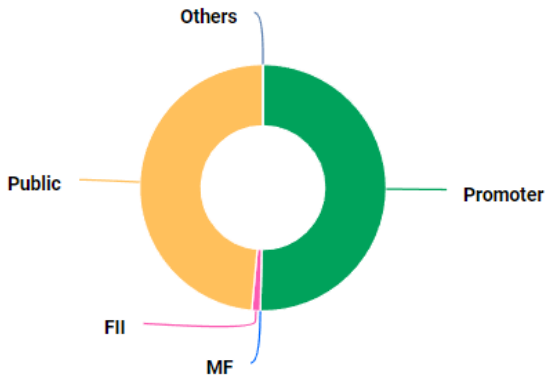
Rico Auto Industries Limited.

1.2 INTRODUCTION

1.2.1 Nature of Business

Rico is a globally renowned engineering firm that provides automotive original equipment manufacturers with an extensive selection of precision, completely machined aluminum and ferrous components and assemblies. Rico's integrated services include design, casting, tooling, development, machining, and assembly. Rico's consolidated group revenue exceeds $245 million.

1.2.2 Ownership Distribution



As of September 2023, for Rico Auto Industries Ltd, promoters hold a huge margin of 50.3% of total equity, followed by public holding 48.6% of the equity, FIIs accounting for 1.12%, and others accounting for almost 0%.

1.2.3 Commencement of Business

Rico Auto Industries Ltd., founded in 1983, is classified as a Small Cap entity operating in the Auto Ancillaries sector. Produce and supply to the world's foremost OEMs fully machined, high-precision aluminium and ferrous components and assemblies of the highest calibre.

1.2.4 Overall Greatness of the Company

- During the fiscal year that concluded on March 31, 2015, the organization achieved a gross turnover of Rs. 90.95 crores, an improvement from the previous year's figure of Rs. 85.44 crores. In the fiscal year that concluded on March 31, 2015, the organization achieved a net profit of Rs.1.07 crores, an increase from the previous year's net profit of Rs.1.02 crores. The Company has refrained from announcing any dividends for the fiscal year that expired on March 31, 2015.
- Rico has been designated as FORD Q1 since July 2007.
- The company was awarded best retention strategy in 2007.

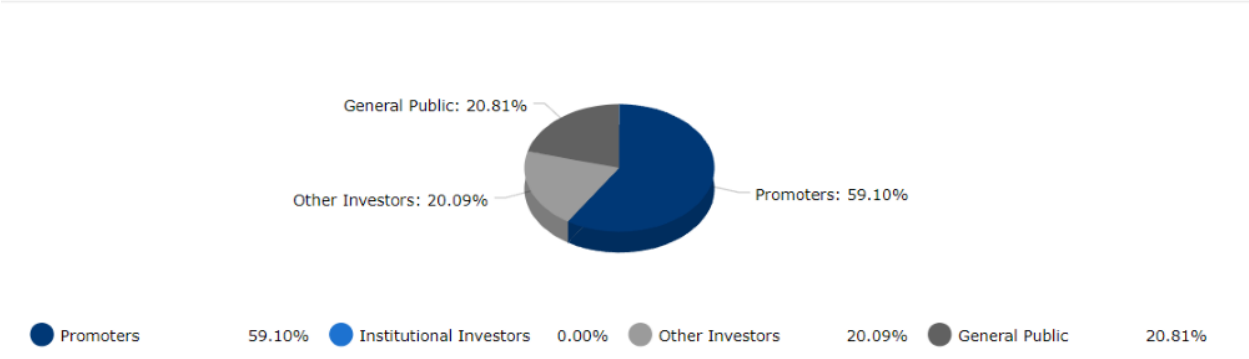
SOMI CONVEYOR BELTINGS LTD.

1.3 INTRODUCTION

1.3.1 Nature of Business

Somi Conveyor Beltings LTD is a public limited corporation listed on the NSE and BSE. Its headquarters are located in Jodhpur, India, which features two state-of-the-art manufacturing facilities and superior rail, road, and air connectivity. The manufacturer of conveyor belts is marketed as Somiflex. A selection of conveyor belts with a width of 2000mm and an annual installed capacity of 9,00,000 meters, which is comparable in width to that of Fenner, Yokohama, Dunlop, and Continental.

1.3.2 Ownership Distribution



As of September 2023, for CONVEYOR BELTINGS LTD, the total promoter shareholding is 59.10%, the general public accounts for 20.81%, and other investors contribute for 20.09%.

1.3.3 Commencement of Business

Under its original name, Omi Conveyor Beltings Limited, Somi Conveyor Beltings Ltd. was duly incorporated on June 16, 2000. Since October 31, 2000, the organization has operated as an exporter and manufacturer of all classes of material-handling rubber conveyor belts under the name Somi Conveyor Beltings Limited (SCBL). Riico Industrial Area, Sangaria District, Jodhpur, Rajasthan, is the whereabouts of the organization's establishment. With an initial capacity of 36,000 operational meters annually, the organization commenced commercial production of conveyor belts in February 2002. This capacity increased gradually over time to an annual rate of 72,000 meters. The unit has acquired an additional 1,67,660 meters of capacity over time.

1.3.4 Overall Greatness of the Company

- The company supplies belts used for conveyer to a GoI Undertaking.
- SOMICONVEY is an ISO–9001 Certified company.
- Prominent clients of the organization include ACC, TATAs, Ambuja Group, and others in the private sector who have placed repeated orders with the company.

TAJGVK Hotels & Resorts LTD

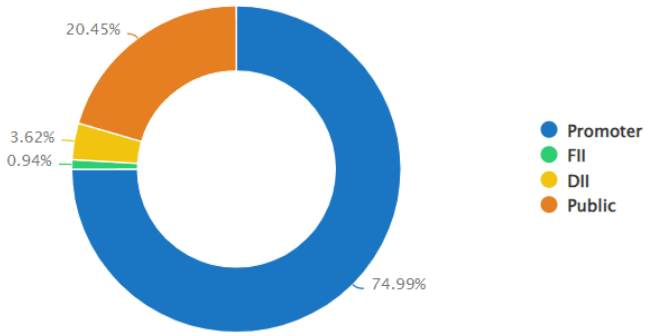
1.4 INTRODUCTION

1.4.1 Nature of Business

TAJGVK is a public limited company that is simultaneously listed on NSE and BSE. Co-founded in 1999 through a Strategic Alliance, TAJGVK Hotels & Resorts Limited (TAJGVK) is an enterprise that collaborates with GVK Group, based in Hyderabad, and the Indian Hotels Company Limited (IHCL). With its headquarters in Hyderabad, GVK Group is a multi-product, multi-location business conglomerate that controls a number of integrated organizations in India and abroad. A hotel chain is owned by IHCL, a subsidiary of TATA that manages and administers a variety of hotels domestically and internationally and owns the Taj Group of Hotels. The management of these properties is entrusted to the Organization through Green Woods Palaces and Resorts Pvt. Ltd., a joint venture corporation.

1.4.2 Ownership Distribution

As of September 2023, for TAJGVK Hotels & Resorts LTD, the total promoter shareholding is 74.99%, while the public sector accounts for 20.45%, and domestic Institutions is 3.62%. Foreign institutions account for just 0.94%.



1.4.3 Commencement of Business

The formal incorporation of TajGVK Hotels & Resorts Ltd. took place in 1995. The organization formed a strategic alliance with the preeminent hotel chain, Taj Group of Hotels, during the 1999-2000 fiscal year. In addition, Indian Hotels Company Ltd. had provided an investment of 40 crore rupees to the organization. Furthermore, the organization undertook the construction of The Deccan Hall, a substantial convention center that was specifically engineered to host major conferences, exhibitions, and weddings, among other functions. Following the acquisition of 100% equity, Punjab Hotels Ltd., the proprietor of the Chandigarh hotel project, was transformed into a wholly owned subsidiary of the corporation.In 2003-04, a substantial renovation was undertaken in the Banquet Hall of Taj Krishna, culminating in the establishment of The Grand Bal Room, an area that emanated an extravagant and sophisticated ambiance. The organization commenced operations at The Taj Chandigarh, the first branded five-star hotel in the city of Chandigarh, on June 20, 2005. The establishment marks the city's inaugural branded five-star hotel. The company unveiled Taj Mount Road, Chennai, a newly constructed five-star luxury hotel situated in the central area of the city, in December 2008. The organization is identifying and acquiring land in Bangalore and other cities for hotel development purposes.

1.4.4 Overall Greatness of the Company

- In 2022 and 2023, the Brand Finance Hotels 50 Report 2022 and the India 100 Report 2020, 2022, and 2023, respectively, ranked the organization as the preeminent hotel brand globally and within India.
- The company acquired “The Pierre” in New York in 2005.
- The Taj Exotica Resort & Spa, The Palm, Dubai, commenced operations on March 9, 2022. Recently, this hotel was added to The Taj Hotel conglomerate. The group also owns the Taj Dubai and Taj Jumeirah Lakes Towers Dubai, among other properties.

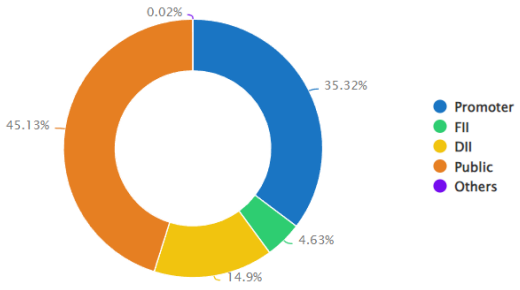
Tamilnadu Newsprint & Print LTD.

1.4 INTRODUCTION

1.5.1 Nature of Business

The Tamil Nadu Newsprint and Papers Limited (TNPL) was established by the Tamil Nadu government to produce newsprint and writing paper from bagasse, a byproduct of sugarcane. The paper mill was recognised as one of the world's most ecologically sustainable paper mills in April 1979 by the Tamil Nadu government, in compliance with the Companies Act of 1956. The plant is located in the Tamil Nadu districts of Manapparai in the Trichy District and Kagithapuram in the Karur District. The organization's registered office is located in Chennai's Guindy district.

1.5.2 Ownership Distribution



As of September 2023, for TNPL, the total promoter shareholding is 35.32%, and domestic Institutions is 14.9%. Foreign shareholding accounts for 4.63% and also consists of FIIs/FPI/QFIs. Individual shareholders account for 45.13%

1.5.3 Commencement of Business

When the company first started producing in 1984, it could produce 90,000 tonnes of goods annually. In January 1996, TNPL began producing newsprint on a commercial scale with its recently acquired Paper Machine No. 2. The machine has significantly expanded the scope of newspaper manufacture. It was supplied in partnership with Larsen & Toubro Limited, the licensee in India, and Voith Sulzer Paper Technology [4]. It is designed particularly to run only on bagasse. In its lifetime, the company increased its annual output to 2,45,000 tonnes and became the world's leading bagasse-based paper mill, using an estimated one million tonnes of bagasse annually. As of right now, the Organisation is working hard to put the Expansion into action, hoping to reach 4,000,000 tonnes of annual capacity by July 2010.

1.5.4 Overall Greatness of the Company

- TNPL has received ISO 9001–2000 certification from RWTUV of Germany for the design, production, and distribution of newsprint, as well as writing and printing paper.
- ISO14001:2004 accreditation has been bestowed upon TNPL in acknowledgment of its effective environmental management system. "Than 40,000 acres of forest land are annually spared depletion by TNPL through the use of bagasse as its primary raw material."
- TNPL employs a sophisticated sediment treatment system in order to treat effluent water. Approximately 250 farmers who are affiliated with the TNPL Effluent Water Lift Irrigation Society employ the purified effluent water for the purpose of irrigating a saline expanse spanning 1,250 acres. It is mandatory for the effluents of TNPL to conform to the criteria set forth by the TNPCB.

Selan Exploration Technology Ltd.

Selan Exploration Technology Limited

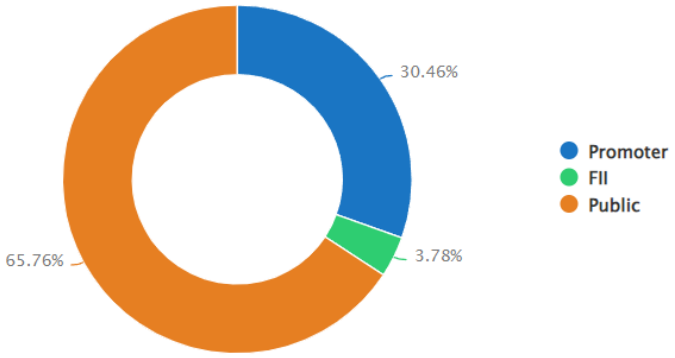
1.6 INTRODUCTION

1.6.1 Nature of Business

Selan Exploration Technology Limited, a prominent publicly traded corporation founded in 1985, has been involved in the exploration and production (E&P) of oil and gas since 1992. BSE and the NSE both list the organization. As an early adopter in the Indian exploration and petroleum (E&P) sector, the organization was among the first private sector entities authorized to develop oilfields discovered in Gujarat following the Indian government's 1992 decision to permit private investment in the industry.

1.6.2 Ownership Distribution

As of September 2023, for Vaibhav Global LTD, the total promoter shareholding is 30.46%. Foreign shareholding accounts for just 3.78% and also consists of FIIs/FPI/QFIs. Individual shareholders account for 65.76%.



1.6.3 Commencement of Business

Selan Exploration Technology Limited is a notable publicly traded company that operates within the private sector, specializing in the exploration and production (E&P) of oil and gas. The organization successfully executed the development of 1666 ground line kilometers (GLK) between 1991 and 1995. The organization issued a public offering in February 1995 in order to finance the development of the newly discovered hydrocarbon deposits. In December 1995, the organization obtained tangible possession of the oil fields, and the extraction of hydrocarbons commenced in January 1996. In 2009-2010, the organization commenced the commercialization of Associated Natural Gas, albeit with some restrictions. A comprehensive drilling campaign was commenced in all existing fields during the fiscal year 2022-23.

1.6.4 Overall Greatness of the Company

- The organization was one of the initial private sector entities to secure development rights for oilfields discovered in Gujarat.
- Their manufacturing and development processes adhere to the most stringent Health, Safety, Sustainability, and Environmental criteria.

Section 2: CAPM MODEL

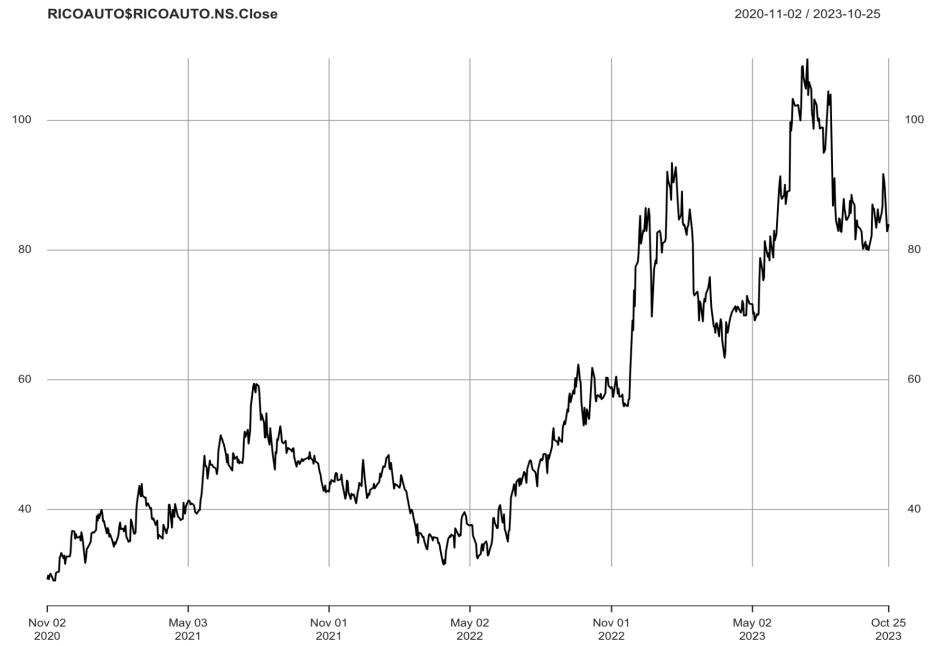
CAPM Model on Daily Returns

CAPM Model on Weekly Returns

CAPM Model on Monthly Returns

2.1 Rico Auto Industries Ltd

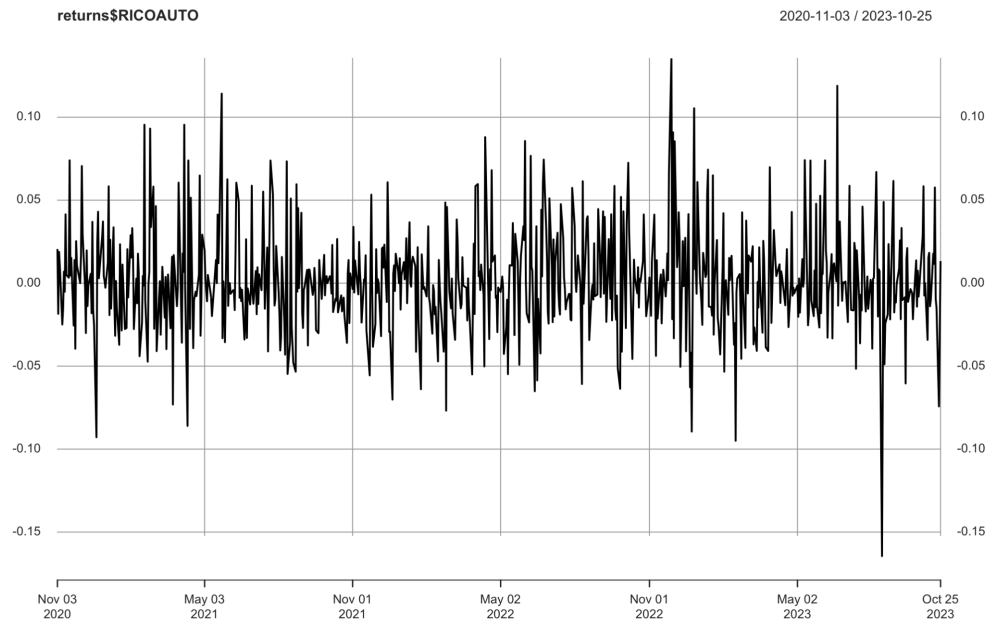
2.1.1 RICO CAPM (Daily Returns)



The above figure shows the weekly closing prices of RICOAUTO from November 2, 2020, to October 25, 2023.

```
> mean(returns$RICOAUTO)
[1] 0.001917211
> var(returns$RICOAUTO)
              RICOAUTO
RICOAUTO 0.0009762906
>
```

The mean and variance of the daily excess returns of RICO AUTO were 0.191% and 0.0976%, respectively.



The above figure shows the daily excess returns of RICO AUTO from November 3, 2020, to October 25, 2023.

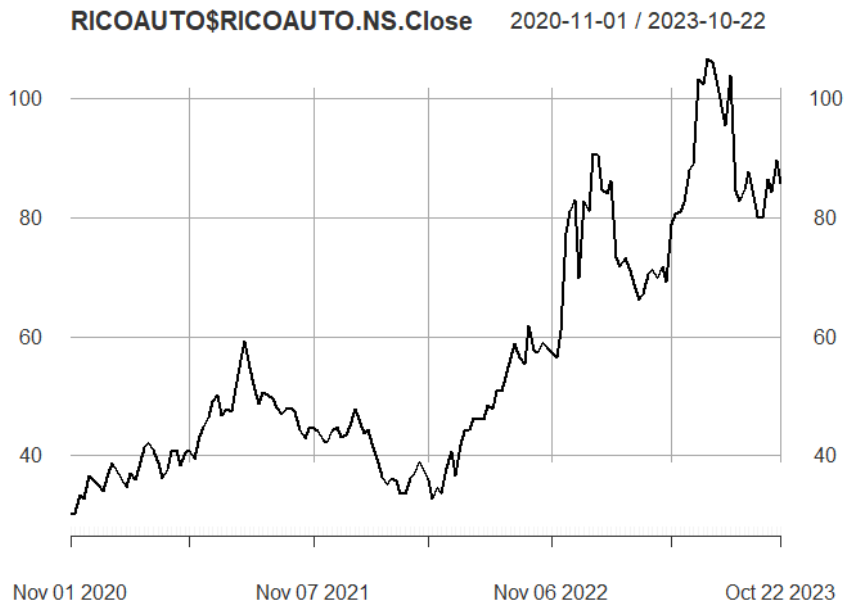
Now, the market Daily Excess Returns and RICO AUTO Daily Excess Returns are regressed and results in the following:

```
Call:
lm(formula = returns$RICOAUTO ~ returns$EXCESS_NSE)

Residuals:
      Min        1Q    Median        3Q       Max
-0.164963 -0.017063 -0.003867  0.013525  0.133152

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)        0.019976   0.002324   8.596   <2e-16 ***
returns$EXCESS_NSE 1.025118   0.114446   8.957   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.02958 on 720 degrees of freedom
  (16 observations deleted due to missingness)
Multiple R-squared:  0.1003,    Adjusted R-squared:  0.09901
F-statistic: 80.23 on 1 and 720 DF,  p-value: < 2.2e-16

>
```

Interpretation (Daily Returns):

The daily returns of RICO AUTO will grow by 1.025% if the daily returns of the market index portfolio increase by 1%, as seen by the preceding figure, which also reveals that the beta for daily returns (risk unadjusted) is 1.025. Furthermore, it can be said that even at a 99% confidence level, the regression beta is significant since the p-value is smaller than 0.01. The intercept was found to be 0.019976, indicating that RICO AUTO would display a 0.019976% return if the market return is 0%.

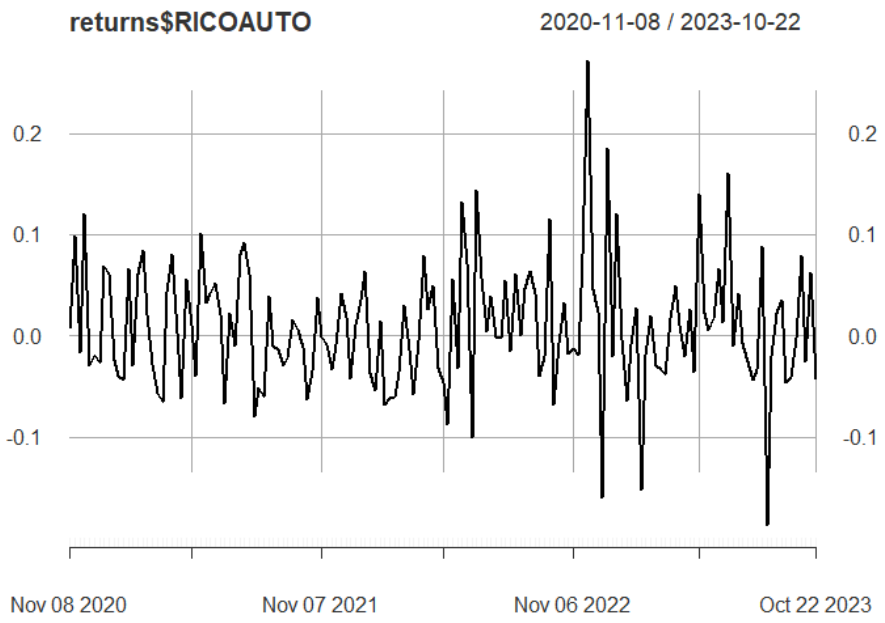
2.1.2 RICO CAPM (Weekly Returns)



The above figure shows the closing prices of RICOAUTO from November 2, 2020, to October 25, 2023

```
> mean(returns$RICOAUTO)
[1] 0.008657108
> var(returns$RICOAUTO)
             RICOAUTO
RICOAUTO 0.003881423
```

The mean and variance of the weekly excess returns of RICO AUTO were 0.865% and 0.0388%, respectively.



The above figure shows the weekly excess returns of RICO AUTO from November 3, 2020, to October 25, 2023.

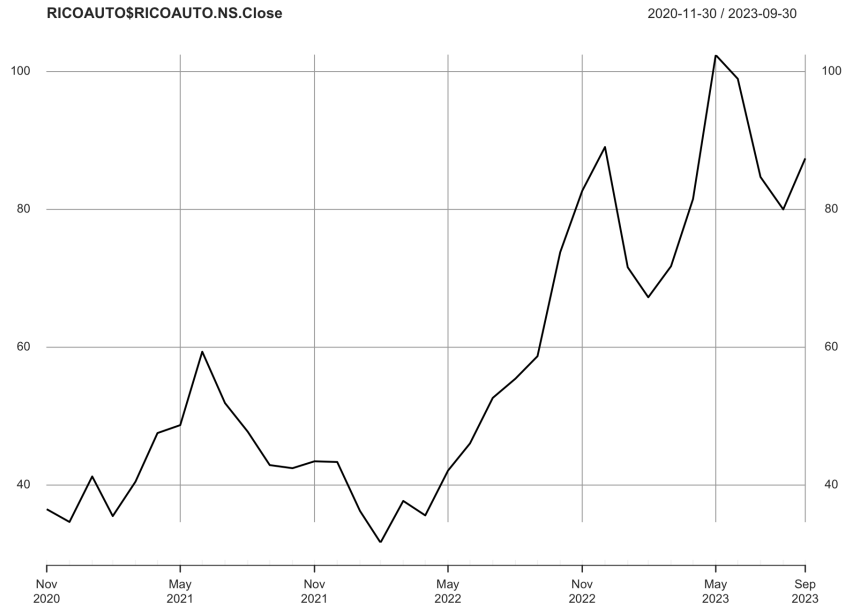
Now, the market Weekly Excess Returns and RICO AUTO Weekly Excess Returns are regressed and results in the following:

```
Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)        0.09926    0.02602   3.814 0.000198 ***
returns$EXCESS_NSE 0.70824    0.19987   3.544 0.000525 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.06027 on 152 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.07631,   Adjusted R-squared:  0.07023
F-statistic: 12.56 on 1 and 152 DF,  p-value: 0.0005248
```

Interpretation (Weekly Returns):

The weekly returns of RICO AUTO will increase by 0.708% if the weekly returns of the market index portfolio grow by 1%, as seen by the preceding figure, which displays the beta for weekly returns (risk unadjusted) of 0.708. Furthermore, it can be said that even at a 99% confidence level, the regression beta is significant. The intercept was found to be 0.09926, indicating that RICO AUTO would display a 0.09926% return if the market return is 0%.

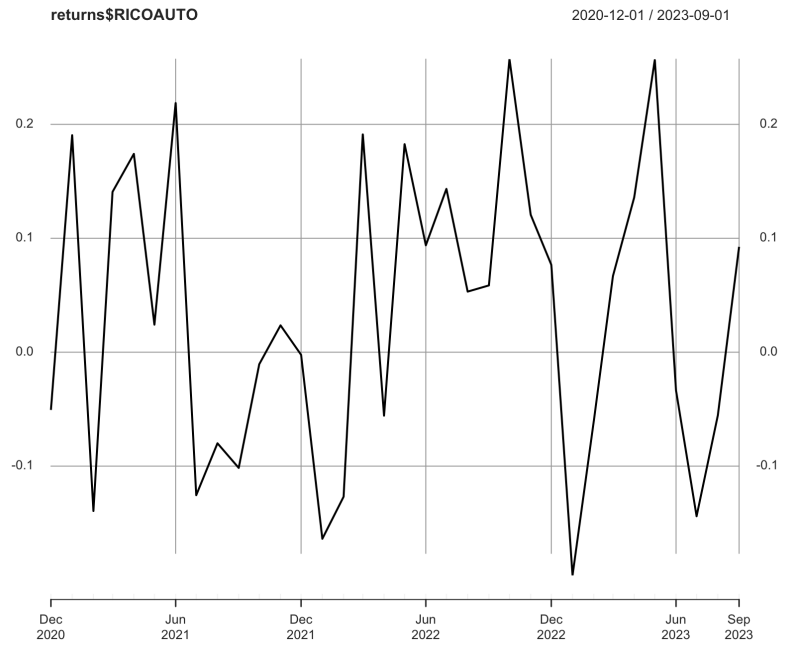
2.1.3 RICO CAPM (Monthly Returns)



Closing Prices show the closing prices of RICOAUTO from November 2 2020 to October 25 2023.

```
> mean(returns$RICOAUTO)
[1] 0.03396026
> var(returns$RICOAUTO)
           RICOAUTO
RICOAUTO 0.01676322
```

The mean and variance of the monthly excess returns of RICO AUTO were 3.396% and 1.676%, respectively.



The above figure shows the monthly excess returns of RICO AUTO from November 3, 2020, to October 25, 2023.

Now, the market monthly Excess Returns and RICO AUTO monthly Excess Returns are regressed and results in the following:

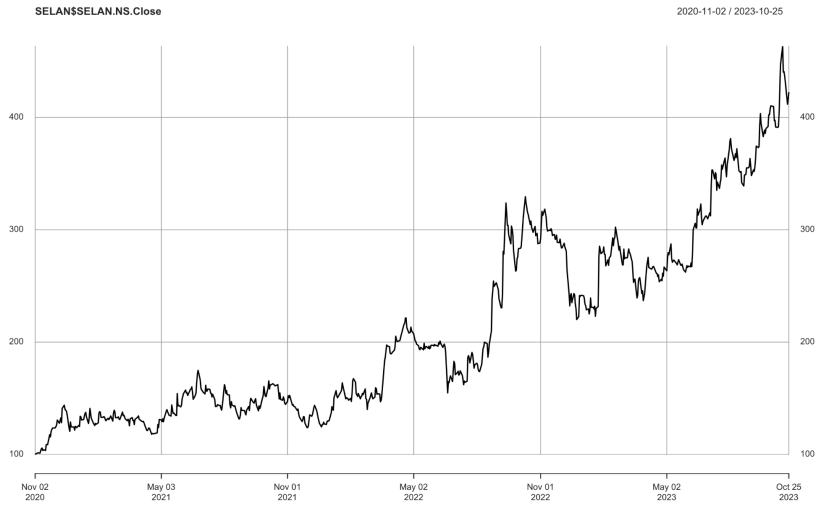
```
Call:
lm(formula = returns$RICOAUTO ~ returns$EXCESS_NSE)

Residuals:
      Min        1Q    Median        3Q
-0.226728 -0.091238  0.005047  0.104533
      Max
 0.224211

Coefficients:
                   Estimate Std. Error
(Intercept)         0.05761    0.20495
returns$EXCESS_NSE  0.04245    0.36569
                   t value Pr(>|t|)
(Intercept)          0.281    0.780
returns$EXCESS_NSE   0.116    0.908

Residual standard error: 0.1315 on 32 degrees of freedom
Multiple R-squared:  0.000421,  Adjusted R-squared:  -0.03082
F-statistic: 0.01348 on 1 and 32 DF,  p-value: 0.9083
```

Interpretation Monthly Returns:

The monthly returns of RICO AUTO will increase by 0.116% if the monthly returns of the market index portfolio grow by 1%, as seen by the preceding figure, which also reveals that the beta for monthly returns (risk unadjusted) is 0.116. Furthermore, it can be said that even at a 99% confidence level, the regression beta is significant. The intercept was 0.281, indicating that RICO AUTO would display a 0.281% return if the market returns zero per cent.

2.2 Selan Exploration Technology Ltd

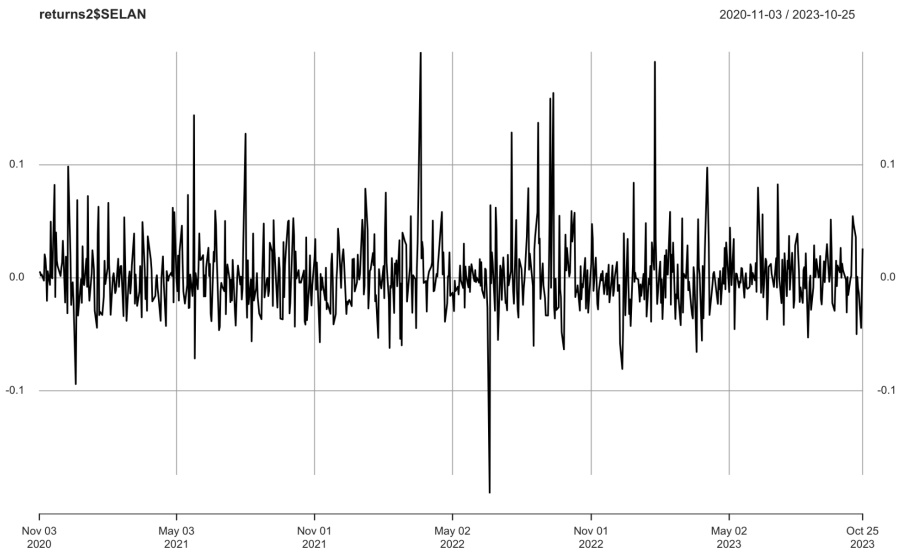
2.2.1 SELAN CAPM (Daily Returns)



The above figure shows SELAN's daily closing prices from November 2, 2020, to October 25, 2023.

```
> mean(returns2$SELAN)
[1] 0.002452594
> var(returns2$SELAN)
              SELAN
SELAN 0.001017264
```

The mean and variance of SELAN's daily excess returns were 0.245% and 0.0101%, respectively.



The above figure shows SELAN's daily excess returns from November 3, 2020, to October 25, 2023.

Now, the market daily Excess Returns and RICO AUTO daily Excess Returns are regressed and results in the following:

```
Call:
lm(formula = returns2$SELAN ~ returns2$EXCESS_NSE)

Residuals:
      Min        1Q    Median        3Q       Max
-0.193982 -0.017131 -0.003375  0.012144  0.204786

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)        0.014760   0.002434   6.064 2.15e-09 ***
returns2$EXCESS_NSE 0.695618   0.119882   5.803 9.79e-09 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Interpretation Daily Returns:

The daily returns of SELAN will increase by 0.695% if the daily returns of the market index portfolio grow by 1%, as seen by the preceding figure, which displays the beta for daily returns (risk unadjusted) of 0.695. Furthermore, it can be said that even at a 99% confidence level, the regression beta is significant. The intercept was found to be 0.014760, indicating that SELAN would display a 0.014760% return if the market return is 0%.

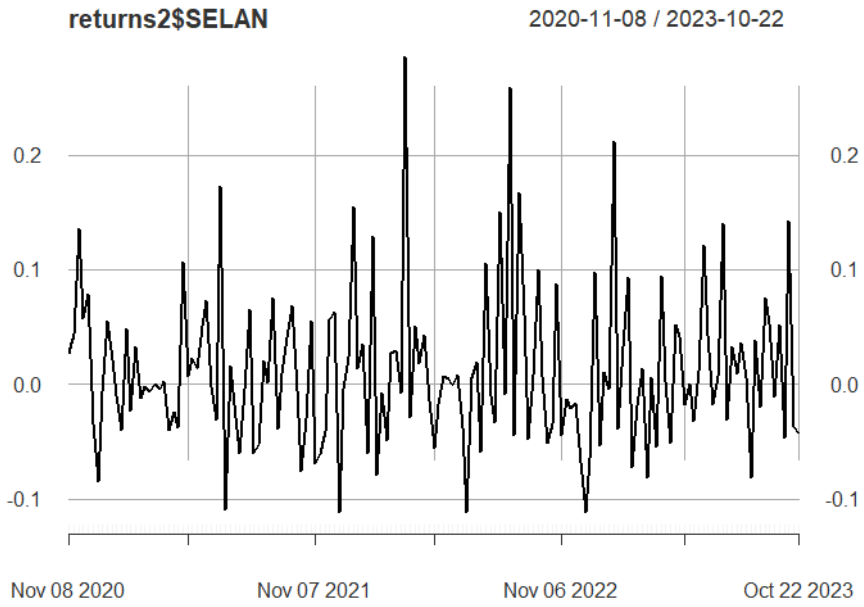
2.2.2 SELAN CAPM (Weekly Returns)

Closing Prices: The above figure shows SELAN's closing prices from November 2 2020 to October 25 2023.

```
> mean(returns2$SELAN)
[1] 0.01122846
> var(returns2$SELAN)
              SELAN
SELAN 0.004543085
```

The mean and variance of SELAN's weekly excess returns were 1.122% and 0.454%, respectively.

Now, the market Weekly Excess Returns and SELAN weekly Excess Returns are regressed and results in the following:



The above figure shows SELAN's weekly excess returns from November 3, 2020, to October 25, 2023.

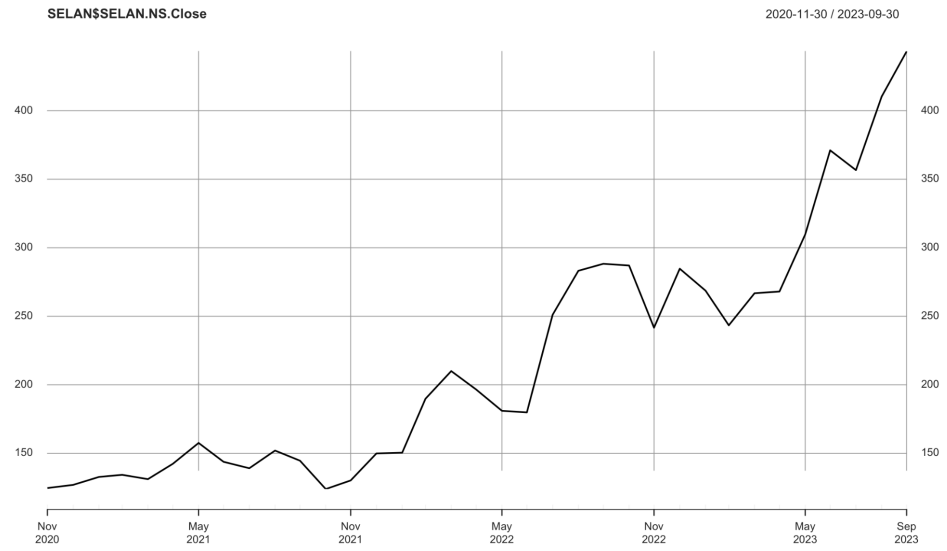
Now, the market weekly Excess Returns and RICO AUTO weekly Excess Returns are regressed and results in the following:

```
Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)        0.08952    0.02856   3.134  0.00207 **
returns2$EXCESS_NSE  0.61287    0.21939   2.794  0.00588 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.06616 on 152 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.04883,   Adjusted R-squared:  0.04258
F-statistic: 7.804 on 1 and 152 DF,  p-value: 0.005884
```

Interpretation Weekly Returns:

According to the preceding figure, the beta for weekly returns (risk unadjusted) is 0.6128, meaning that a 1% increase in the daily returns of the market index portfolio would result in a 0.6128% increase in SELAN's weekly returns. Furthermore, it can be said that even at a 99% confidence level, the regression beta is significant. The intercept was found to be 0.08952, indicating that SELAN would display a 0.08952% return if the market return is 0%.

2.2.3 SELAN CAPM (Monthly Returns)

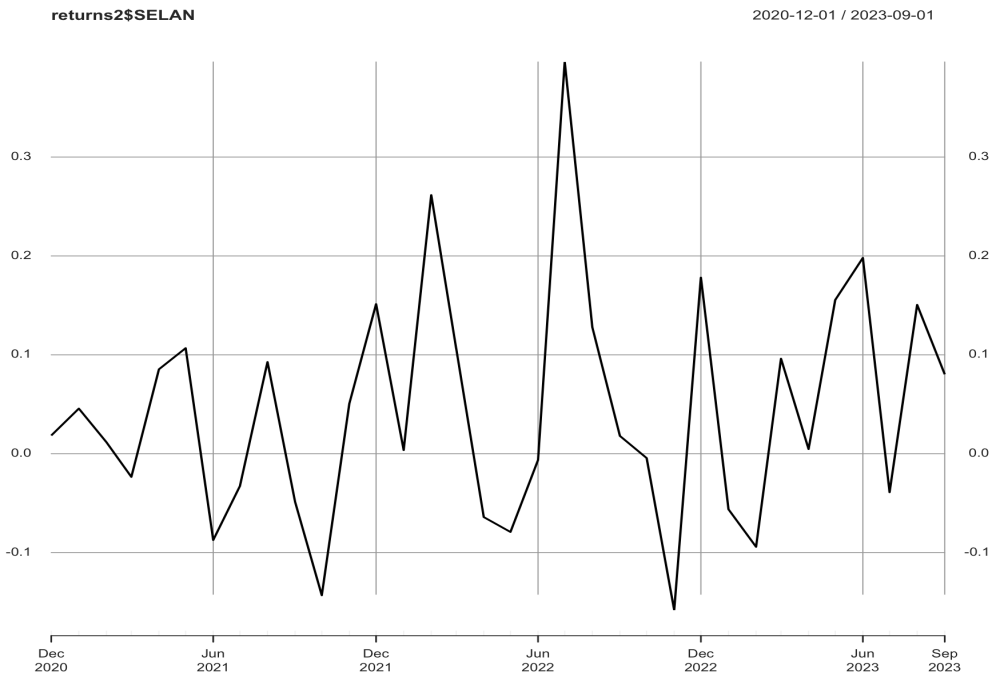


Closing Prices show the closing prices of SELAN from November 2 2020 to October 25 2023.

```
> mean(returns2$SELAN)
[1] 0.04421915
> var(returns2$SELAN)
            SELAN
SELAN 0.01384368
>
```

The mean and variance of SELAN's monthly excess returns were 4.421% and 1.3843%, respectively.

Now, the market monthly Excess Returns and SELAN monthly Excess Returns are regressed and results in the following:



The above figure shows SELAN's monthly excess returns from November 3, 2020, to October 25, 2023.

Now, the market monthly Excess Returns and SELAN monthly Excess Returns are regressed and results in the following:

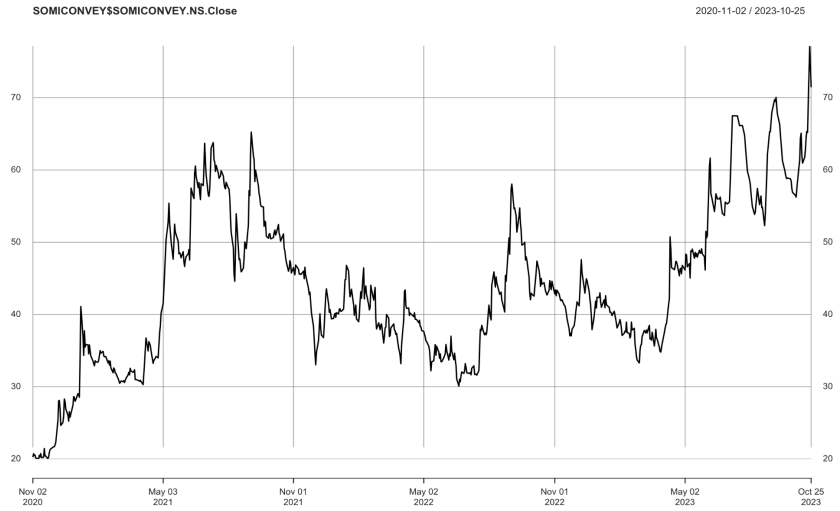
```
Call:
lm(formula = returns2$SELAN ~ returns2$EXCESS_NSE)

Residuals:
     Min       1Q   Median       3Q      Max
-0.18420 -0.08180 -0.03019  0.06597  0.35594

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)          0.1684     0.1850   0.911    0.369
returns2$EXCESS_NSE  0.2230     0.3300   0.676    0.504

Residual standard error: 0.1186 on 32 degrees of freedom
Multiple R-squared:  0.01406,   Adjusted R-squared:  -0.01675
F-statistic: 0.4565 on 1 and 32 DF,  p-value: 0.5041
```

Interpretation of Results Monthly:

According to the following figure, the beta for monthly returns (risk unadjusted) is 0.2230, meaning that a 1% increase in the monthly returns of the market index portfolio would result in a 0.2230% increase in the monthly returns of SELAN. Furthermore, it can be said that even at a 99% confidence level, the regression beta is significant. The intercept was found to be 0.1684, meaning that SELAN would display a 0.1684% return if the market return is 0%.

2.3 Somi Conveyor Beltings Ltd.

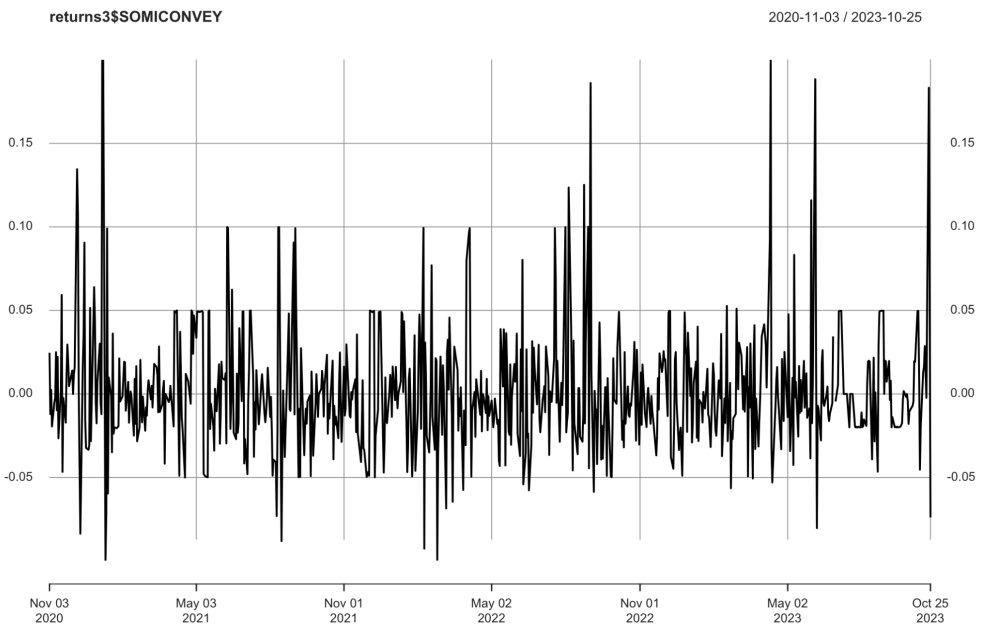
2.3.1 SOMICONVEYOR (Daily Returns)



The above figure shows the closing prices of SOMICONVEY from November 2, 2020 to October 25, 2023.

```
> mean(returns3$SOMICONVEY)
[1] 0.01344788
> var(returns3$SOMICONVEY)
            SOMICONVEY
SOMICONVEY 0.008925359
```

The mean and variance of the daily excess returns of SOMICONVEY were 1.344% and 0.8925% respectively.



The above figure shows the daily excess returns of SOMICONVEY from November 3, 2020, to October 25, 2023.

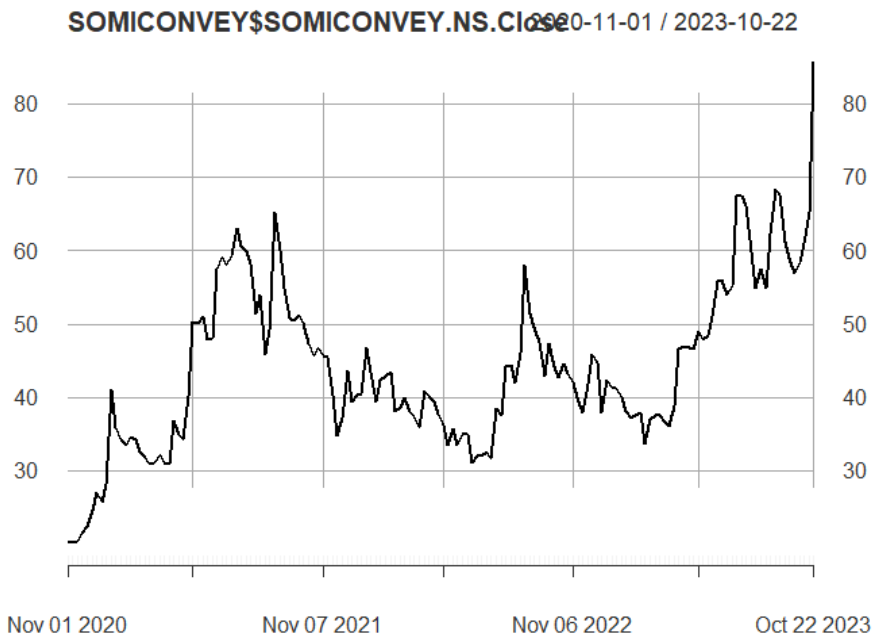
Now, the market daily Excess Returns and SOMICONVRY daily Excess Returns are regressed and results in the following:

```
Call:
lm(formula = returns3$SOMICONVEY ~ returns3$EXCESS_NSE)

Residuals:
      Min        1Q    Median        3Q       Max
-0.109910 -0.021086 -0.004983  0.014842  0.196555

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)         0.01479    0.00286   5.170 3.04e-07 ***
returns3$EXCESS_NSE  0.69706    0.14080   4.951 9.21e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.03638 on 719 degrees of freedom
  (17 observations deleted due to missingness)
Multiple R-squared:  0.03297,   Adjusted R-squared:  0.03162
F-statistic: 24.51 on 1 and 719 DF,  p-value: 9.213e-07
```

Interpretation of Results Daily:

The above figure shows that the Beta for daily returns (risk unadjusted) is 0.967, which means that if the market index portfolio's daily returns rise by 1%, then the daily returns of SOMICONVEY will increase by 0.697%. Moreover, since the p-value for the regression beta is less than 0.01, it can be concluded that the beta is significant even at a 99% confidence level. The intercept came out to be 0.01479, which means that if the market return is 0%, then SOMICONVEY will show a 0.01479% return.

2.3.2 SOMICONVEYOR (Weekly Returns)

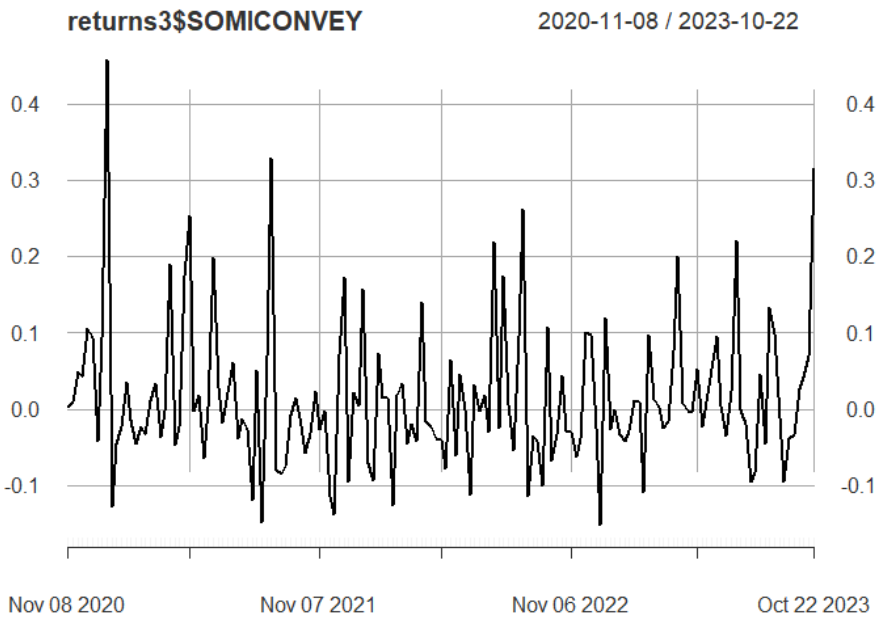


The above figure shows the closing prices of SOMICONVEY from November 2, 2020, to October 25, 2023.

```
> mean(returns3$SOMICONVEY)
[1] 0.01344788
> var(returns3$SOMICONVEY)
            SOMICONVEY
SOMICONVEY 0.008925359
```

The mean and variance of the weekly excess returns of SOMICONVEY were 1.344% and 0.892%, respectively.

Now, the market Weekly Excess Returns and SOMICONVEY Weekly Excess Returns are regressed and results in the following:



The above figure shows the weekly excess returns of SOMICONVEY from November 3, 2020, to October 25, 2023.

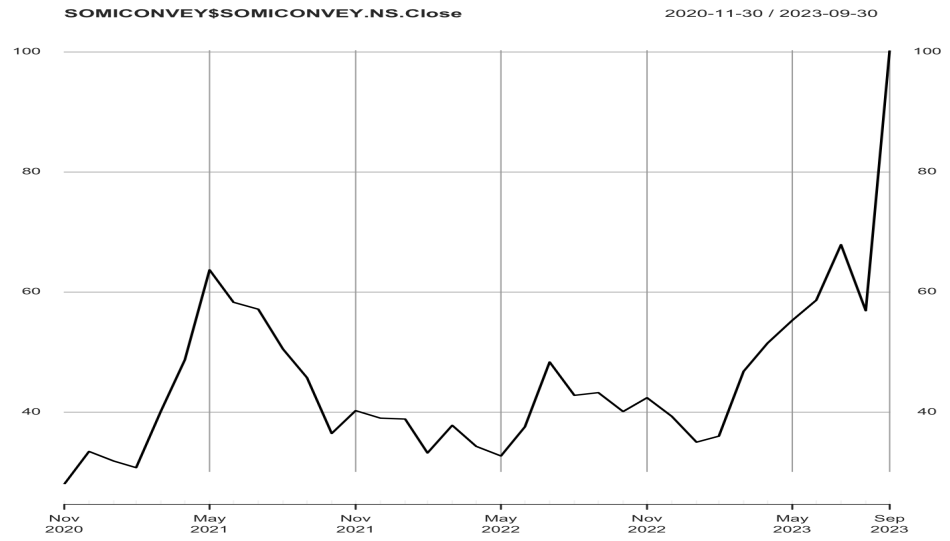
Now, the market weekly Excess Returns and SOMICONVEY weekly Excess Returns are regressed and results in the following:

```
Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)         0.13993    0.03971   3.524 0.000562 ***
returns3$EXCESS_NSE  0.98829    0.30498   3.241 0.001466 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.09197 on 152 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.06462,   Adjusted R-squared:  0.05847
F-statistic:  10.5 on 1 and 152 DF,  p-value: 0.001466
```

Interpretation of Results Weekly:

The weekly returns of SOMICONVEY will grow by 0.9882% if the daily returns of the market index portfolio increase by 1%, as seen by the following figure, which displays the beta for weekly returns (risk unadjusted) of 0.9882. Furthermore, it can be said that even at a 99% confidence level, the regression beta is significant. With an intercept of 0.1399, RICO AUTO will display a 0.1399% return if the market return is 0%.

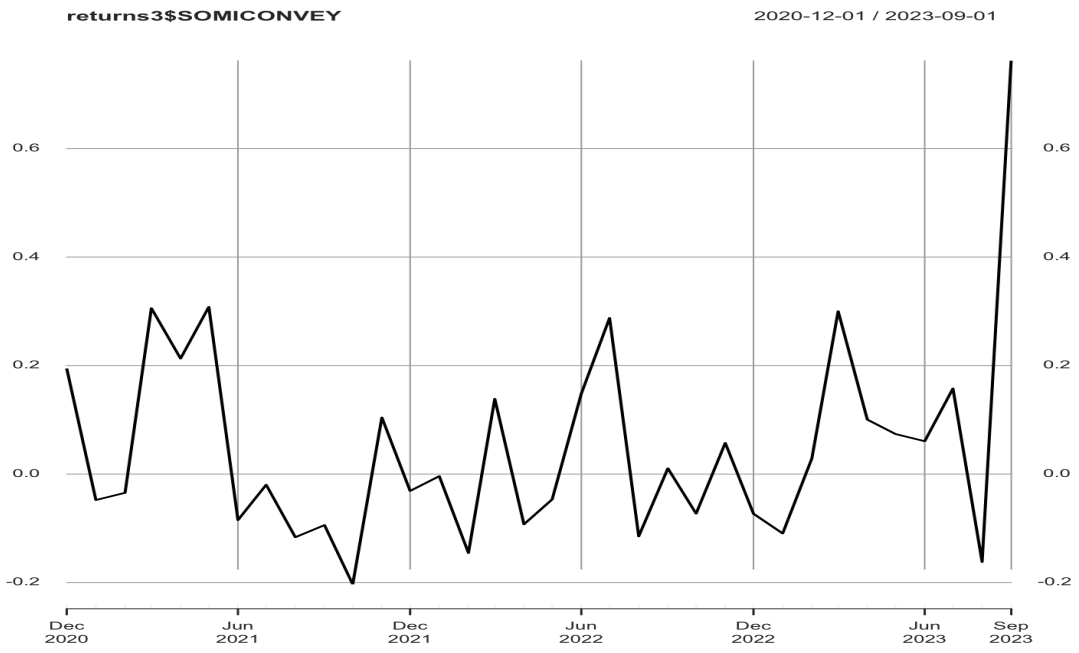
2.3.3 SOMICONVEYOR (Monthly Returns)



Closing Prices show the closing prices of SOMICONVEY from November 2, 2020, to October 25, 2023.

```
> mean(returns3$SOMICONVEY)
[1] 0.05289874
> var(returns3$SOMICONVEY)
           SOMICONVEY
SOMICONVEY 0.03635179
>
```

The mean and variance of the monthly excess returns of SOMICONVEY were 5.2898% and 3.6351%, respectively.



The above figure shows the monthly excess returns of SOMICONVEY from November 3, 2020, to October 25, 2023.

Now, the market monthly Excess Returns and SOMICONVEY monthly Excess Returns are regressed and results in the following:

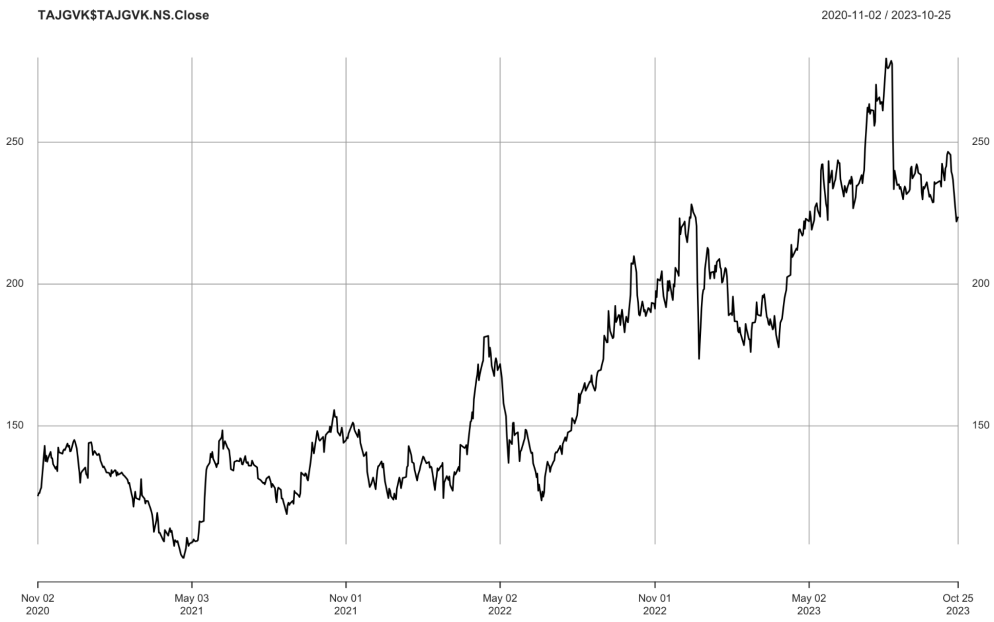
```
Call:
lm(formula = returns3$SOMICONVEY ~ returns3$EXCESS_NSE)

Residuals:
     Min       1Q   Median       3Q      Max
-0.25641 -0.13440 -0.04987  0.09313  0.70780

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)          0.04390    0.30188   0.145    0.885
returns3$EXCESS_NSE -0.01615    0.53862  -0.030    0.976

Residual standard error: 0.1936 on 32 degrees of freedom
Multiple R-squared:  2.809e-05, Adjusted R-squared:  -0.03122
F-statistic: 0.000899 on 1 and 32 DF,  p-value: 0.9763

>
```

Interpretation of Results Monthly:

The above figure shows that the Beta for monthly returns (risk unadjusted) is -0.01615, which means that if the market index portfolio's monthly returns rise by 1%, then the monthly returns of SOMICONVEY will decrease by 0.01615%. Moreover, since the p-value for the regression beta is less than 0.01, it can be concluded that the beta is significant even at a 99% confidence level. The intercept came out to be 0.04390, which means that if the market return is 0%, then SOMICONVEY will show a 0.04390% return.

2.4 TAJ GVK Hotels and Resorts Ltd

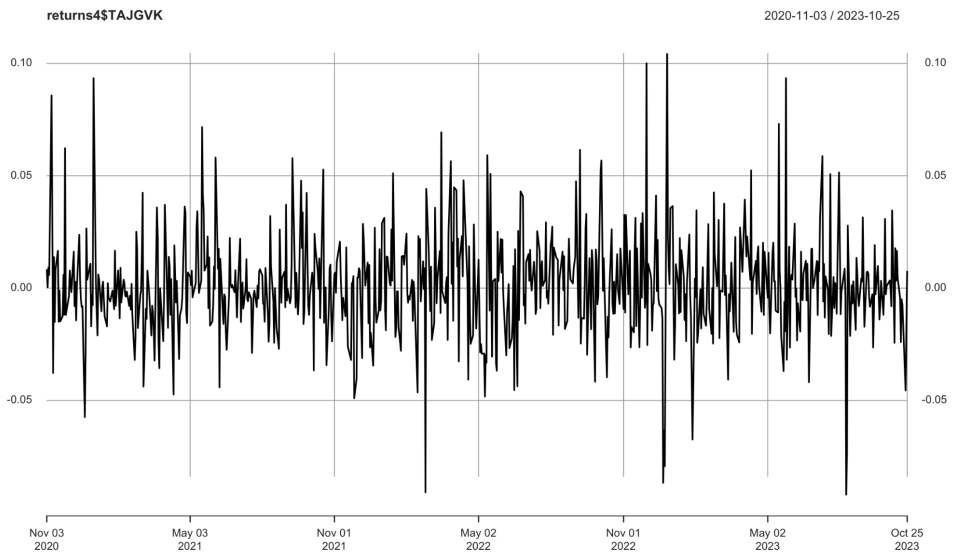
2.4.1 TAJGVK (Daily Returns):



The above figure shows the closing prices of TAJGVK from November 2, 2020, to October 25, 2023.

```
> mean(returns4$TAJGVK)
[1] 0.001039486
> var(returns4$TAJGVK)
             TAJGVK
TAJGVK 0.0005093099
>
```

The mean and variance of the daily excess returns of TAJGVK were 0.103% and 0.0509%, respectively.



The above figure shows the daily excess returns of TAJGVK from November 3, 2020, to October 25, 2023.

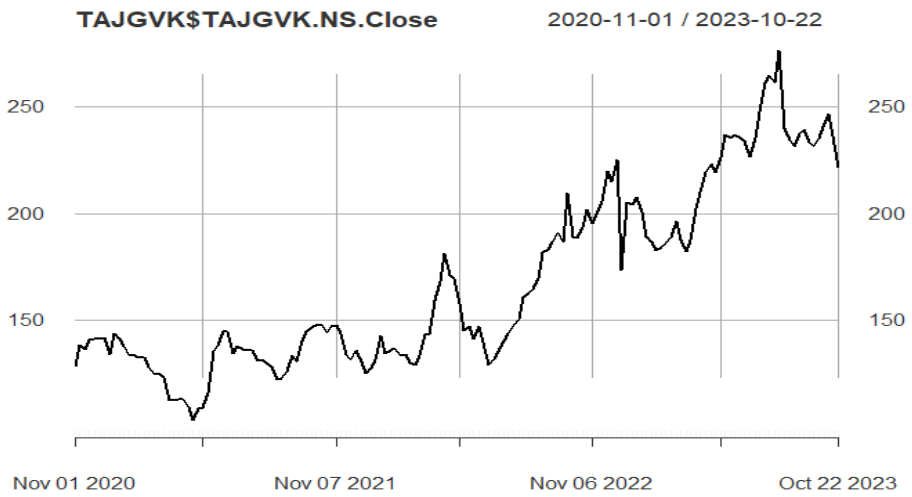
Now, the market Daily Excess Returns and TAJGVK Daily Excess Returns are regressed and results in the following:

```
Call:
lm(formula = returns4$TAJGVK ~ returns4$EXCESS_NSE)

Residuals:
      Min        1Q    Median        3Q       Max
-0.094278 -0.012622 -0.002094  0.010051  0.095655

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)         0.015882   0.001663   9.549   <2e-16 ***
returns4$EXCESS_NSE 0.837111   0.081912  10.220   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.02117 on 720 degrees of freedom
  (16 observations deleted due to missingness)
Multiple R-squared:  0.1267,    Adjusted R-squared:  0.1255
F-statistic: 104.4 on 1 and 720 DF,  p-value: < 2.2e-16
```

Interpretation Daily:

The above figure shows that the Beta for daily returns (risk unadjusted) is 0.837, which means that if the market index portfolio's daily returns rise by 1%, then the daily returns of TAJGVK will increase by 0.837%. Moreover, it can be concluded that the beta is significant even at a 99% confidence level. The intercept came out to be 0.015882, which means that if the market return is 0%, then TAJGVK will show a 0.015882% return.

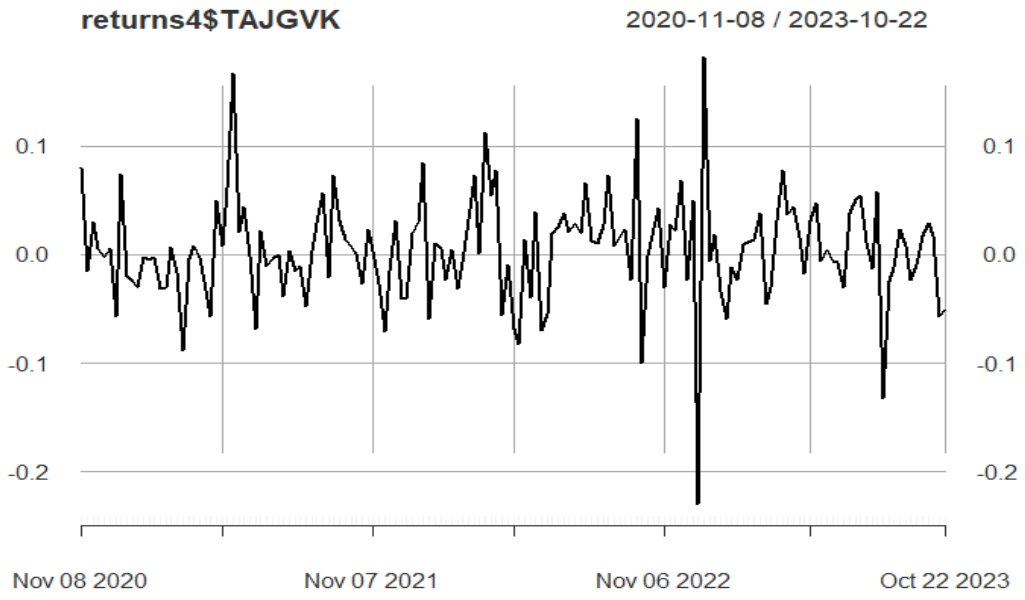
2.4.2 TAJGVK (Weekly Returns):



The above figure shows the closing prices of TAJGVK from November 2, 2020, to October 25, 2023.

```
> mean(returns4$TAJGVK)
[1] 0.004726323
> var(returns4$TAJGVK)
              TAJGVK
TAJGVK 0.002400175
```

The mean and variance of the Weelky excess returns of TAJGVK were 0.472% and 0.240% respectively.



The above figure shows the weekly excess returns of TAJGVK from November 3, 2020, to October 25, 2023.

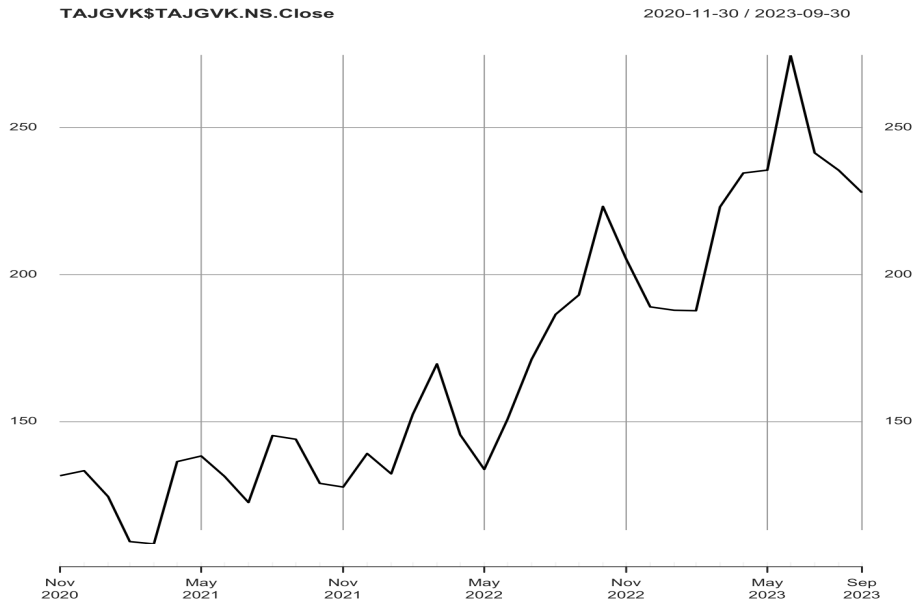
Now, the market weekly Excess Returns and TAJGVK weekly Excess Returns are regressed and results in the following:

```
Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)         0.10151    0.01954   5.195 6.48e-07 ***
returns4$EXCESS_NSE  0.76050    0.15007   5.068 1.15e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.04525 on 152 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.1445,    Adjusted R-squared:  0.1389
F-statistic: 25.68 on 1 and 152 DF,  p-value: 1.155e-06
```

Interpretation Weekly:

The above figure shows that the Beta for weekly returns (risk unadjusted) is 0.76050. If the market index portfolio's daily returns rise by 1%, then the weekly returns of TAJGVK will increase by 0.76050%. Moreover, since the p-value for the regression beta is less than 0.01, it can be concluded that the beta is significant even at a 99% confidence level. The intercept came out to be 0.10151, which means that if the market return is 0%, then TAJGVK will show a 0.10151% return.

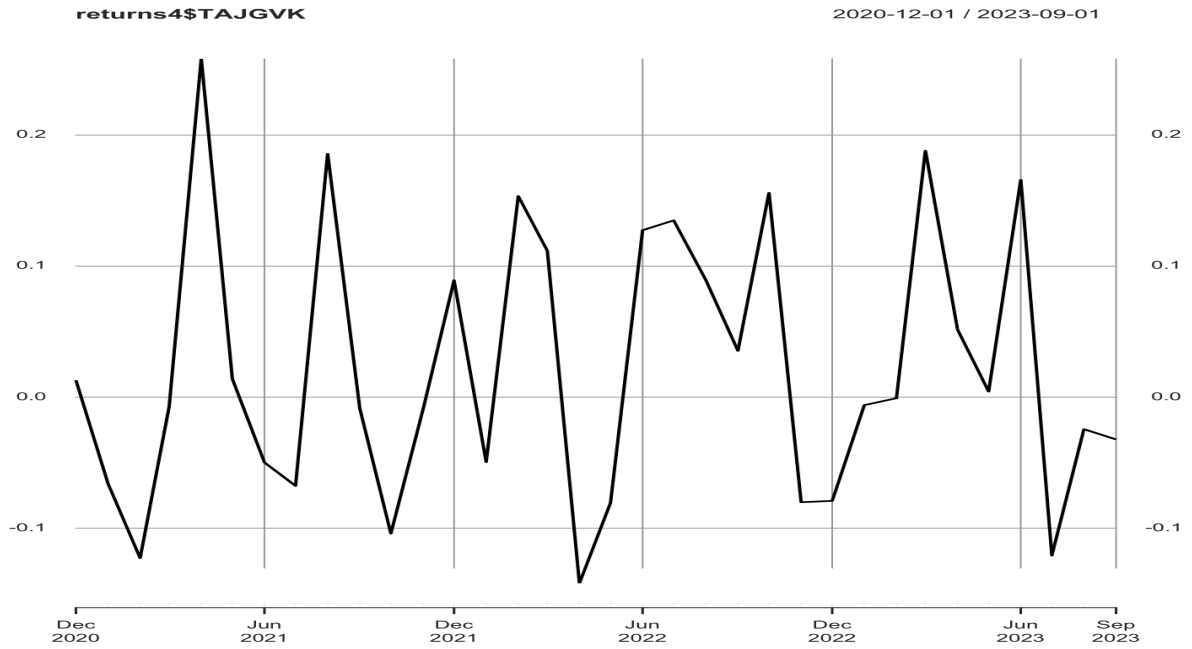
2.4.3 TAJGVK (Monthly Returns):



Closing Prices show the closing prices of TAJGVK from November 2 2020 to October 25 2023.

```
> mean(returns4$TAJGVK)
[1] 0.02133118
> var(returns4$TAJGVK)
              TAJGVK
TAJGVK 0.01088499
```

The mean and variance of the monthly excess returns of TAJGVK were 2.133118% and 1.088499%, respectively.



The above figure shows the monthly excess returns of TAJGVK from November 3, 2020, to October 25, 2023.

Now, the market monthly Excess Returns and TAJGVK monthly Excess Returns are regressed and results in the following:

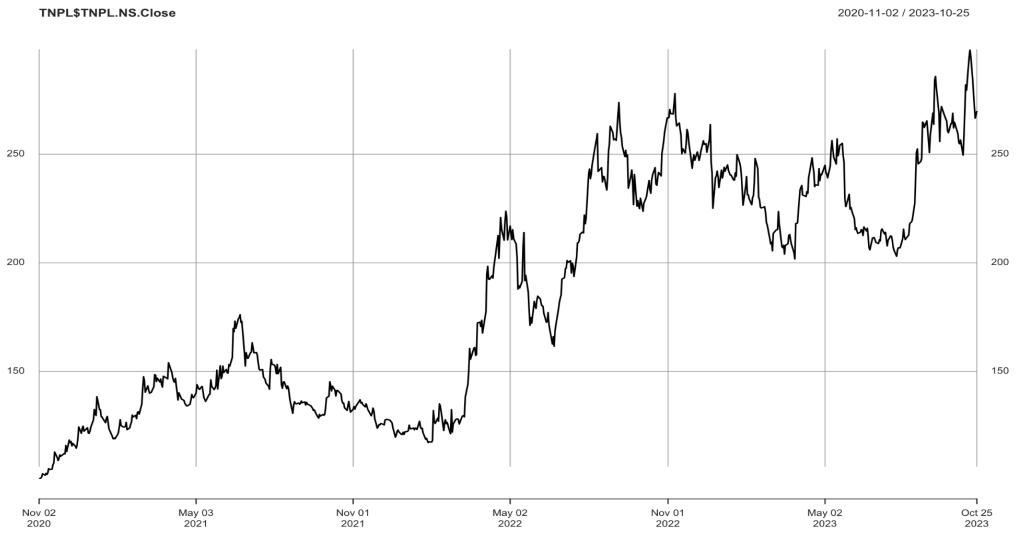
```
Call:
lm(formula = returns4$TAJGVK ~ returns4$EXCESS_NSE)

Residuals:
     Min       1Q   Median       3Q      Max
-0.16423 -0.06480 -0.02465  0.09947  0.18800

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)           0.2489     0.1602   1.554    0.130
returns4$EXCESS_NSE   0.4084     0.2858   1.429    0.163

Residual standard error: 0.1027 on 32 degrees of freedom
Multiple R-squared:  0.06001,   Adjusted R-squared:  0.03063
F-statistic: 2.043 on 1 and 32 DF,  p-value: 0.1626
```

Interpretation Monthly:

The monthly returns of TAJGVK will grow by 0.4084% if the monthly returns of the market index portfolio increase by 1%, as seen by the preceding figure, indicating that the beta for monthly returns (risk unadjusted) is 0.4084. Furthermore, it can be said that even at a 99% confidence level, the regression beta is significant. The intercept was 0.2489, indicating that TAJGVK would display a 0.2489% return if the market return were 0%.

2.5 Tamilnadu Newsprint & Papers Ltd

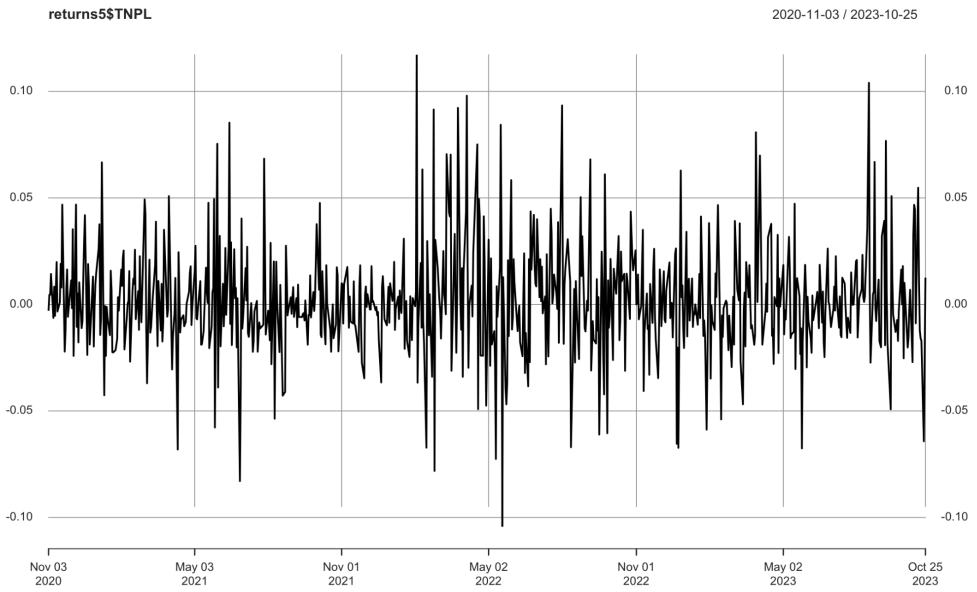
2.5.1 TNPL (Daily Returns):



Closing Prices: The above figure shows the closing prices of TNPL from November 2 2020 to October 25 2023.

```
> mean(returns5$TNPL)
[1] 0.001660273
> var(returns5$TNPL)
              TNPL
TNPL 0.0006555346
```

The mean and variance of the daily excess returns of TNPL were 0.166% and 0.0655%, respectively.



The above figure shows the daily excess returns of NPTL from November 3, 2020, to October 25, 2023.

Now, the market daily Excess Returns and TNPL daily Excess Returns are regressed results in the following:

```
Call:
lm(formula = returns5$TNPL ~ returns5$EXCESS_NSE)

Residuals:
      Min        1Q    Median        3Q       Max
-0.082888 -0.013406 -0.002291  0.010304  0.105980

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)        0.017998   0.001875    9.60   <2e-16 ***
returns5$EXCESS_NSE 0.926219   0.092335   10.03   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.02387 on 720 degrees of freedom
  (16 observations deleted due to missingness)
Multiple R-squared:  0.1226,    Adjusted R-squared:  0.1214
F-statistic: 100.6 on 1 and 720 DF,  p-value: < 2.2e-16
```

Interpretation Daily:

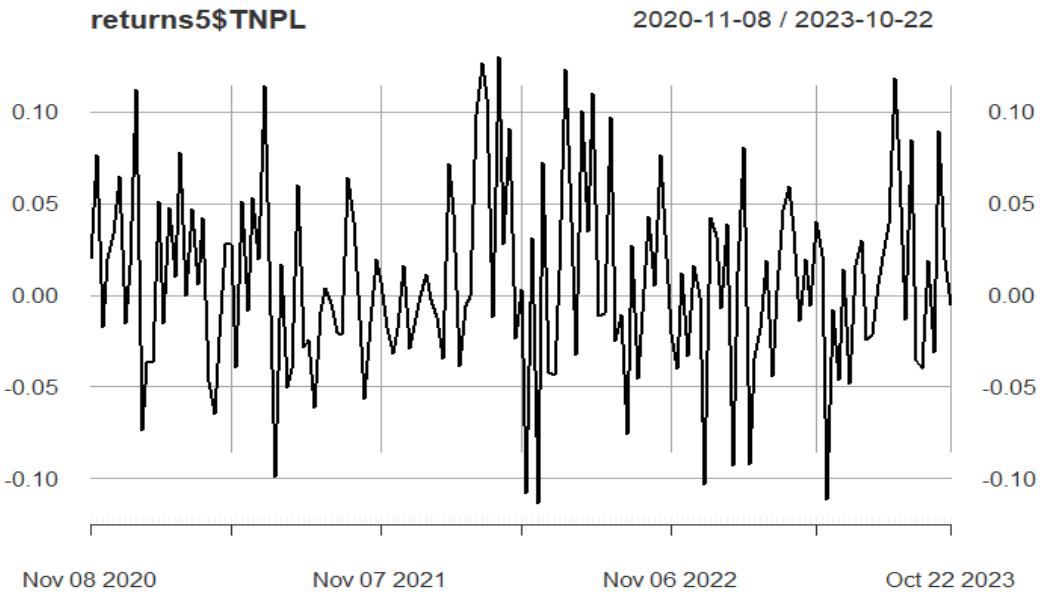
The daily returns of TNPL will grow by 0.9262% if the daily returns of the market index portfolio increase by 1%, as seen by the preceding figure, which also reveals that the beta for daily returns (risk unadjusted) is 0.926. Furthermore, it can be said that even at a 99% confidence level, the regression beta is significant since the p-value is smaller than 0.01. The intercept was found to be 0.017998, indicating that TNPL would display a 0.017998% return if the market return is 0%.

2.5.2 TNPL (Weekly Returns):

Closing Prices: The above figure shows the closing prices of TNPL from November 2 2020 to October 25 2023.

```
> mean(returns5$TNPL)
[1] 0.007827795
> var(returns5$TNPL)
             TNPL
TNPL 0.0025868
```

The mean and variance of the Weekly excess returns of TNPL were 0.782% and 0.258% respectively.



The above figure shows the weekly excess returns of TNPL from November 3, 2020, to October 25, 2023.

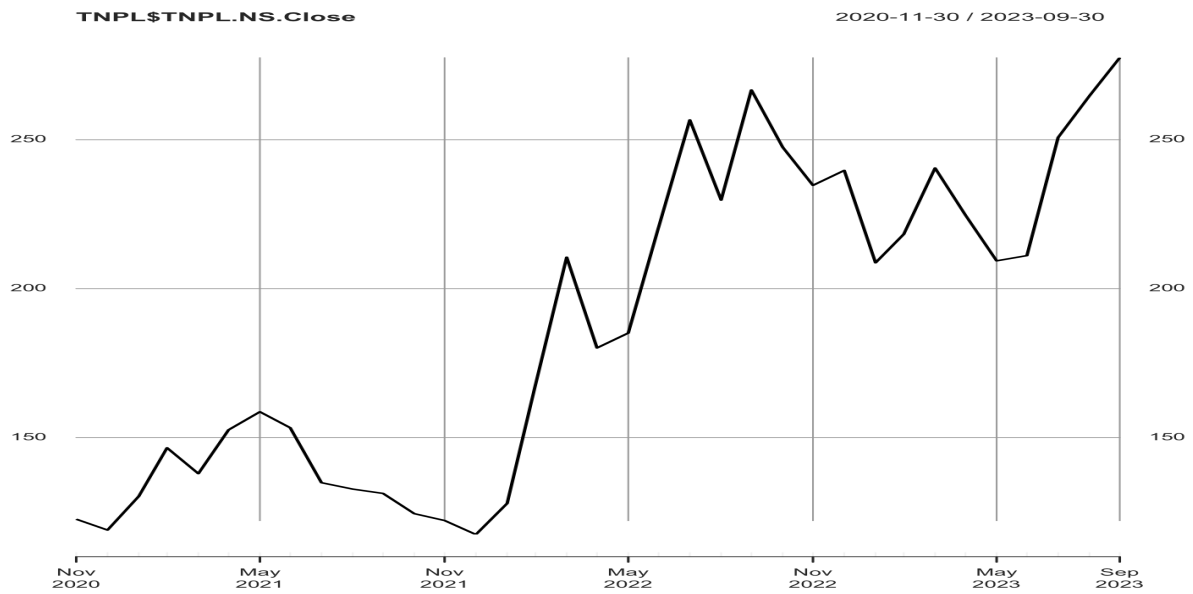
Now, the market weekly Excess Returns and TNPL weekly Excess Returns are regressed and results in the following:

```
Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)         0.07981    0.02128   3.750 0.000251 ***
returns5$EXCESS_NSE 0.56334    0.16348   3.446 0.000736 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.0493 on 152 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.07246,   Adjusted R-squared:  0.06636
F-statistic: 11.87 on 1 and 152 DF,  p-value: 0.0007358
```

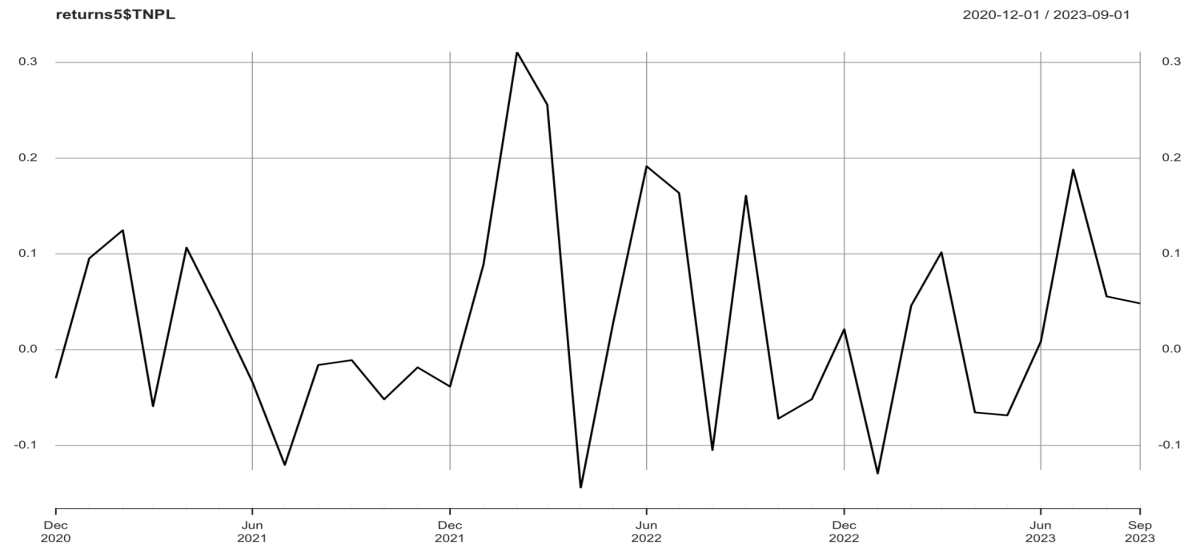
Interpretation of Results Weekly:

The above figure shows that the Beta for weekly returns (risk unadjusted) is 0.5633, which means that if the market index portfolio’s weekly returns rise by 1%, then the weekly returns of TNPL will increase by 0.58334%. Moreover, it can be concluded that the beta is significant even at a 99% confidence level. The intercept came out to be 0.09926, which means that if the market return is 0%, then TNPL will show a 0.09926% return.

2.5.3 TNPL (Monthly Returns):



Closing Prices shows the closing prices of TNPL from November 2 2020 to October 25 2023.



```
> mean(returns5$TNPL)
[1] 0.03000647
> var(returns5$TNPL)
           TNPL
TNPL 0.0124604
>
```

The mean and variance of the monthly excess returns of TNPL were 3.000647% and 1.24604%, respectively.

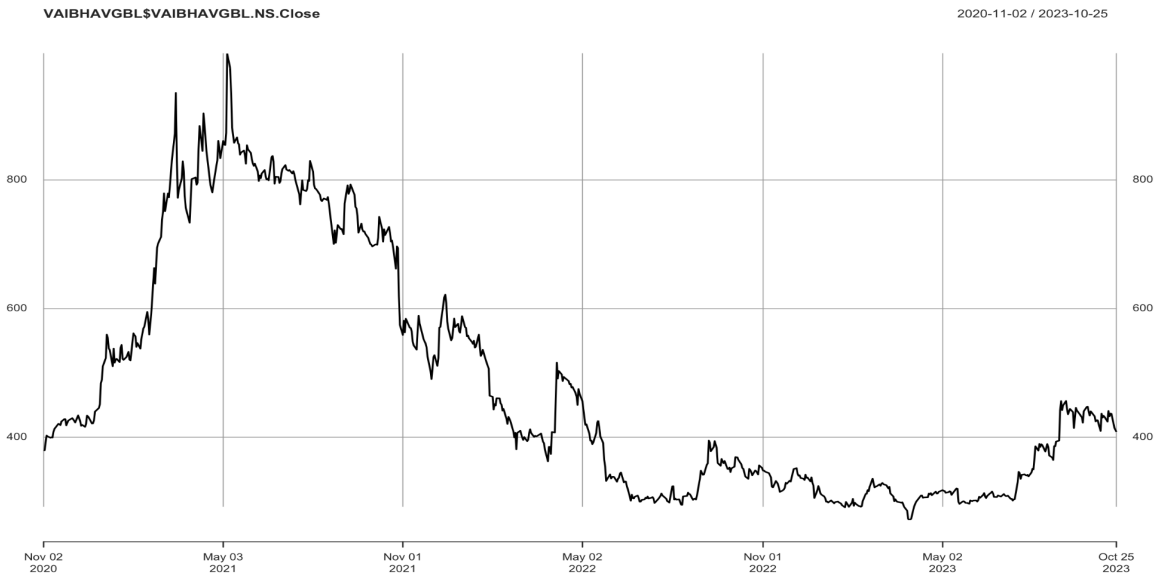
```
Call:
lm(formula = returns5$TNPL ~ returns5$EXCESS_NSE)

Residuals:
     Min       1Q   Median       3Q      Max
-0.16789 -0.07773 -0.01002  0.06250  0.27625

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)           0.1070     0.1762   0.607    0.548
returns5$EXCESS_NSE   0.1382     0.3144   0.439    0.663

Residual standard error: 0.113 on 32 degrees of freedom
Multiple R-squared:  0.005999,  Adjusted R-squared:  -0.02506
F-statistic: 0.1931 on 1 and 32 DF,  p-value: 0.6633
```

Interpretation of Results Monthly:

The above figure shows that the Beta for monthly returns (risk unadjusted) is 0.1382, which means that if the market index portfolio's monthly returns rise by 1%, then the monthly returns of TNPL will increase by 0.1382%. Moreover, since the p-value for the regression beta is less than 0.01, it can be concluded that the beta is significant even at a 99% confidence level. The intercept came out to be 0.1070, which means that if the market return is 0%, then TNPL will show a 0.1070% return.

2.6 Vaibhav Global Ltd

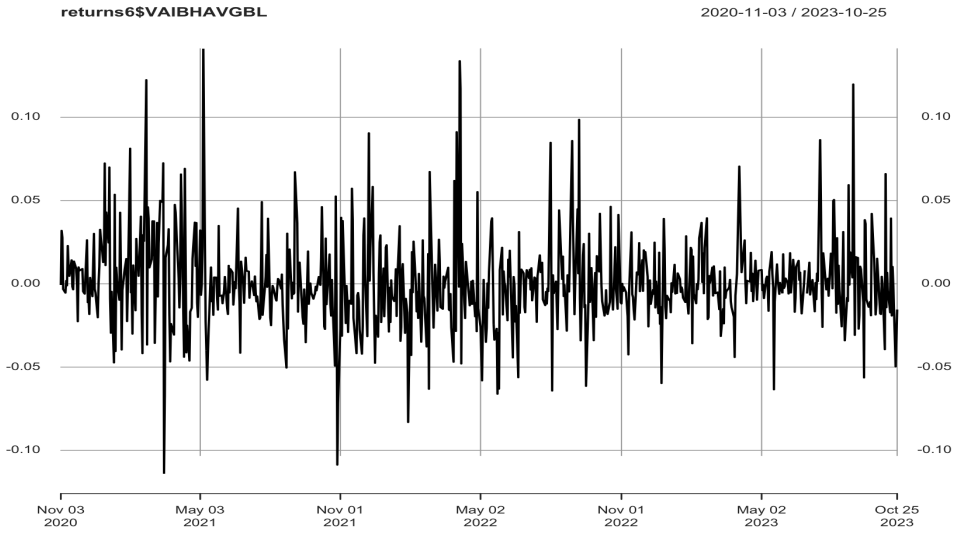
2.6.1 VAIBHAVGBL (Daily Returns):



Closing Prices: The above figure shows the closing prices of VAIBHAVGBL from November 2 2020 to October 25 2023.

The mean and variance of the daily excess returns of VAIBHAVGBL were 0.165% and 0.372%, respectively.

```
> mean(returns6$VAIBHAVGBL)
[1] 0.001652956
> var(returns6$VAIBHAVGBL)
             VAIBHAVGBL
VAIBHAVGBL 0.003720162
```



The above figure shows the daily excess returns of VAIBHAVGBL from November 3, 2020, to October 25, 2023.

Now, the market daily Excess Returns and VAIBHAVGBL daily Excess Returns are regressed and result in the following:

```
Call:
lm(formula = returns6$VAIBHAVGBL ~ returns6$EXCESS_NSE)

Residuals:
      Min        1Q    Median        3Q       Max
-0.104690 -0.013701 -0.002383  0.010286  0.138840

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)        0.014308   0.002045   6.995 6.07e-12 ***
returns6$EXCESS_NSE 0.798548   0.100691   7.931 8.34e-15 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.02602 on 719 degrees of freedom
  (17 observations deleted due to missingness)
Multiple R-squared:  0.08044,   Adjusted R-squared:  0.07916
F-statistic:  62.9 on 1 and 719 DF,  p-value: 8.34e-15
```

Interpretation Daily:

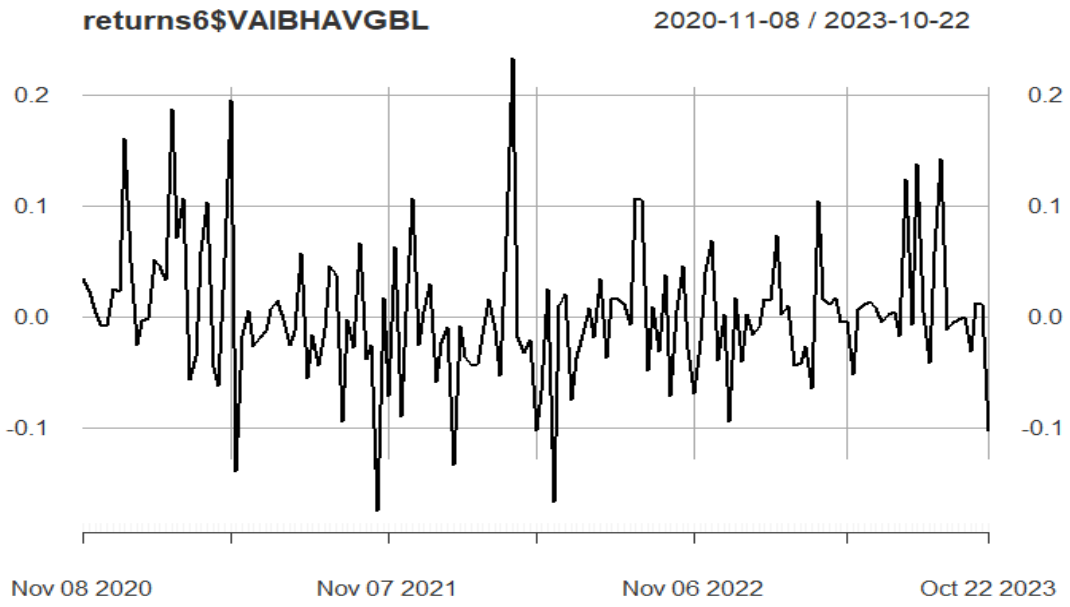
The daily returns of VAIBHAVGBL will increase by 0.798 if the daily returns of the market index portfolio grow by 1%, as shown by the following figure, which displays the beta for daily returns (risk unadjusted) of 0.798. Furthermore, it can be said that even at a 99% confidence level, the regression beta is significant since the p-value is smaller than 0.01. The intercept was found to be 0.014308; if the market return is zero, VAIBHAVGBL will display a return of 0.014308%.

2.6.2 VAIBHAVGBL (Weekly Returns):

Closing Prices: The above figure shows the closing prices of VAIBHAVGBL from November 2 2020 to October 25 2023.

```
> mean(returns6$VAIBHAVGBL)
[1] 0.001652956
> var(returns6$VAIBHAVGBL)
             VAIBHAVGBL
VAIBHAVGBL 0.003720162
```

The mean and variance of the Weekly excess returns of VAIBHAVGBL were 0.165% and 0.372%, respectively.



The above figure shows the weekly excess returns of VAIBHAVGBL from November 3, 2020, to October 25, 2023.

Now, the market weekly Excess Returns and VAIBHAVGBL weekly Excess Returns are regressed and result in the following:

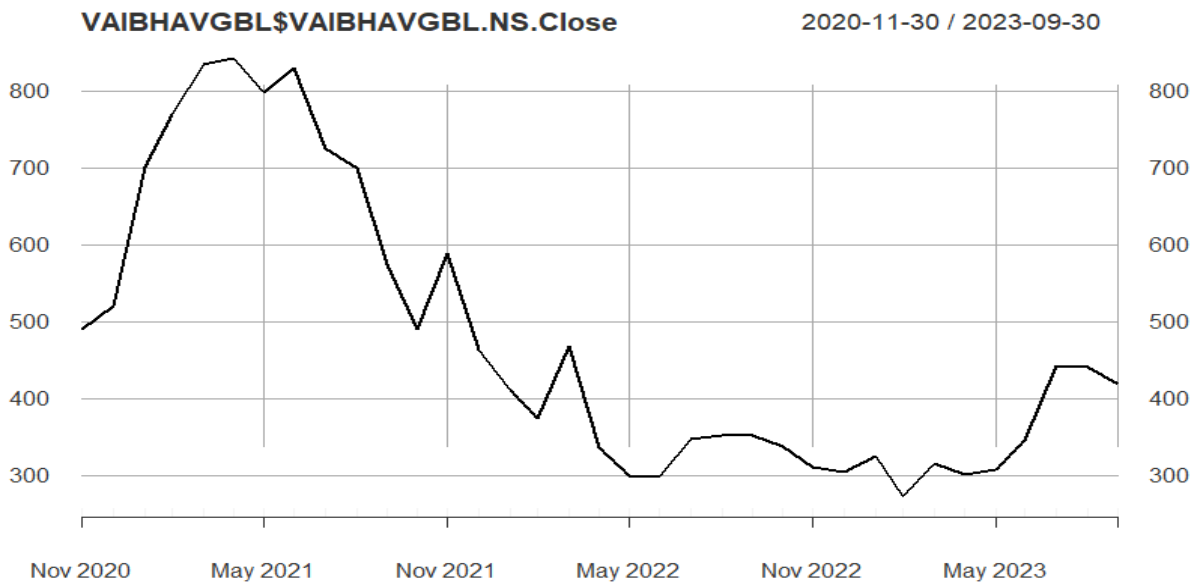
```
Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)        0.09926    0.02602   3.814 0.000198 ***
returns$EXCESS_NSE 0.70824    0.19987   3.544 0.000525 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.06027 on 152 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.07631,   Adjusted R-squared:  0.07023
F-statistic: 12.56 on 1 and 152 DF,  p-value: 0.0005248
```

Interpretation Weekly Returns:

The above figure shows that the Beta for weekly returns (risk unadjusted) is 0.7083. If the market index portfolio’s weekly returns rise by 1%, then the weekly returns of VAIBHAVGBL

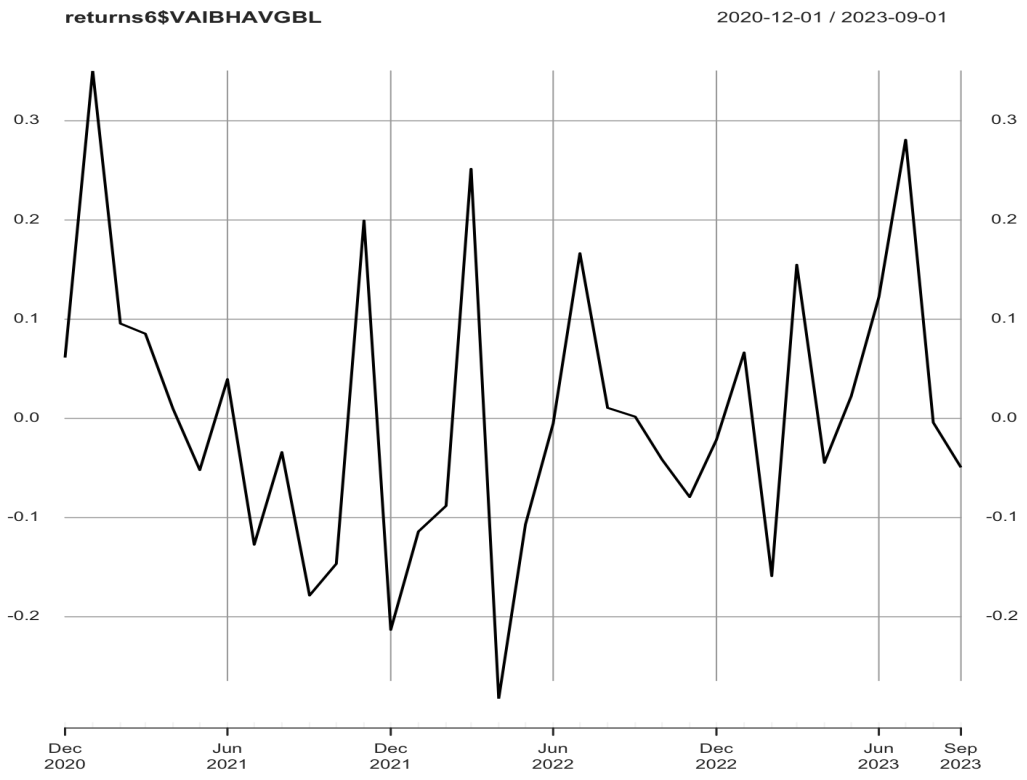
will increase by 0.70825%. Moreover, it can be concluded that the beta is significant even at a 99% confidence level. The intercept came out to be 0.09926, which means that if the market return is 0%, then VAIBHAVGBL will show a 0.09926% return.

2.6.3 VAIBHAVGBL (Monthly Returns):




```
> mean(returns6$VAIBHAVGBL)
[1] 0.004999908
> var(returns6$VAIBHAVGBL)
            VAIBHAVGBL
VAIBHAVGBL 0.02018739
>
```

The mean and variance of the monthly excess returns of VAIBHAVGBL were 0.4999908% and 2.018739%, respectively.



The above figure shows the monthly excess returns of VAIBHAVGBL from November 3, 2020, to October 25, 2023.

Now, the market monthly Excess Returns and VAIBHAVGBL monthly Excess Returns are regressed and results in the following:

```
Call:
lm(formula = returns6$VAIBHAVGBL ~ returns6$EXCESS_NSE)

Residuals:
     Min       1Q   Median       3Q      Max
-0.25915 -0.07964 -0.01053  0.06870  0.30332

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)          0.2375     0.2211   1.074    0.291
returns6$EXCESS_NSE  0.4173     0.3946   1.058    0.298

Residual standard error: 0.1418 on 32 degrees of freedom
Multiple R-squared:  0.03378,   Adjusted R-squared:  0.003588
F-statistic: 1.119 on 1 and 32 DF,  p-value: 0.2981

>
```

Interpretation Monthly Returns:

The above figure shows that the Beta for monthly returns (risk unadjusted) is 0.4137, which means that if the market index portfolio's monthly returns rise by 1%, then the monthly returns of VAIBHAVGBL will increase by 0.4137%. Moreover, since the p-value for the regression beta is less than 0.01, it can be concluded that the beta is significant even at a 99% confidence level. The intercept came out to be 0.2375, which means that if the market return is 0%, then VAIBHAVGBL will show a 0.2375% return.

SECTION 3: Autoregressive integrated moving average

ARIMA Daily

ARIMA Weekly

ARIMA Monthly

3.1. Rico Auto Industries Ltd

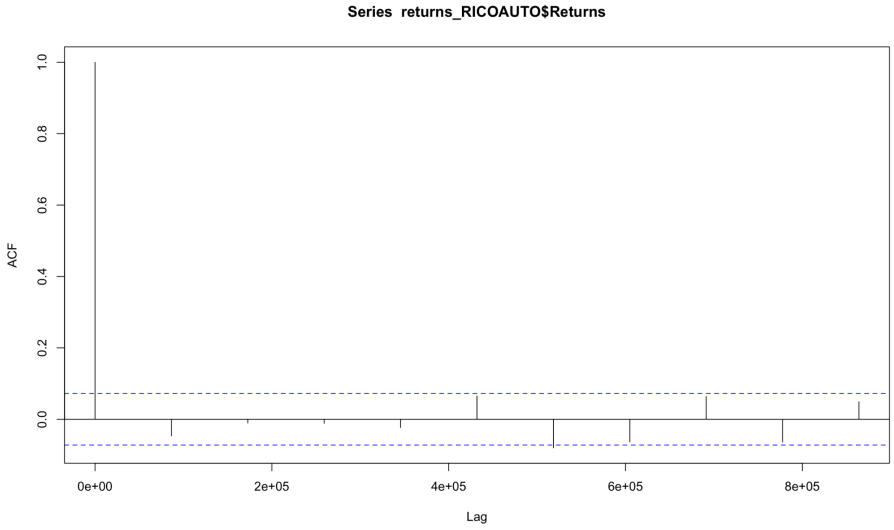
3.1.1 Rico Auto Industries Ltd (Daily)

The values of Auto-Regressive (AR) and Moving Average (MA) can be obtained from the ACF and PACF plots.

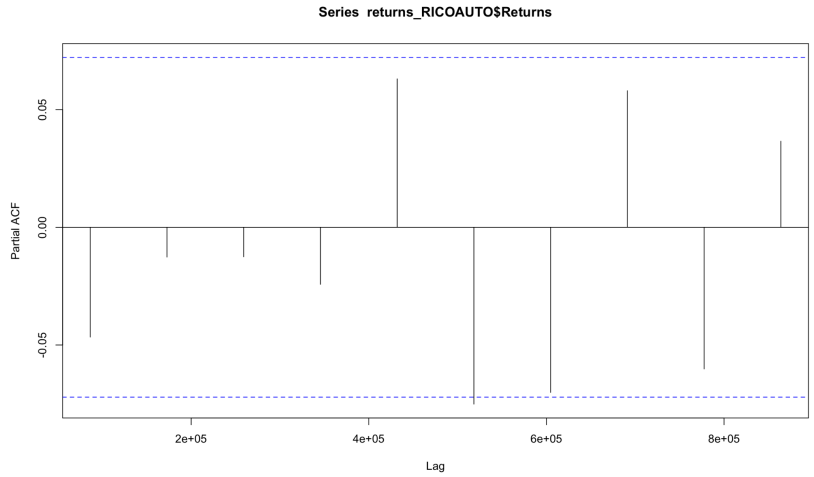
An augmented Dickey-Fuller (ADF) test is performed to check for stationarity.

```
        Augmented Dickey-Fuller Test

data:  returns_RICOAUTO$Returns
Dickey-Fuller = -8.8927, Lag order = 9, p-value = 0.01
alternative hypothesis: stationary
```

The series is not stationary, according to the null hypothesis of the Augmented Dickey-Fuller test, while the related alternative hypothesis is that the series is stationary. The series is stationary because the null hypothesis may be rejected due to the test's p-value of 0.01 above. Plots for ACF and PACF: The moving average order value to be used in the ARIMA model is shown by the ACF plot. It is an MA(0) order because the graphic below demonstrates that all lag terms are relevant except for the 0th lag.



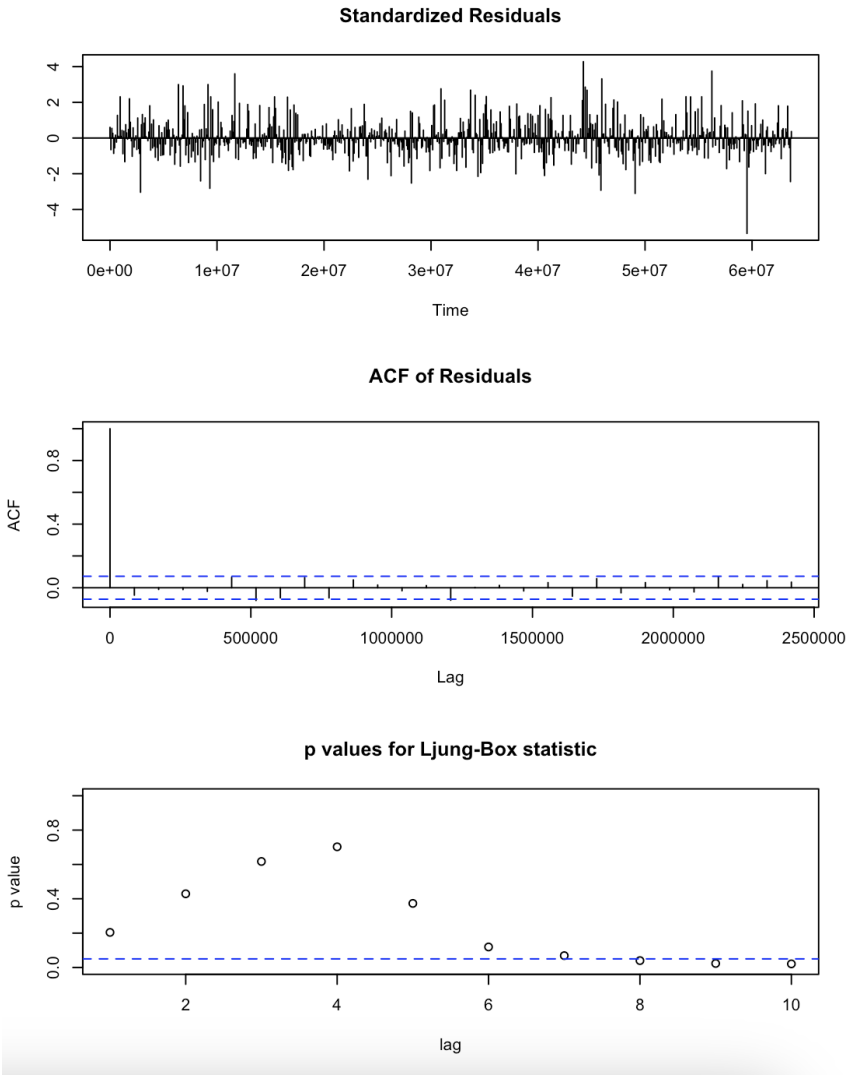
PACF plot tells us the value of the order of the Auto Regressive to use in the ARIMA model. The figure below shows that no lag term is significant; hence, it's an AR(0) order.



From the ACF and PACF it has been found that RICO AUTO daily returns follow a (0,0,0) ARIMA model. To confirm the best model, auto.arima() function of R can be used.

```
> arima_final_RICOAUTO

Call:
arima(x = returns_RICOAUTO$Returns, order = c(0, 0, 0))

Coefficients:
      intercept
         0.0087
s.e.     0.0050

sigma^2 estimated as 0.003856:  log likelihood = 210.81,  aic = -417.62
```

Since AIC of arima final<auto.arima we go with order c(0,0,0). Figure below shows diagnostic test of the model.



It is evident from figures 1 and 2 that the residuals do not exhibit any discernible pattern, and the ACF has no peak other than lag-0.To determine whether the residuals have been dispersed independently of one another or not, the Ljung-Box test is used. The alternative hypothesis contends that they are not independent, contrary to the null hypothesis' assertion that they are. It is evident from graph 3 that every p-value is higher than the t-statistic. Therefore, we are unable to determine that the residuals are independent and reject the null hypothesis.

Forecasting using the ARIMA Model: Using the best ARIMA model, the forecasted results are shown below.

```
> predicted_RICOAUTO<-predict(arima_final_RICOAUTO , n.ahead=10)
> predicted_RICOAUTO
$pred
Time Series:
Start = 63763201
End = 64540801
Frequency = 1.15740740740741e-05
 [1] 0.001917211 0.001917211 0.001917211 0.001917211 0.001917211 0.001917211 0.001917211 0.001917211 0.001917211
[10] 0.001917211

$se
Time Series:
Start = 63763201
End = 64540801
Frequency = 1.15740740740741e-05
 [1] 0.03122447 0.03122447 0.03122447 0.03122447 0.03122447 0.03122447 0.03122447 0.03122447 0.03122447 0.03122447
```

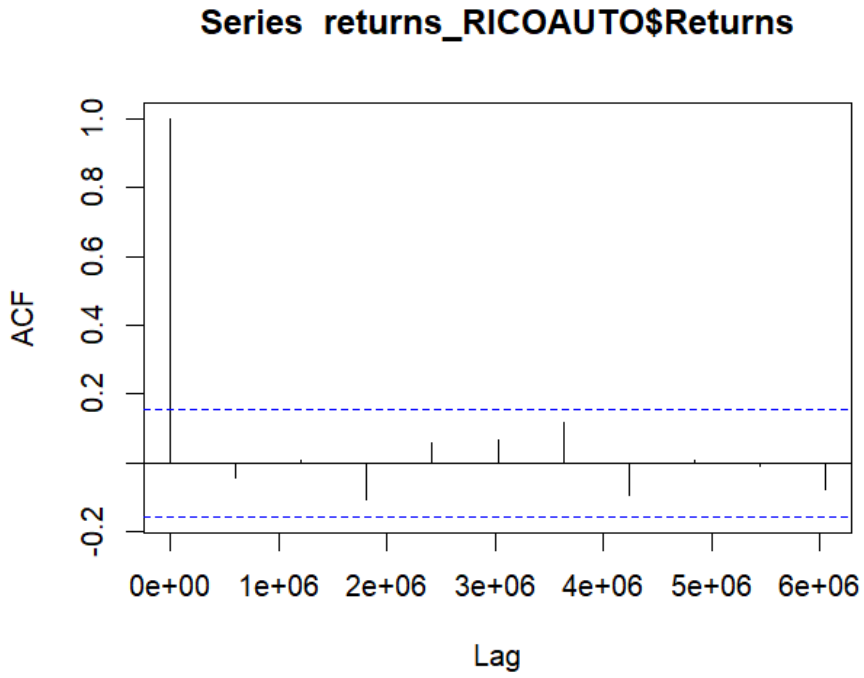
Since all the forecasts for returns are positive, the stock price will increase in the future days.

3.1.2 Rico Auto Industries Ltd (Weekly)

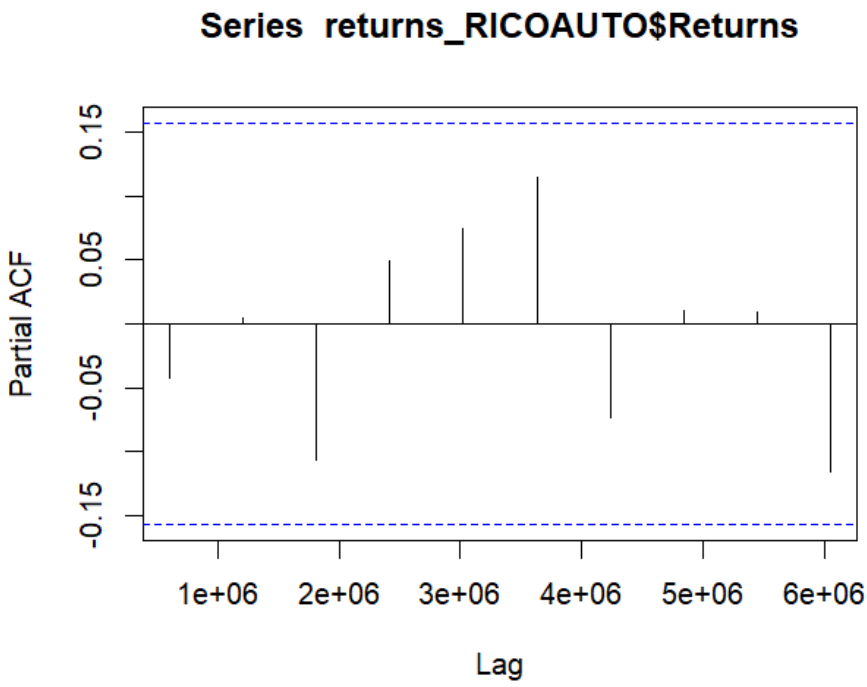
An augmented Dickey-Fuller (ADF) test is performed to check for stationarity.

```
        Augmented Dickey-Fuller Test

data:  returns_RICOAUTO$Returns
Dickey-Fuller = -4.163, Lag order = 5, p-value = 0.01
alternative hypothesis: stationary
```

The Augmented Dickey-Fuller test null hypothesis states that a unit root exists, i.e., the series is not stationary, and the corresponding alternative hypothesis is that the series is stationary. Since the p-value of the test shown above is 0.01, the null hypothesis can be rejected; thus, the series is Stationary. ACF and PACF plots: The ACF plot tells us the value of the order of the Moving average to use in the ARIMA model. Figure below shows that no lag term except the 0th lag is significant; hence, it's a MA(0) order.



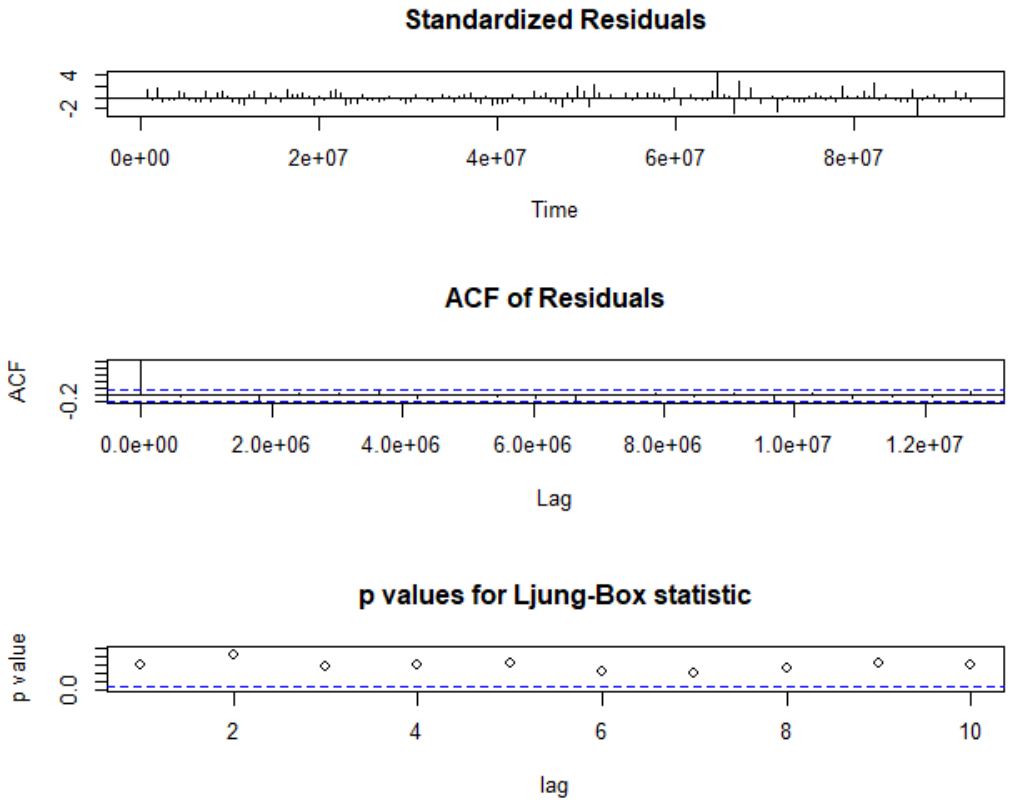
PACF plot tells us the value of the order of the Auto Regressive to use in the ARIMA model. Figure below shows that no lag term is significant; hence, it's an AR(0) order.



Identifying the best ARIMA Model: From the ACF and PACF it has been found that RICO AUTO weekly returns follow a (0,0,0) ARIMA model. To confirm the best model, auto.arima() function of R can be used.

```
Series: returns_RICOAUTO$Returns
ARIMA(0,0,0) with non-zero mean

Coefficients:
        mean
      0.0087
s.e.  0.0050

sigma^2 = 0.003881:  log likelihood = 210.81
AIC=-417.62   AICc=-417.54   BIC=-411.54
> arima_final_RICOAUTO <- arima(returns_RICOAUTO$Returns , order = c(0,0,0))
> arima_final_RICOAUTO
```

Since AIC of arima final<auto.arima we go with order c(0,0,0). Figure below shows diagnostic test of the model.



From graphs 1 and 2, it can be seen that the residuals do not follow any particular pattern, and even the ACF has no peak except lag-0. The Ljung-Box test is used to check whether the residuals have been independently distributed or not from each other. Its null hypothesis says they are independent, whereas the alternative hypothesis says they are not. From graph 3, t can be seen that all the p-values are above the t-statistic. Hence, we cannot reject the null hypothesis and conclude that the residuals are independent.

Forecasting using the ARIMA Model: Using the best ARIMA model, the forecasted results are shown below.

```
> predicted_RICOAUTO<-predict(arima_final_RICOAUTO , n.ahead=10)
> predicted_RICOAUTO
$pred
Time Series:
Start = c(93744001, 1)
End = c(99187201, 1)
Frequency = 1.65343915343915e-06
 [1] 0.008657108 0.008657108 0.008657108 0.008657108 0.008657108 0.008657108 0.008657108 0.008657108 0.008657108
[10] 0.008657108

$se
Time Series:
Start = c(93744001, 1)
End = c(99187201, 1)
Frequency = 1.65343915343915e-06
 [1] 0.06209977 0.06209977 0.06209977 0.06209977 0.06209977 0.06209977 0.06209977 0.06209977 0.06209977
```

Since all the forecasts for returns are positive, the stock price will increase in the future days.

3.1.3 Rico Auto Industries Ltd (Monthly)

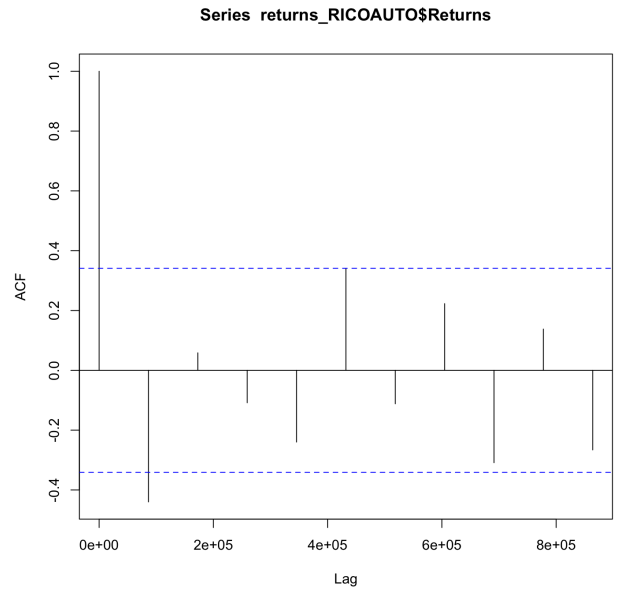
```
        Augmented Dickey-Fuller Test

data:  returns_RICOAUTO$Returns
Dickey-Fuller = -3.4369, Lag order = 3, p-value = 0.06887
alternative hypothesis: stationary
```

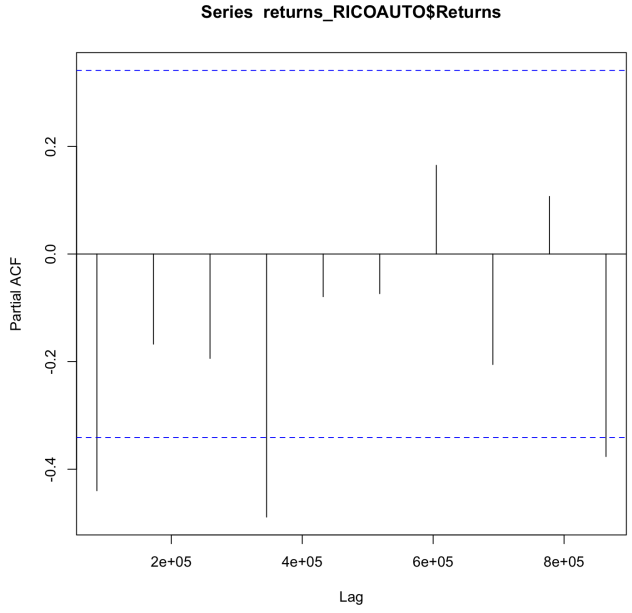
Since the series is not stationary, we try differencing.

```
returns_RICOAUTO$Returns<- diff(returns_RICOAUTO$Returns)
returns_RICOAUTO<- na.omit(returns_RICOAUTO)
adf.test(returns_RICOAUTO$Returns , alternative = "stationary")
```

```
        Augmented Dickey-Fuller Test

data:  returns_RICOAUTO$Returns
Dickey-Fuller = -6.4347, Lag order = 3, p-value = 0.01
alternative hypothesis: stationary
```

Post differencing, our series is stationary.





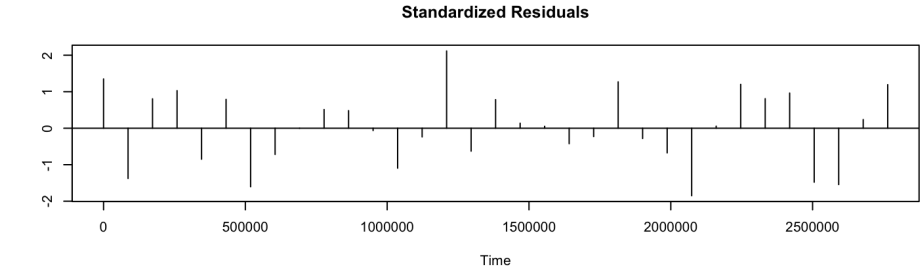
MA(1) ORDER AND AR(0) ORDER, or we can directly use ARIMA(0,1,1) ON THE ORIGINAL DATA.

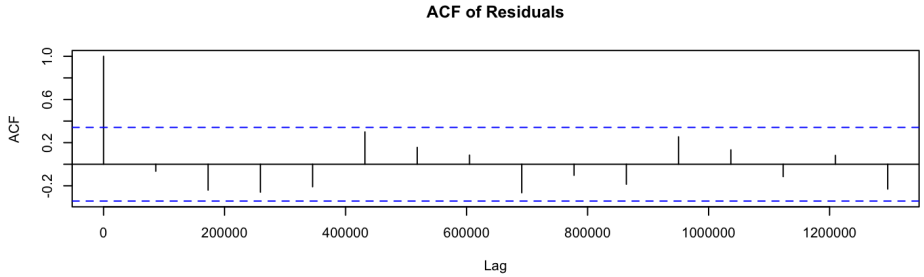
```
Series: returns_RICOAUTO$Returns
ARIMA(1,0,0) with zero mean

Coefficients:
          ar1
      -0.4631
s.e.   0.1573

sigma^2 = 0.02509:  log likelihood = 14.37
AIC=-24.73   AICc=-24.33   BIC=-21.74
```

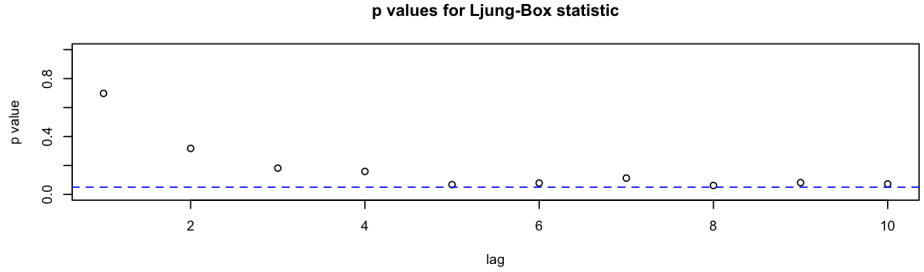
```
Call:
arima(x = returns_RICOAUTO$Returns, order = c(0, 0, 1))

Coefficients:
          ma1  intercept
      -0.9997     0.0005
s.e.   0.0942     0.0023

sigma^2 estimated as 0.01674:  log likelihood = 18.9,  aic = -31.8
```

Since, AIC of arima_final>auto.arima we go with order c(0,0,0) with zero mean.

```
Time Series:
Start = 2851201
End = 3628801
Frequency = 1.15740740740741e-05
 [1] -6.852860e-02  3.173303e-02 -1.469438e-02  6.804415e-03 -3.150870e-03  1.459050e-03
 [7] -6.756313e-04  3.128596e-04 -1.448735e-04  6.708551e-05

$se
Time Series:
Start = 2851201
End = 3628801
Frequency = 1.15740740740741e-05
 [1] 0.1584099 0.1745694 0.1778433 0.1785375 0.1786861 0.1787179 0.1787247 0.1787262
 [9] 0.1787265 0.1787266
```


Standardized Residuals
2
1
0
-1
-2
0
500000
1000000
1500000
2000000
2500000
Time


ACF of Residuals
ACF
1.0
0.6
0.2
-0.2
0
200000
400000
600000
800000
1000000
1200000
Lag


p values for Ljung-Box statistic
p value
0.8
0.4
0.0
2
4
6
8
10
lag

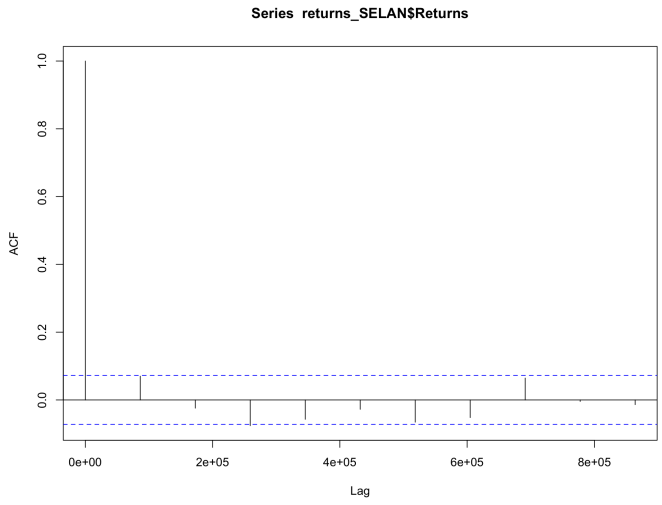
3.2 Selan Exploration Technology Ltd

3.2.1 SELAN (Daily)

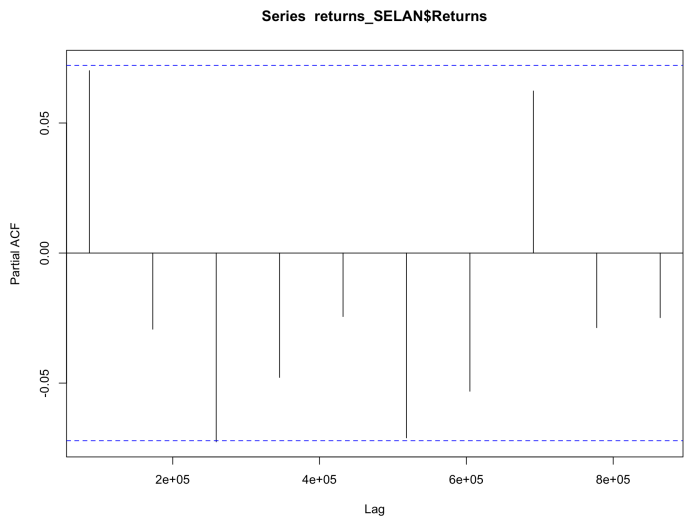
An augmented Dickey-Fuller (ADF) test is performed to check for stationarity.

```
        Augmented Dickey-Fuller Test

data:  returns_SELAN$Returns
Dickey-Fuller = -9.5547, Lag order = 9, p-value = 0.01
alternative hypothesis: stationary
```

ACF and PACF plots: The ACF plot tells us the value of the order of the Moving average to use in the ARIMA model. Figure below shows that no lag term except the 0th lag is significant; hence, it's a MA(0) order.



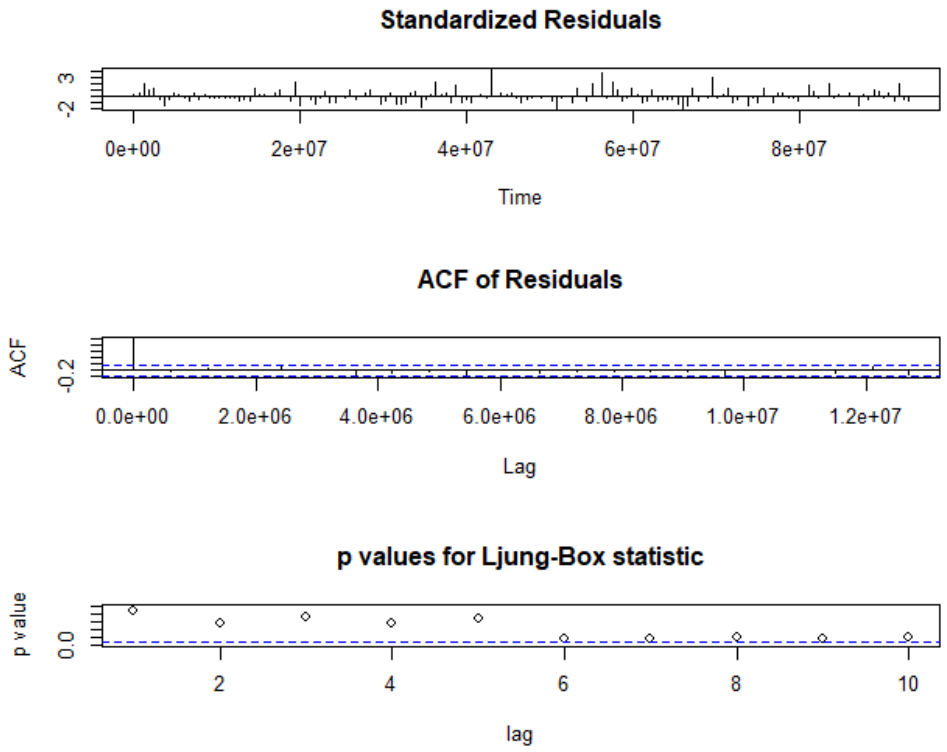
PACF plot tells us the value of the order of the Auto Regressive to use in the ARIMA model. Figure below shows that no lag term is significant; hence, it's an AR(4) order.



Identifying the best ARIMA Model: From the ACF and PACF it has been found that RICO AUTO daily returns follow a (0,0,4) ARIMA model. To confirm the best model, auto.arima() function of R can be used.

```
Series: returns_SELAN$Returns
ARIMA(0,0,4) with non-zero mean

Coefficients:
         ma1      ma2      ma3      ma4    mean
      0.0640  -0.0309  -0.0923  -0.0618  0.0025
s.e.  0.0368   0.0369   0.0392   0.0348  0.0010

sigma^2 = 0.001007:  log likelihood = 1501.55
AIC=-2991.09   AICc=-2990.98   BIC=-2963.47
> arima_final_SELAN <- arima(returns_SELAN$Returns , order = c(0,0,4))
> arima_final_SELAN
```

Since AIC of arima final<auto.arima we go with order c(0,0,4).



From graphs 1 and 2, it can be seen that the residuals do not follow any particular pattern, and even the ACF has no peak except lag-0. The Ljung-Box test is used to check whether the residuals have been independently distributed or not from each other. Its null hypothesis says they are independent, whereas the alternative hypothesis says they are not. From graph 3, t can be seen that all the p-values are above the t-statistic. Hence, we cannot reject the null hypothesis and conclude that the residuals are independent.

Forecasting using the ARIMA Model: Using the best ARIMA model, the forecasted results are shown below.

```
Time Series:
Start = 63763201
End = 64540801
Frequency = 1.15740740740741e-05
 [1] 0.0076734918 0.0071506281 0.0030309895 0.0008577651 0.0024606180 0.0024606180 0.0024606180
 [8] 0.0024606180 0.0024606180 0.0024606180

$se
Time Series:
Start = 63763201
End = 64540801
Frequency = 1.15740740740741e-05
 [1] 0.03173973 0.03180463 0.03181980 0.03195443 0.03201461 0.03201461 0.03201461 0.03201461
 [9] 0.03201461 0.03201461
```

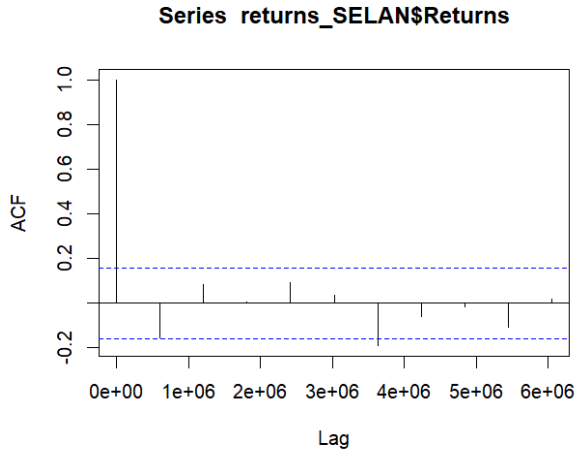
Since all the forecasts for returns are positive, the stock price will increase in the future days.

3.2.2 SELAN (Weekly)

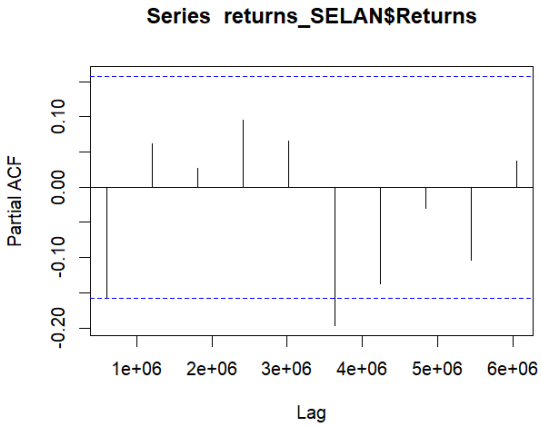
An augmented Dickey-Fuller (ADF) test is performed to check for stationarity.

```
        Augmented Dickey-Fuller Test

data:  returns_SELAN$Returns
Dickey-Fuller = -5.4059, Lag order = 5, p-value = 0.01
alternative hypothesis: stationary
```

Since the p-value of the test shown above is 0.01, the null hypothesis can be rejected; thus, the series is Stationary. ACF and PACF plots: The ACF plot tells us the value of the order of the Moving average to use in the ARIMA model. Figure below shows that no lag term except the 0th lag is significant; hence, it's a MA(0) order.



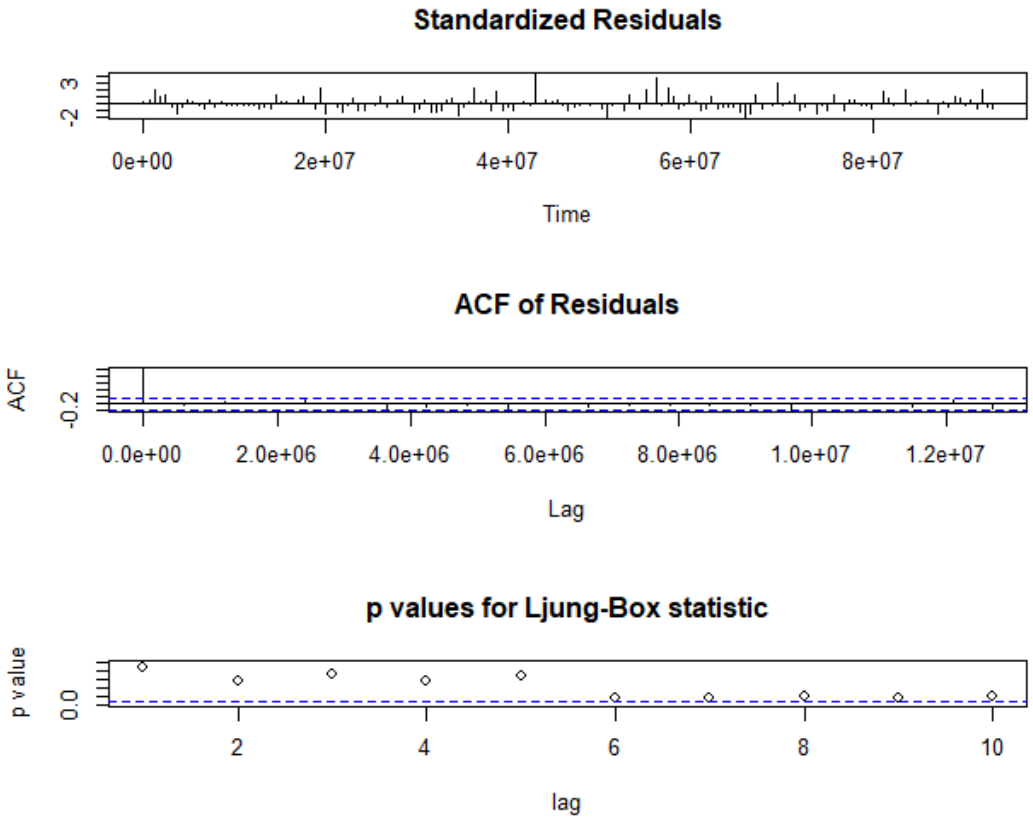
PACF plot tells us the value of the order of the Auto Regressive to use in the ARIMA model. Figure below shows that no lag term is significant; hence, it's an AR(1) order.



Identifying the best ARIMA Model: From the ACF and PACF it has been found that RICO AUTO weekly returns follow a (0,0,1) ARIMA model. To confirm the best model, auto.arima() function of R can be used.

```
> auto.arima(returns_SELAN$Returns)
Series: returns_SELAN$Returns
ARIMA(0,0,1) with non-zero mean

Coefficients:
          ma1    mean
      -0.1360  0.0113
s.e.   0.0728  0.0046

sigma^2 = 0.004474:  log likelihood = 200.29
AIC=-394.59   AICc=-394.43   BIC=-385.46
>
```

Since AIC of arima final<auto.arima we go with order c(0,0,1).



From graphs 1 and 2, it can be seen that the residuals do not follow any particular pattern, and even the ACF has no peak except lag-0. The Ljung-Box test is used to check whether the residuals have been independently distributed or not from each other. Its null hypothesis says they are independent, whereas the alternative hypothesis says they are not. From graph 3, t can be seen that all the p-values are above the t-statistic. Hence, we cannot reject the null hypothesis and conclude that the residuals are independent.

Forecasting using the ARIMA Model: Using the best ARIMA model, the forecasted results are shown below.

```
Series: returns_SELAN$Returns
ARIMA(0,0,1) with non-zero mean

Coefficients:
          ma1    mean
      -0.1360  0.0113
s.e.   0.0728  0.0046

sigma^2 = 0.004474:  log likelihood = 200.29
AIC=-394.59   AICc=-394.43   BIC=-385.46
> arima_final_SELAN <- arima(returns_SELAN$Returns , order = c(0,0,1))
> arima_final_SELAN

Call:
arima(x = returns_SELAN$Returns, order = c(0, 0, 1))

Coefficients:
          ma1  intercept
      -0.1360     0.0113
s.e.   0.0728     0.0046

sigma^2 estimated as 0.004416:  log likelihood = 200.29,  aic = -394.59
```

```
$pred
Time Series:
Start = c(93744001, 1)
End = c(99187201, 1)
Frequency = 1.65343915343915e-06
 [1] 0.01917066 0.01125967 0.01125967 0.01125967 0.01125967 0.01125967 0.01125967 0.01125967 0.01125967

$se
Time Series:
Start = c(93744001, 1)
End = c(99187201, 1)
Frequency = 1.65343915343915e-06
 [1] 0.06645608 0.06706775 0.06706775 0.06706775 0.06706775 0.06706775 0.06706775 0.06706775 0.06706775
```

Since all the forecasts for returns are positive, the stock price will increase in the future days.

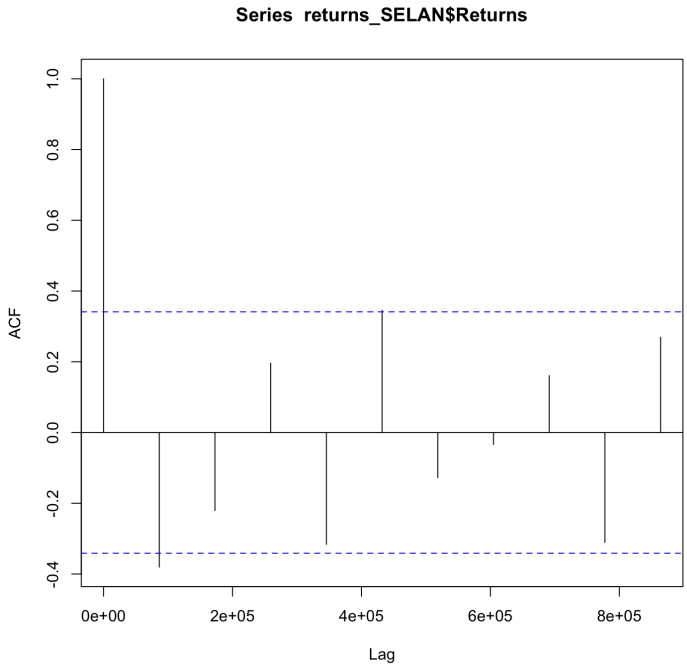
3.2.3 SELAN (Monthly)

An augmented Dickey-Fuller (ADF) test is performed to check for stationarity.

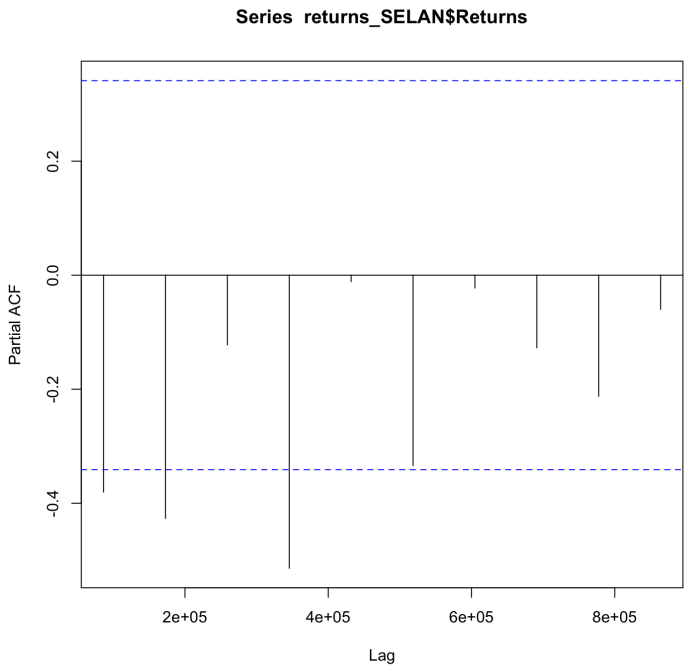
```
        Augmented Dickey-Fuller Test

data:  returns_SELAN$Returns
Dickey-Fuller = -4.1223, Lag order = 3, p-value = 0.01683
alternative hypothesis: stationary
```

Series, not stationary. To make it stationary, we tried differencing once.

Since the p-value of the test shown above is 0.01, the null hypothesis can be rejected; thus, the series is Stationary. ACF and PACF plots: The ACF plot tells us the value of the order of the Moving average to use in the ARIMA model. Figure below shows that no lag term except the 0th lag is significant; hence, it's a MA(1) order.



PACF plot tells us the value of the order of the Auto Regressive to use in the ARIMA model. Figure below shows that no lag term is significant; hence, it's an AR(1) order.

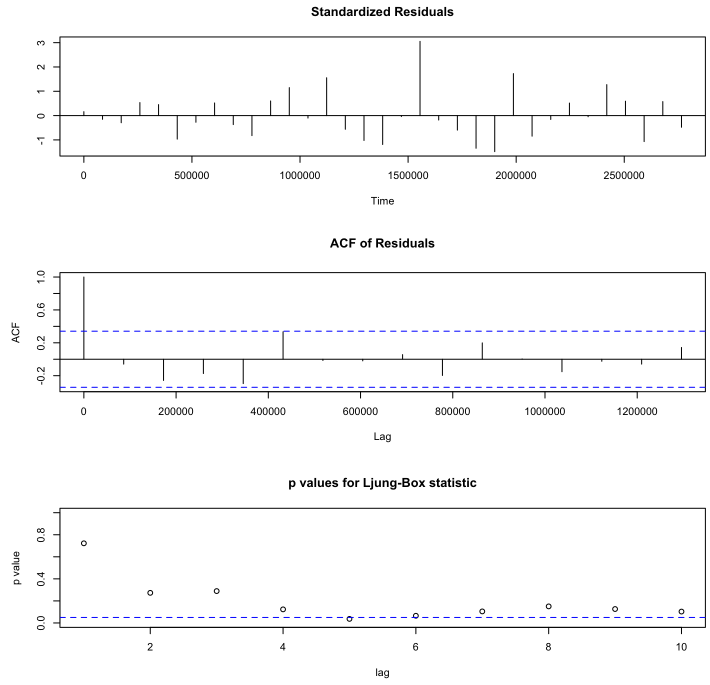


MA(1) ORDER AND AR(0) ORDER or we can directly use ARIMA(0,1,1) ON THE ORIGINAL NON DIFFERENCED DATA.

Identifying the best ARIMA Model: From the ACF and PACF it has been found that SELAN monthly returns follow a (0,1,1) ARIMA model. To confirm the best model, auto.arima() function of R can be used.

```
Series: returns_SELAN$Returns
ARIMA(2,0,0) with zero mean

Coefficients:
          ar1      ar2
      -0.5277  -0.4135
s.e.   0.1556   0.1542

sigma^2 = 0.02027:  log likelihood = 18.27
AIC=-30.55   AICc=-29.72   BIC=-26.06
```

Since order of auto.arima, same as asarima_final, we go with order c(0,1,1) and zero mean which has better AIC.



From graphs 1 and 2, it can be seen that the residuals do not follow any particular pattern, and even the ACF has no peak except lag-0. The Ljung-Box test is used to check whether the residuals have been independently distributed or not from each other. Its null hypothesis says they are independent, whereas the alternative hypothesis says they are not. From graph 3, t can be seen that all the p-values are above the t-statistic. Hence, we cannot reject the null hypothesis and conclude that the residuals are independent.

Forecasting using the ARIMA Model: Using the best ARIMA model, the forecasted results are shown below.

```
Time Series:
Start = 2851201
End = 3628801
Frequency = 1.15740740740741e-05
 [1] -4.128698e-02  5.084801e-02 -9.759151e-03 -1.587803e-02  1.241496e-02  1.475664e-05
 [7] -5.141965e-03  2.707392e-03  6.977150e-04 -1.487831e-03

$se
Time Series:
Start = 2851201
End = 3628801
Frequency = 1.15740740740741e-05
 [1] 0.1423657 0.1609730 0.1621174 0.1672747 0.1678429 0.1681266 0.1684769 0.1684854
 [9] 0.1685238 0.1685438
```

Since all the forecasts for returns are positive, the stock price will increase in the future days.

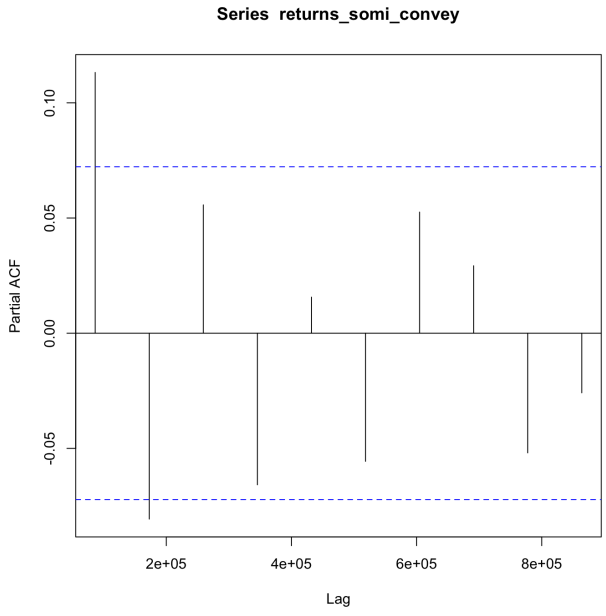
3.3 Somi Conveyor Beltings Ltd

3.3.1 SOMICONVEY (Daily)

An augmented Dickey-Fuller (ADF) test is performed to check for stationarity.

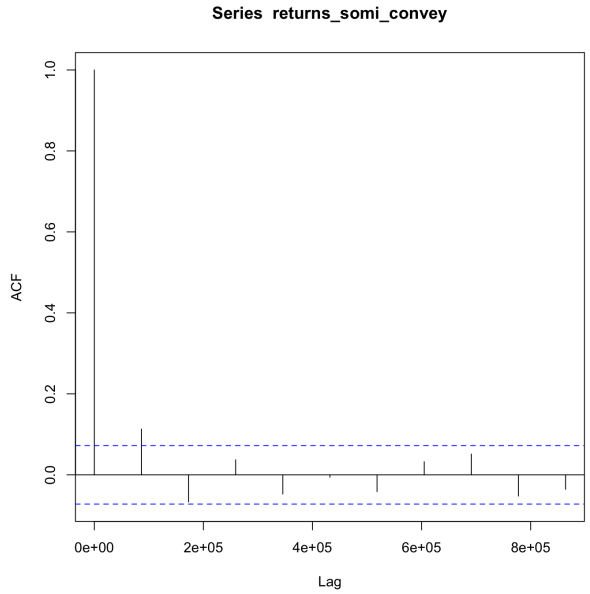
```
        Augmented Dickey-Fuller Test

data:  returns_no_missing
Dickey-Fuller = -8.8789, Lag order = 9, p-value = 0.01
alternative hypothesis: stationary
```

The Augmented Dickey-Fuller test null hypothesis states that a unit root exists, i.e., the series is not stationary, and the corresponding alternative hypothesis is that the series is stationary. Since the p-value of the test shown above is 0.01, the null hypothesis can be rejected; thus, the series is Stationary. ACF and PACF plots: The ACF plot tells us the value of the order of the Moving average to use in the ARIMA model. Figure below shows that no lag term except the 0th lag is significant; hence, it's a MA(0) order.



PACF plot tells us the value of the order of the Auto Regressive to use in

the ARIMA model. Figure below shows that no lag term is significant; hence, it's an AR(1) order.

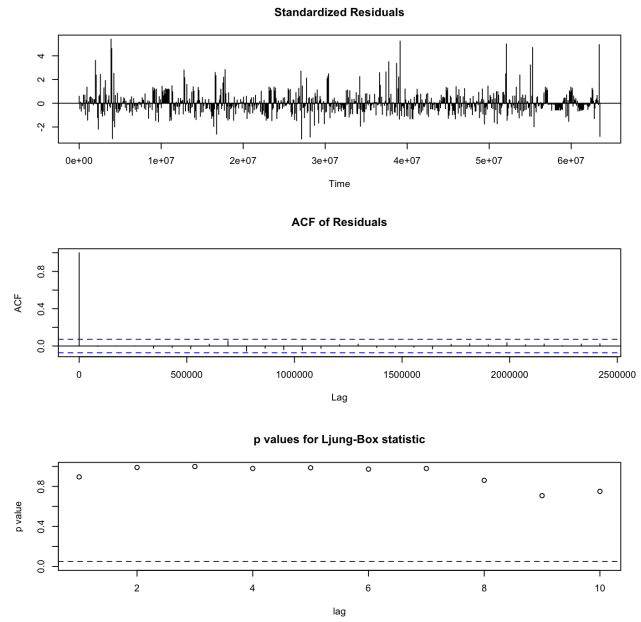


Identifying the best ARIMA Model: From the ACF and PACF it has been found that SOMICONVEY daily returns follow a (1,0,1) ARIMA model. To confirm the best model, auto.arima() function of R can be used.

```
> auto.arima(returns_no_missing)
Series: returns_no_missing
ARIMA(1,0,1) with non-zero mean

Coefficients:
          ar1     ma1    mean
      -0.5949  0.7380  0.0024
s.e.   0.1035  0.0863  0.0015

sigma^2 = 0.001348:  log likelihood = 1389.38
AIC=-2770.76   AICc=-2770.71   BIC=-2752.36
>
```

```
Call:
arima(x = returns_no_missing, order = c(1, 0, 1))

Coefficients:
          ar1     ma1  intercept
      -0.5949  0.7380     0.0024
s.e.   0.1035  0.0863     0.0015

sigma^2 estimated as 0.001342:  log likelihood = 1389.38,  aic = -2770.76
>
```

Since order of auto.arima, same as asarima_final, we go with order c(1,0,1) and zero mean which has better AIC.



From graphs 1 and 2, it can be seen that the residuals do not follow any particular pattern, and even the ACF has no peak except lag-0. The Ljung-Box test is used to check whether the residuals have been independently distributed or not from each other. Its null hypothesis says they are independent, whereas the alternative hypothesis says they are not. From graph 3, t can be seen that all the p-values are

above the t-statistic. Hence, we cannot reject the null hypothesis and conclude that the residuals are independent.

Forecasting using the ARIMA Model: Using the best ARIMA model, the forecasted results are shown below.

```
Time Series:
Start = 63763201
End = 64540801
Frequency = 1.15740740740741e-05
 [1] 0.0076734918 0.0071506281 0.0030309895 0.0008577651 0.0024606180 0.0024606180 0.0024606180
 [8] 0.0024606180 0.0024606180 0.0024606180

$se
Time Series:
Start = 63763201
End = 64540801
Frequency = 1.15740740740741e-05
 [1] 0.03173973 0.03180463 0.03181980 0.03195443 0.03201461 0.03201461 0.03201461 0.03201461
 [9] 0.03201461 0.03201461
```

Since all the forecasts for returns are positive, the stock price will increase in the future days.

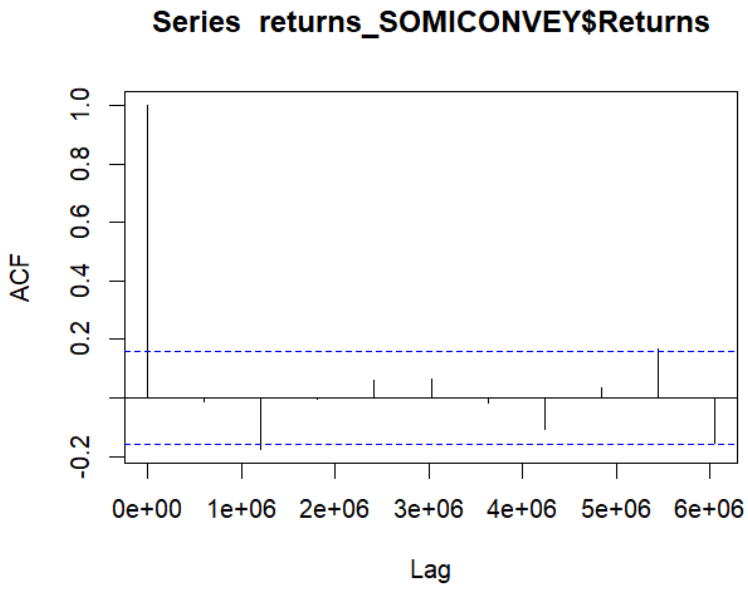
3.3.2 SOMICONVEY (Weekly)

Augmented Dickey-Fuller Test: An augmented Dickey-Fuller (ADF) test is performed to check for stationarity.

```
        Augmented Dickey-Fuller Test

data:  returns_SOMICONVEY$Returns
Dickey-Fuller = -4.5061, Lag order = 5, p-value = 0.01
alternative hypothesis: stationary
```

Again, since the p-value is below 0.05, the null hypothesis is rejected. Hence, the series is stationary, and we can proceed with our analysis.

Since the p-value of the test shown above is 0.01, the null hypothesis can be rejected; thus, the series is Stationary. ACF and PACF plots: The ACF plot tells us the value of the order of the Moving average to use in the ARIMA model. Figure below shows that no lag term except the 0th lag is significant; hence, it's a MA(0) order.

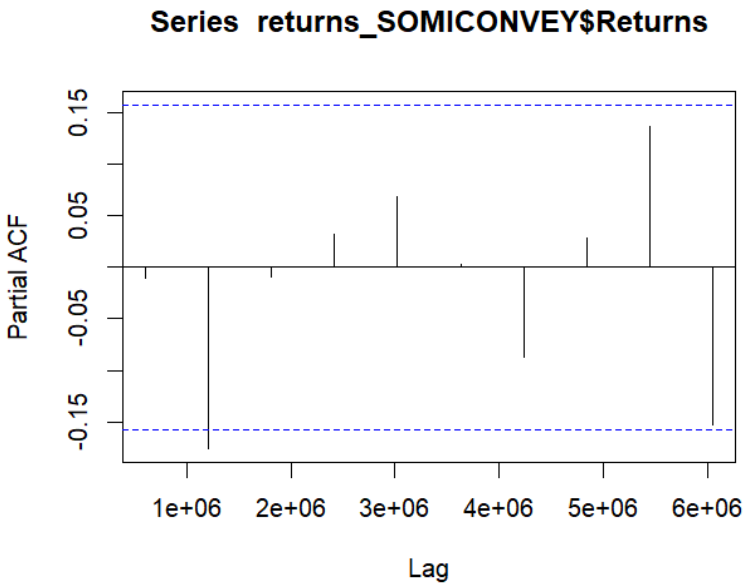


The ACF plot tells us the value of the order of the Moving average to use in the ARIMA model. The figure shows that no lag term except the 0th lag is significant; hence, it's an MA(0) order.

PACF plot tells us the value of the order of the Auto Regressive to use in

the ARIMA model. Figure below shows that no lag term is significant; hence,

it's an AR(0) order.

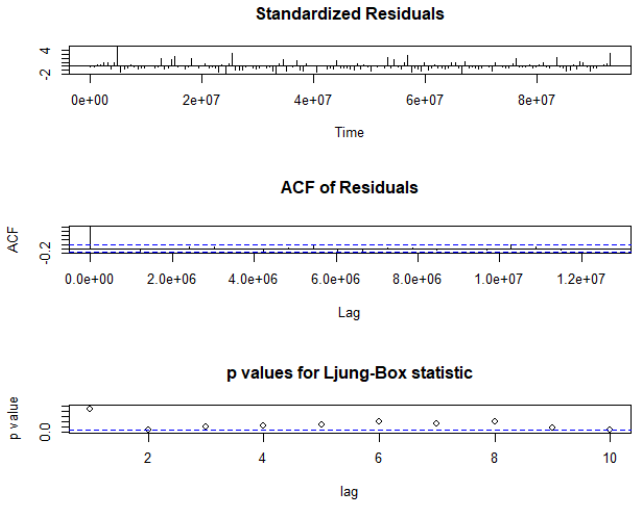


Identifying the best ARIMA Model: From the ACF and PACF it has been found that SOMICONVEY weekly returns follow a (0,0,0) ARIMA model. To confirm the best model, auto.arima() function of R can be used.

PACF plot tells us the value of the order of the Auto Regressive to use in the ARIMA model. From observing the lags in the figure, we can say that it's an AR(0) order.

```
Series: returns_SOMICONVEY$Returns
ARIMA(0,0,0) with non-zero mean

Coefficients:
        mean
      0.0134
s.e.  0.0076

sigma^2 = 0.008925:  log likelihood = 146.28
AIC=-288.56   AICc=-288.48   BIC=-282.47
```

The best model, auto.arima() function of R can be used which turns to be ARIMA(0,0,0).



From graphs 1 and 2, it can be seen that the residuals do not follow any particular pattern, and even the ACF has no peak except lag-0. The Ljung-Box test is used to check whether the residuals have been independently distributed or not from each other. Its null hypothesis says they are independent, whereas the alternative hypothesis says they are not. From graph 3, t can be seen that all the p-values are above the t-statistic. Hence, we cannot reject the null hypothesis and conclude that the residuals are independent.

Forecasting using the ARIMA Model: Using the best ARIMA model, the forecasted results are shown below.

```
$pred
Time Series:
Start = c(93744001, 1)
End = c(99187201, 1)
Frequency = 1.65343915343915e-06
 [1] 0.01917066 0.01125967 0.01125967 0.01125967 0.01125967 0.01125967 0.01125967 0.01125967 0.01125967 0.01125967

$se
Time Series:
Start = c(93744001, 1)
End = c(99187201, 1)
Frequency = 1.65343915343915e-06
 [1] 0.06645608 0.06706775 0.06706775 0.06706775 0.06706775 0.06706775 0.06706775 0.06706775 0.06706775 0.06706775
```

Since all the forecasts for returns are positive, the stock price will increase in the future days.

3.3.3 SOMICONVEY (Monthly)

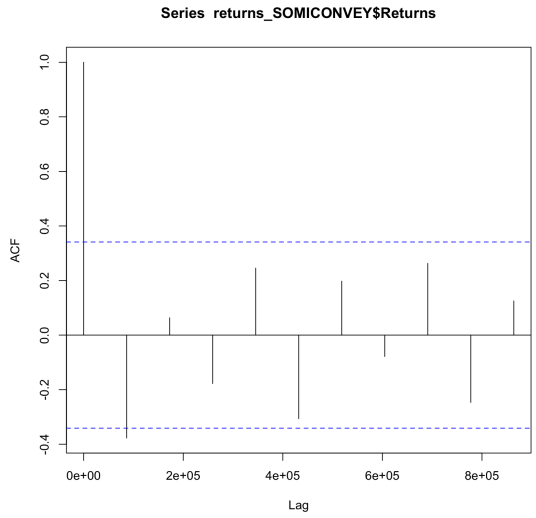
An augmented Dickey-Fuller (ADF) test is performed to check for stationarity.

```
        Augmented Dickey-Fuller Test

data:  returns_SOMICONVEY$Returns
Dickey-Fuller = -3.1906, Lag order = 3, p-value = 0.1126
alternative hypothesis: stationary
```

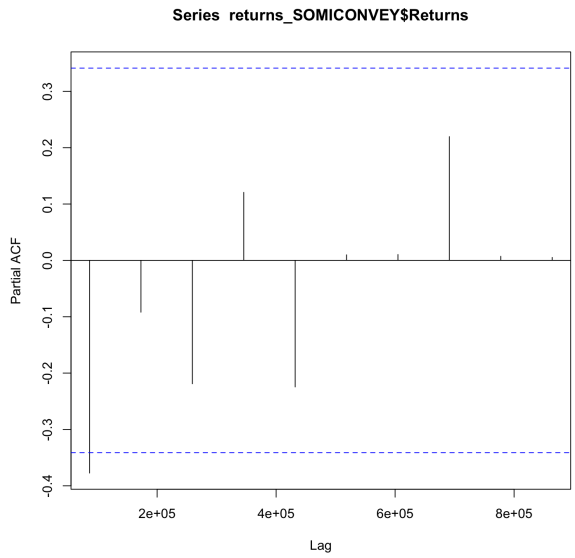
The Augmented Dickey-Fuller test null hypothesis states that a unit root exists, i.e., the series is not stationary, and the corresponding alternative hypothesis is that the series is stationary. Since the p-value of the test shown above is 0.01, the null hypothesis can be rejected; thus, the series is Stationary. ACF and PACF plots: The ACF plot tells us the value of the order of the Moving average to use in the ARIMA model. Figure below shows that no lag term except the 0th lag is significant; hence, it's a MA(2) order.

Since the series is non stationary we use the below code and difference it.

```
adf.test(returns_SOMICONVEY$Returns , alternative = "stationary")
returns_SOMICONVEY$Returns<- diff(returns_SOMICONVEY$Returns)
returns_SOMICONVEY <- na.omit(returns_SOMICONVEY)
```



PACF plot tells us the value of the order of the Auto Regressive to use in the ARIMA model. Figure below shows that no lag term is significant; hence, it's an AR(1) order.

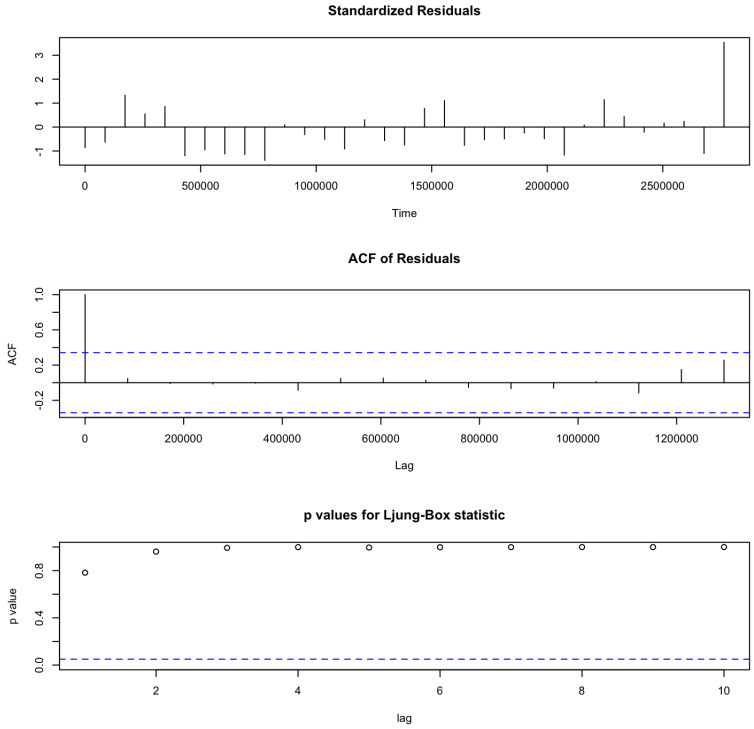


According to the above two graphs, MA(2) ORDER AND AR(1) ORDER.

Identifying the best ARIMA Model: From the ACF and PACF it has been found that SOMICONVEY monthly returns follow a (1,0,2) ARIMA model. To confirm the best model, auto.arima() function of R can be used.

```
Series: returns_SOMICONVEY$Returns
ARIMA(0,0,1) with zero mean

Coefficients:
          ma1
      -0.8804
s.e.   0.1846

sigma^2 = 0.03967:  log likelihood = 6.18
AIC=-8.37   AICc=-7.97   BIC=-5.38
```

Whereas, autoarima gives us ARIMA(0,0,1). Since AIC of arima_final is better than auto.arima we take order (1,0,2).




```
Call:
arima(x = returns_SOMICONVEY$Returns, order = c(1, 0, 2))

Coefficients:
          ar1      ma1      ma2  intercept
      -0.9975  -0.0275  -0.9719     0.0025
s.e.   0.0254   0.3048   0.2990     0.0031

sigma^2 estimated as 0.03146:  log likelihood = 7.93,  aic = -5.86
```

From graphs 1 and 2, it can be seen that the residuals do not follow any particular pattern, and even the ACF has no peak except lag-0. The Ljung-Box test is used to check whether the residuals have been independently distributed or not from each other. Its null hypothesis says they are independent, whereas the alternative hypothesis says they are not. From graph 3, t can be seen that all the p-values are above the t-statistic. Hence, we cannot reject the null hypothesis and conclude that the residuals are independent.

Forecasting using the ARIMA Model: Using the best ARIMA model, the forecasted results are shown below.

```
Time Series:
Start = 2851201
End = 3628801
Frequency = 1.15740740740741e-05
 [1] -4.128698e-02  5.084801e-02 -9.759151e-03 -1.587803e-02  1.241496e-02  1.475664e-05
 [7] -5.141965e-03  2.707392e-03  6.977150e-04 -1.487831e-03

$se
Time Series:
Start = 2851201
End = 3628801
Frequency = 1.15740740740741e-05
 [1] 0.1423657 0.1609730 0.1621174 0.1672747 0.1678429 0.1681266 0.1684769 0.1684854
 [9] 0.1685238 0.1685438
```

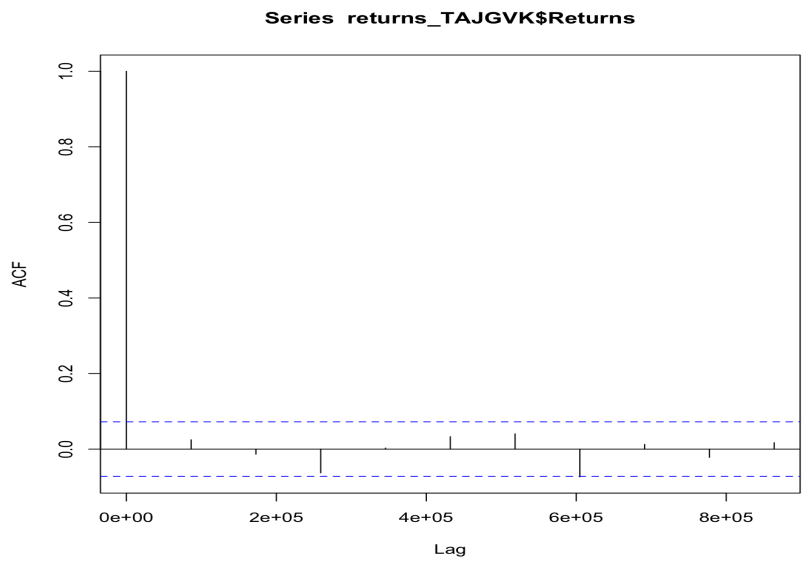
Since all the forecasts for returns are positive, the stock price will increase in the future days.

3.4 TAJ GVK Hotels and Resorts Ltd

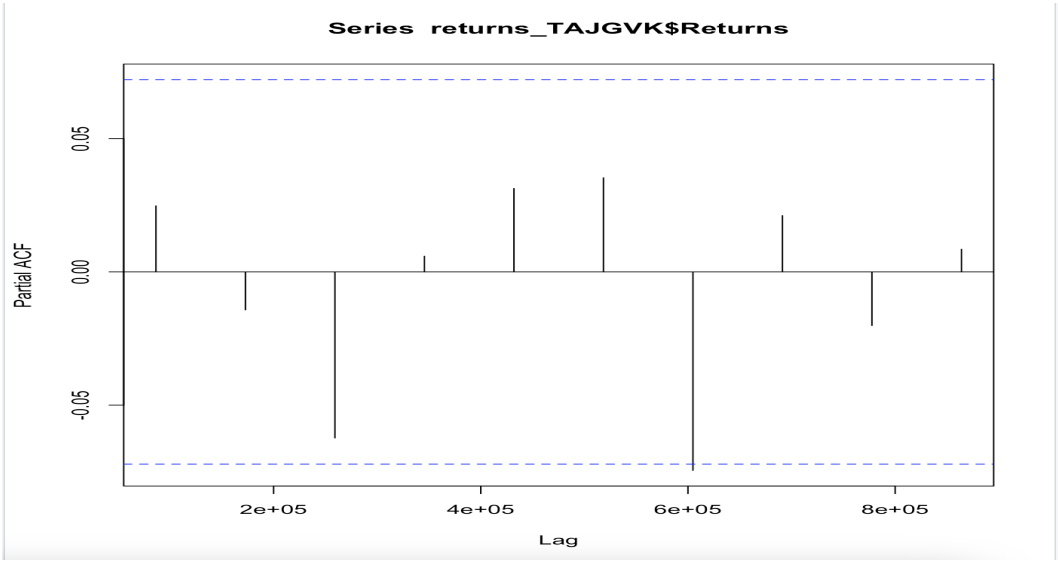
3.4.1 TAJGVK (Daily)

```
        Augmented Dickey-Fuller Test

data:  returns_TAJGVK$Returns
Dickey-Fuller = -8.6623, Lag order = 9, p-value = 0.01
alternative hypothesis: stationary
```

Again, since the p-value is below 0.05, the null hypothesis is rejected. Hence, the series is stationary, and we can proceed with our analysis.



The ACF plot tells us the value of the order of the Moving average to use in the ARIMA model. The figure shows that no lag term except the 0th lag is significant; hence, it's an MA(0) order.

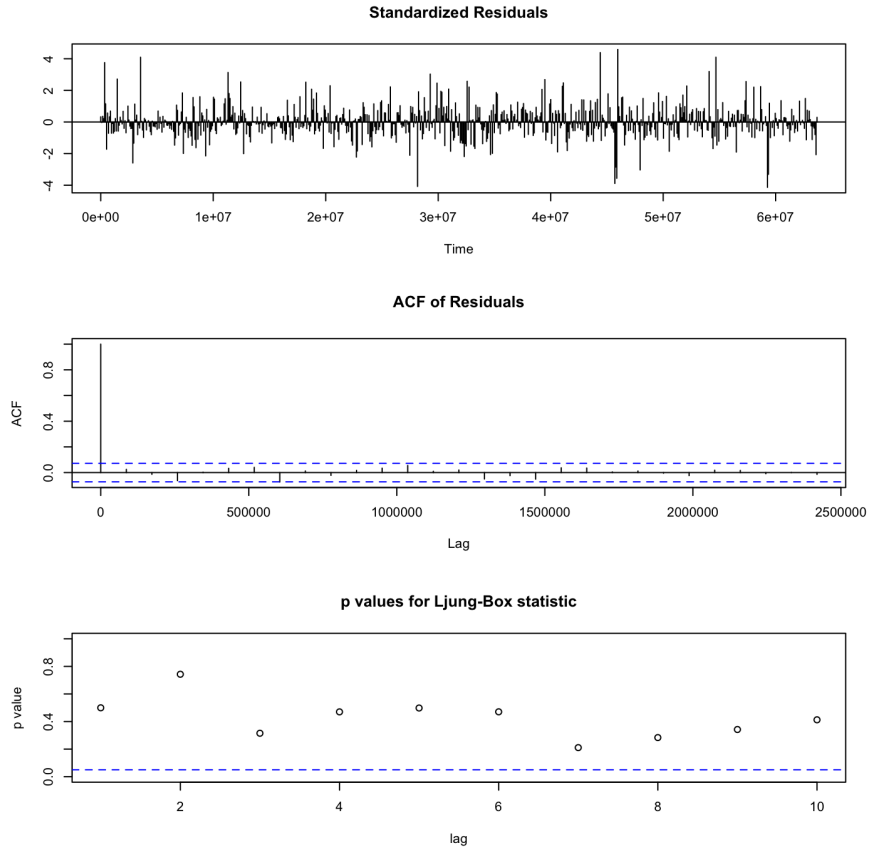


PACF plot tells us the value of the order of the Auto Regressive to use in the ARIMA model. From observing the lags in the figure, we can say that it’s an AR(0) order.

```
Series: returns_TAJGVK$Returns
ARIMA(0,0,0) with zero mean

sigma^2 = 0.0005097:  log likelihood = 1750.47
AIC=-3498.93   AICc=-3498.93   BIC=-3494.33
>
```

The best model, auto.arima() function of R can be used which turns to be ARIMA(0,0,0).

```
Call:
arima(x = returns_TAJGVK$Returns, order = c(0, 0, 0))

Coefficients:
      intercept
          1e-03
s.e.      8e-04

sigma^2 estimated as 0.0005086:  log likelihood = 1751.25,  aic = -3498.5
```



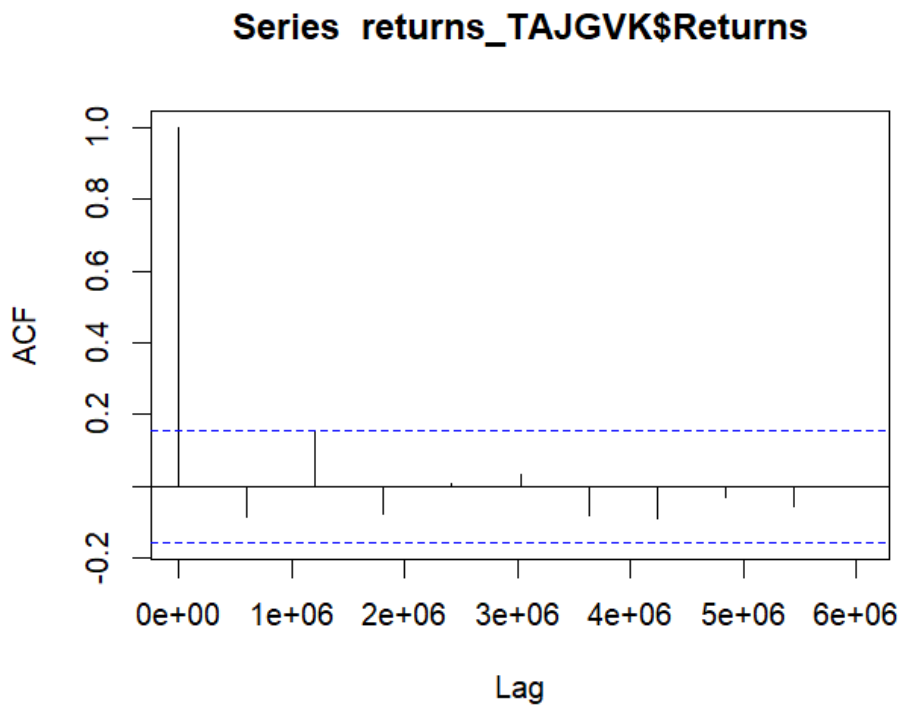

```
Time Series:
Start = 63763201
End = 64540801
Frequency = 1.15740740740741e-05
 [1] 0.001039486 0.001039486 0.001039486 0.001039486 0.001039486 0.001039486 0.001039486
 [8] 0.001039486 0.001039486 0.001039486

$se
Time Series:
Start = 63763201
End = 64540801
Frequency = 1.15740740740741e-05
 [1] 0.0225526 0.0225526 0.0225526 0.0225526 0.0225526 0.0225526 0.0225526 0.0225526 0.0225526
[10] 0.0225526
```

Since all forecast returns are positive, it suggests that the stock price will increase in the coming days.

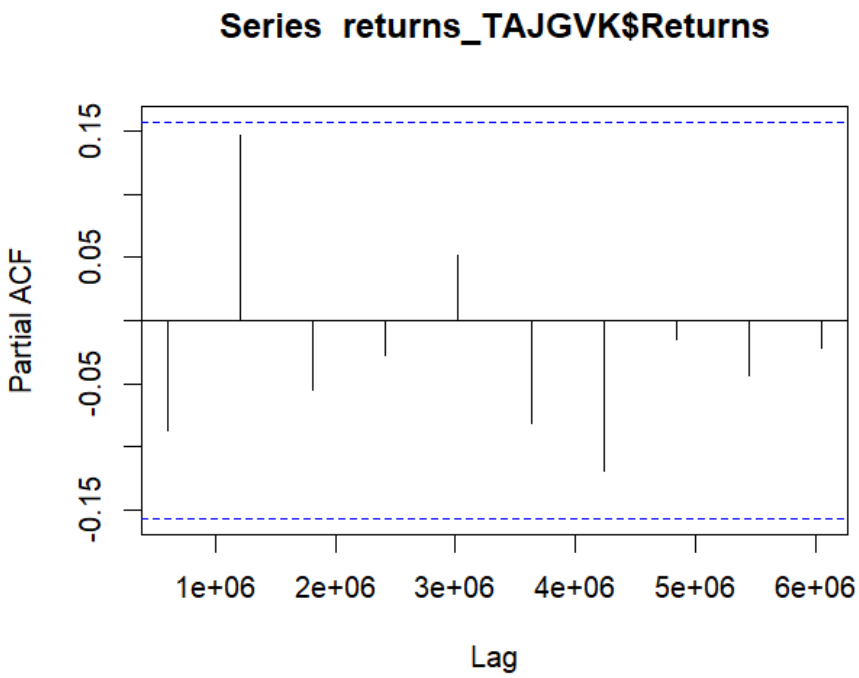
3.4.2 TAJGVK (Weekly)

```
        Augmented Dickey-Fuller Test

data:  returns_TAJGVK$Returns
Dickey-Fuller = -5.0551, Lag order = 5, p-value = 0.01
alternative hypothesis: stationary
```

Again, since the p-value is below 0.05, the null hypothesis is rejected. Hence, the series is stationary, and we can proceed with our analysis.



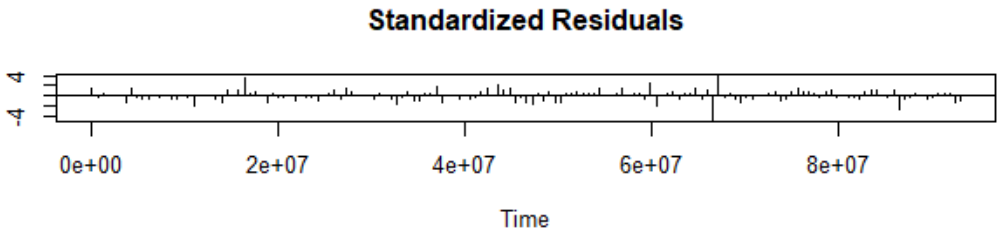
The ACF plot tells us the value of the order of the Moving average to use in the ARIMA model. The figure shows that no lag term except the 0th lag is significant; hence, it's an MA(0) order.

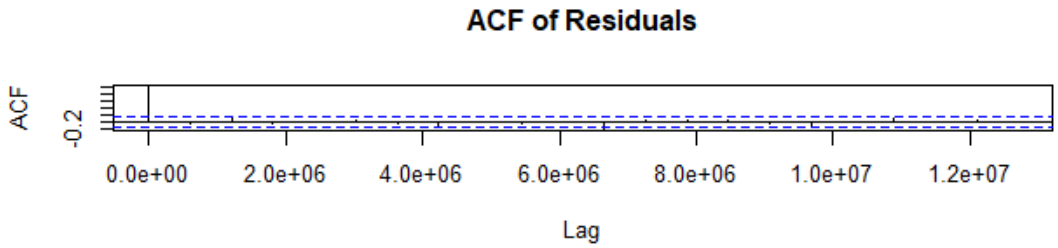


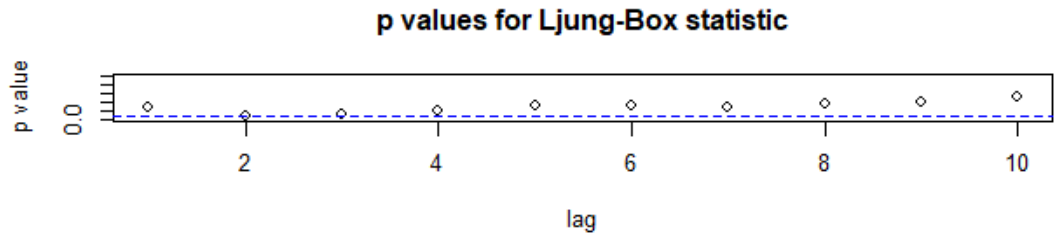
PACF plot tells us the value of the order of the Auto Regressive to use in the ARIMA model. From observing the lags in the figure, we can say that it's an AR(0) order.

```
Series: returns_TAJGVK$Returns
ARIMA(0,0,0) with zero mean

sigma^2 = 0.002407:  log likelihood = 247.34
AIC=-492.68   AICc=-492.65   BIC=-489.64
```

The best model, auto.arima() function of R can be used which turns to be ARIMA(0,0,0).







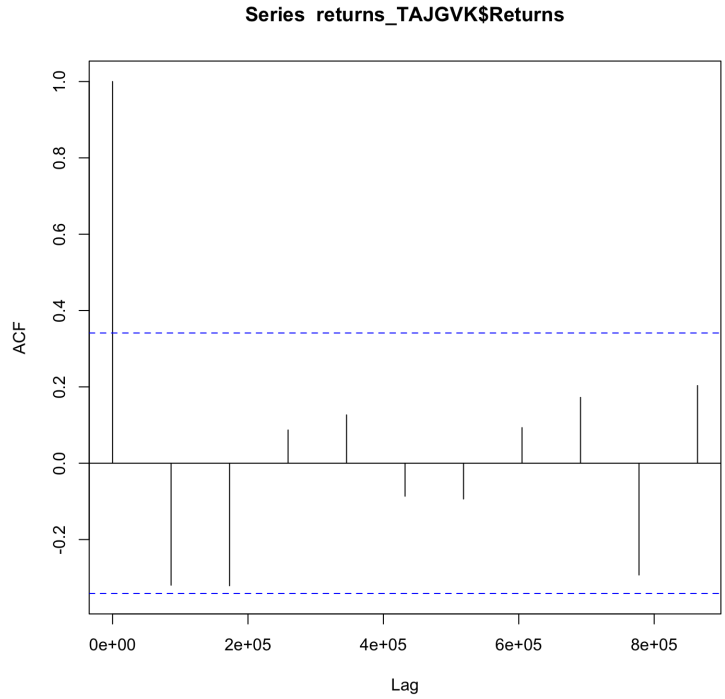

```
$pred
Time Series:
Start = c(93744001, 1)
End = c(99187201, 1)
Frequency = 1.65343915343915e-06
 [1] 0 0 0 0 0 0 0 0 0 0

$se
Time Series:
Start = c(93744001, 1)
End = c(99187201, 1)
Frequency = 1.65343915343915e-06
 [1] 0.04906147 0.04906147 0.04906147 0.04906147 0.04906147 0.04906147 0.04906147 0.04906147 0.04906147 0.04906147
```

Since all forecast returns are positive, it suggests that the stock price will increase in the coming days.

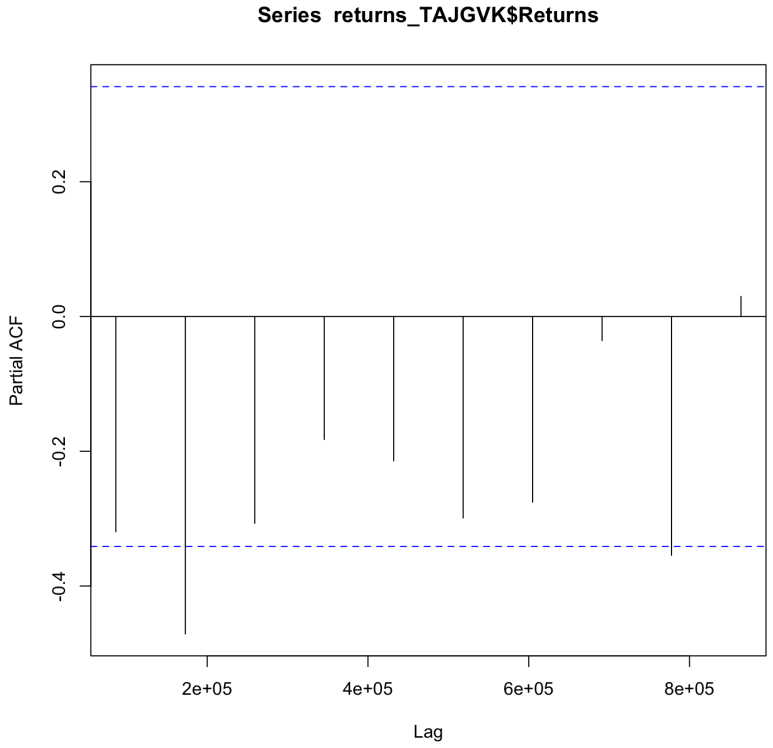
3.4.3 TAJGVK (Monthly)

```
        Augmented Dickey-Fuller Test

data:  returns_TAJGVK$Returns
Dickey-Fuller = -4.0357, Lag order = 3, p-value = 0.02004
alternative hypothesis: stationary
```

Series is stationary.



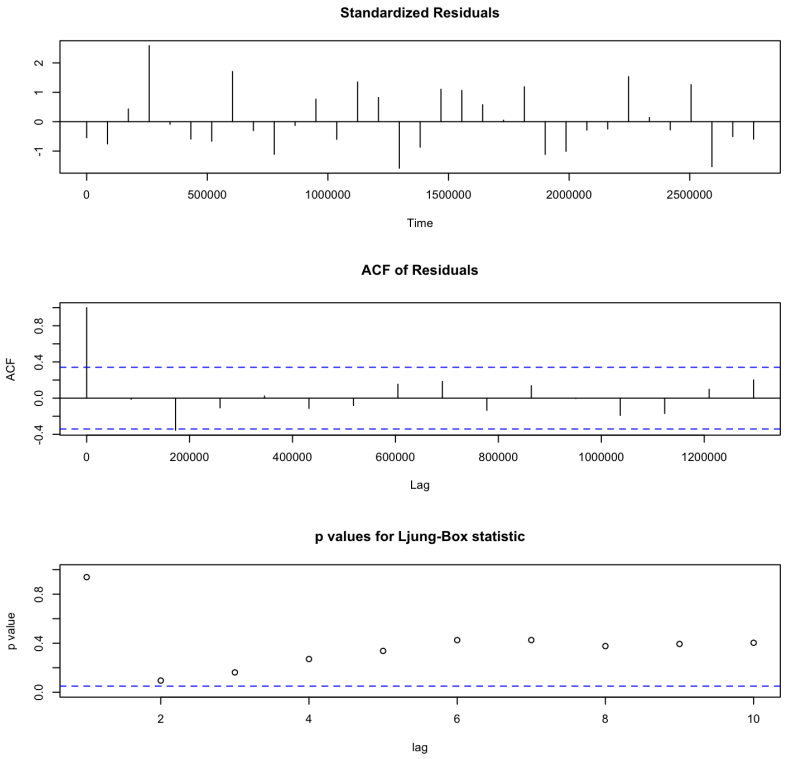
The ACF plot tells us the value of the order of the Moving average to use in the ARIMA model. The figure shows that no lag term except the 0th lag is significant; hence, it's an MA(0) order.



PACF plot tells us the value of the order of the Auto Regressive to use in the ARIMA model. From observing the lags in the figure, we can say that it's an AR(1) order.

```
Series: returns_TAJGVK$Returns
ARIMA(0,0,0) with zero mean

sigma^2 = 0.02168:  log likelihood = 16.39
AIC=-30.78   AICc=-30.65   BIC=-29.28
```

since AIC of arima_final<auto.arima we go with order (1,0,1).




```
Time Series:
Start = 2851201
End = 3628801
Frequency = 1.15740740740741e-05
 [1] 0.0615299722 0.0020853493 0.0005847734 0.0005468940 0.0005459378 0.0005459136
 [7] 0.0005459130 0.0005459130 0.0005459130 0.0005459130

$se
Time Series:
Start = 2851201
End = 3628801
Frequency = 1.15740740740741e-05
 [1] 0.1057488 0.1455548 0.1455767 0.1455767 0.1455767 0.1455767 0.1455767 0.1455767
 [9] 0.1455767 0.1455767
```

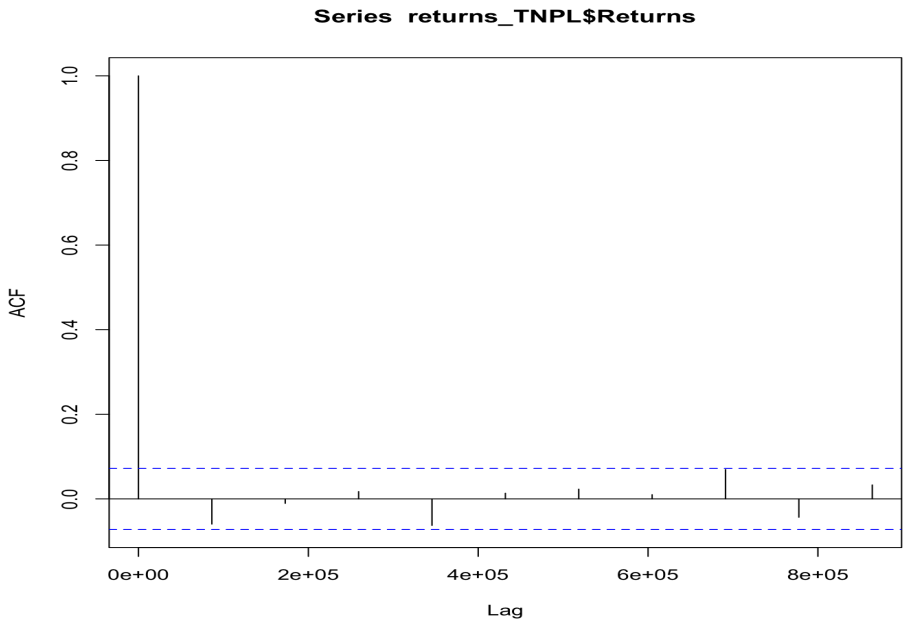
Since all forecast returns are positive, it suggests that the stock price will increase in the coming days.

3.5 Tamilnadu Newsprint & Papers Ltd

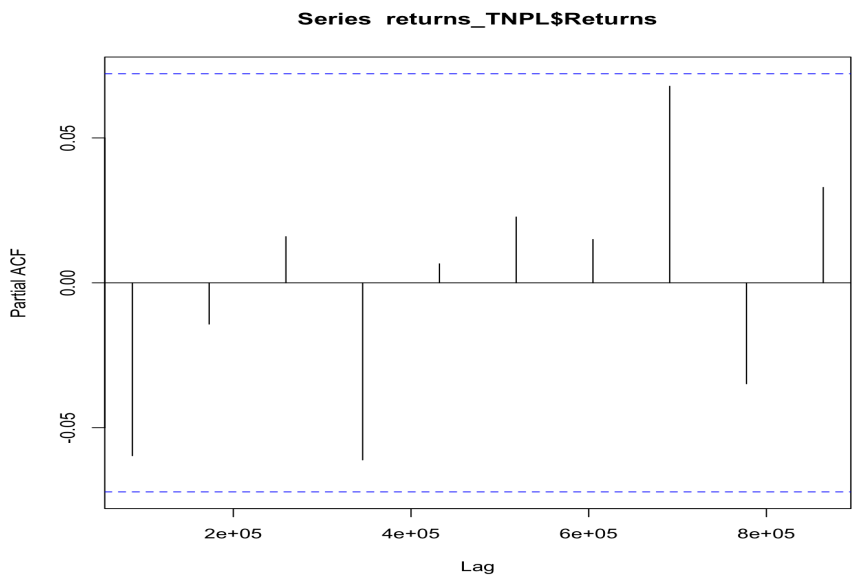
3.5.1 TNPL (Daily)

```
        Augmented Dickey-Fuller Test

data:  returns_TNPL$Returns
Dickey-Fuller = -7.9514, Lag order = 9, p-value = 0.01
alternative hypothesis: stationary
```

ADF Test suggests that series is stationary.



The ACF plot tells us the value of the order of the Moving average to use in the ARIMA model. The figure shows that no lag term except the 0th lag is significant; hence, it's an MA(0) order.

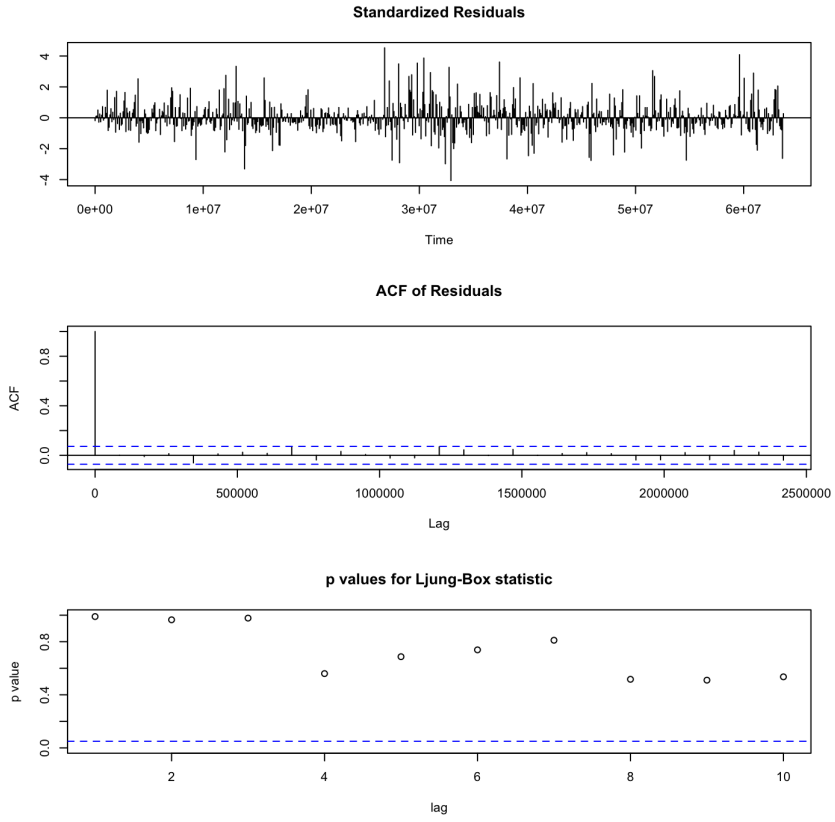


PACF plot tells us the value of the order of the Auto Regressive to use in the ARIMA model. From observing the lags in the figure, we can say that it's an AR(1) order.

```
Series: returns_TNPL$Returns
ARIMA(0,0,1) with non-zero mean

Coefficients:
          ma1    mean
      -0.061  0.0017
s.e.   0.037  0.0009

sigma^2 = 0.000654:  log likelihood = 1659.46
AIC=-3312.92   AICc=-3312.89   BIC=-3299.11
```

Since, AIC of arima_final> auto.arima we go with order c(0,0,1)

```
Call:
arima(x = returns_TNPL$Returns, order = c(0, 0, 1))

Coefficients:
         ma1  intercept
      -0.061     0.0017
s.e.   0.037     0.0009

sigma^2 estimated as 0.0006523:  log likelihood = 1659.46,  aic = -3312.92
```



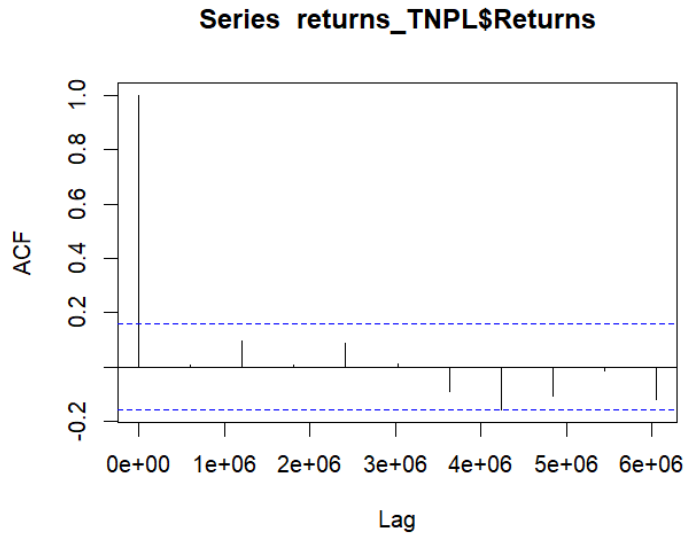
```
Time Series:
Start = 63763201
End = 64540801
Frequency = 1.15740740740741e-05
 [1] 0.001244720 0.001660189 0.001660189 0.001660189 0.001660189 0.001660189 0.001660189
 [8] 0.001660189 0.001660189 0.001660189

$se
Time Series:
Start = 63763201
End = 64540801
Frequency = 1.15740740740741e-05
 [1] 0.02557405 0.02562155 0.02562155 0.02562155 0.02562155 0.02562155 0.02562155 0.02562155
 [9] 0.02562155 0.02562155
```

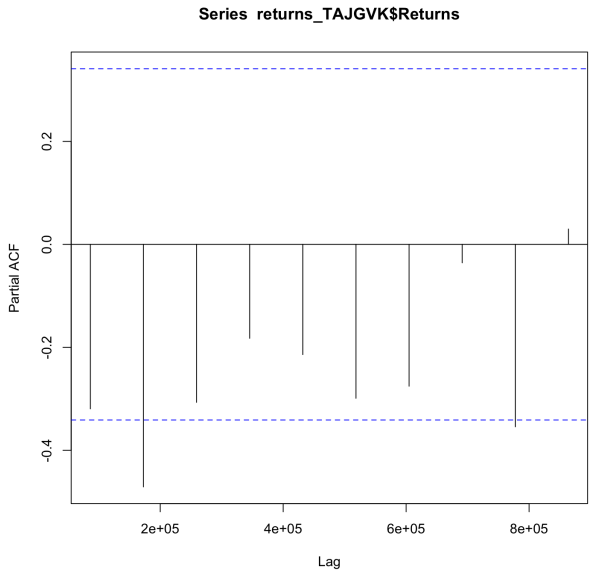
Since all forecast returns are positive, it suggests that the stock price will increase in the coming days.

3.5.2 TNPL (Weekly)

```
        Augmented Dickey-Fuller Test

data:  returns_TNPL$Returns
Dickey-Fuller = -4.9662, Lag order = 5, p-value = 0.01
alternative hypothesis: stationary
```

ADF Test suggests that series is stationary.

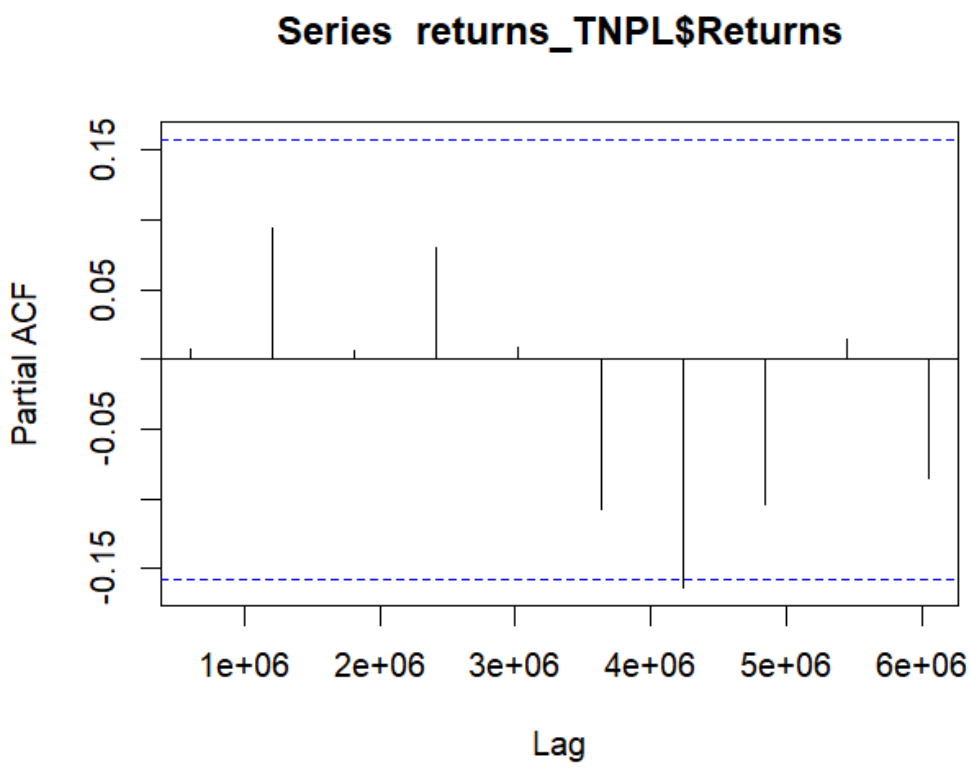




MA(1) ORDER AND AR(1) ORDER.

```
Series: returns_TAJGVK$Returns
ARIMA(0,0,0) with zero mean

sigma^2 = 0.02168:  log likelihood = 16.39
AIC=-30.78   AICc=-30.65   BIC=-29.28
```

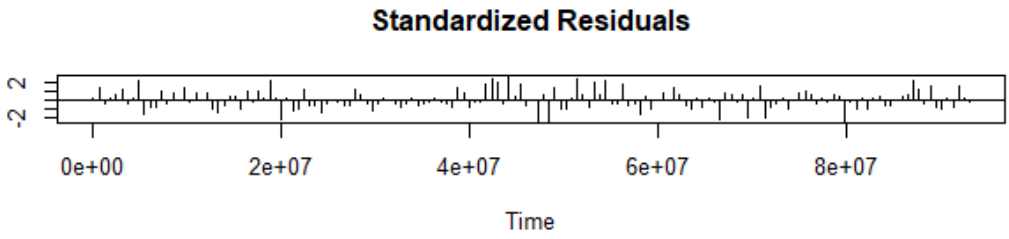
Auto ARIMA tells us ARIMA(0,0,0) The ACF plot tells us the value of the order of the Moving average to use in the ARIMA model. The figure shows that no lag term except the 0th lag is significant; hence, it's an MA(0) order.

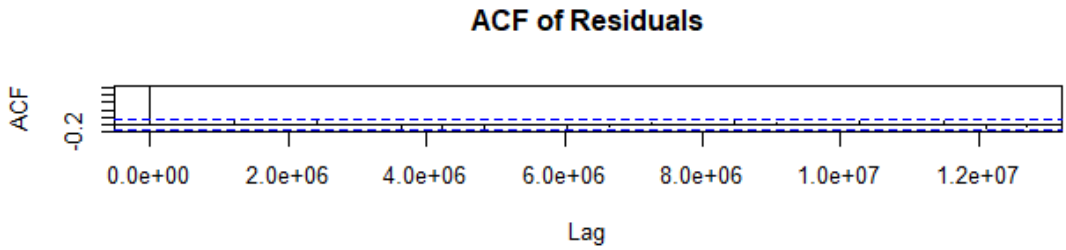


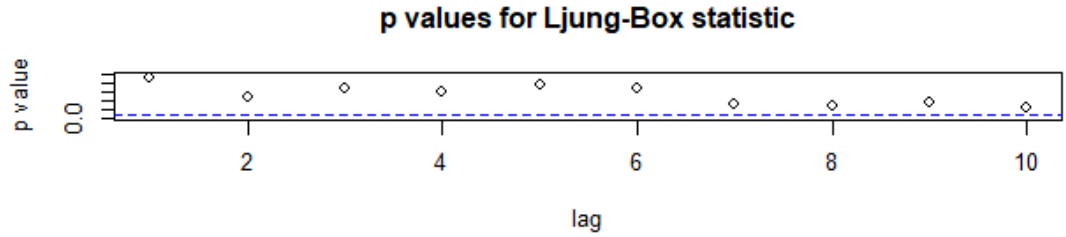
PACF plot tells us the value of the order of the Auto Regressive to use in the ARIMA model. From observing the lags in the figure, we can say that it's an AR(0) order.

```
Series: returns_TNPL$Returns
ARIMA(0,0,0) with non-zero mean

Coefficients:
        mean
      0.0078
s.e.  0.0041

sigma^2 = 0.002587:  log likelihood = 242.26
AIC=-480.52   AICc=-480.44   BIC=-474.43
```

The best model, auto.arima() function of R can be used which turns to be ARIMA(0,0,0).








```
$pred
Time Series:
Start = c(93744001, 1)
End = c(99187201, 1)
Frequency = 1.65343915343915e-06
 [1] 0.007827795 0.007827795 0.007827795 0.007827795 0.007827795 0.007827795 0.007827795 0.007827795 0.007827795
[10] 0.007827795

$se
Time Series:
Start = c(93744001, 1)
End = c(99187201, 1)
Frequency = 1.65343915343915e-06
 [1] 0.05069626 0.05069626 0.05069626 0.05069626 0.05069626 0.05069626 0.05069626 0.05069626 0.05069626
```

Since all forecast returns are positive, it suggests that the stock price will increase in the coming days.

3.5.3 TNPL (Monthly)

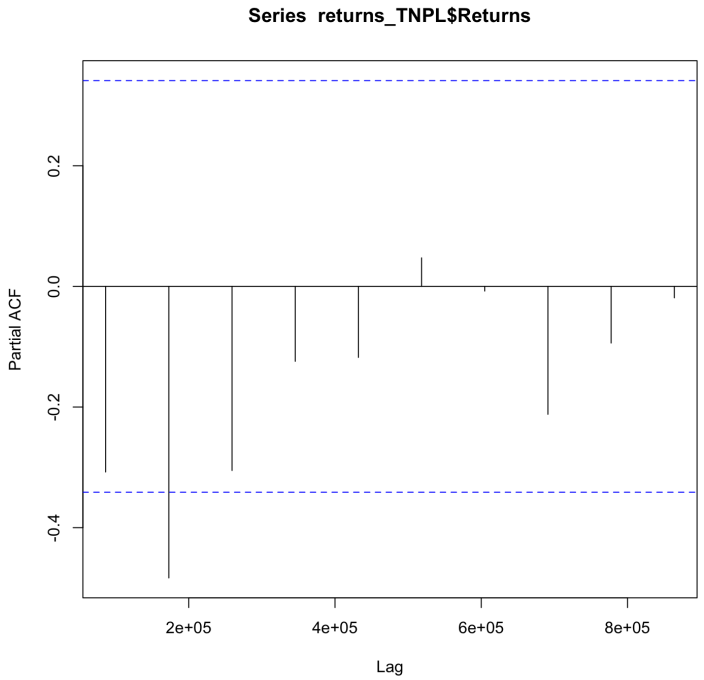
```
        Augmented Dickey-Fuller Test

data:  returns_TNPL$Returns
Dickey-Fuller = -2.1843, Lag order = 3, p-value = 0.5016
alternative hypothesis: stationary
```

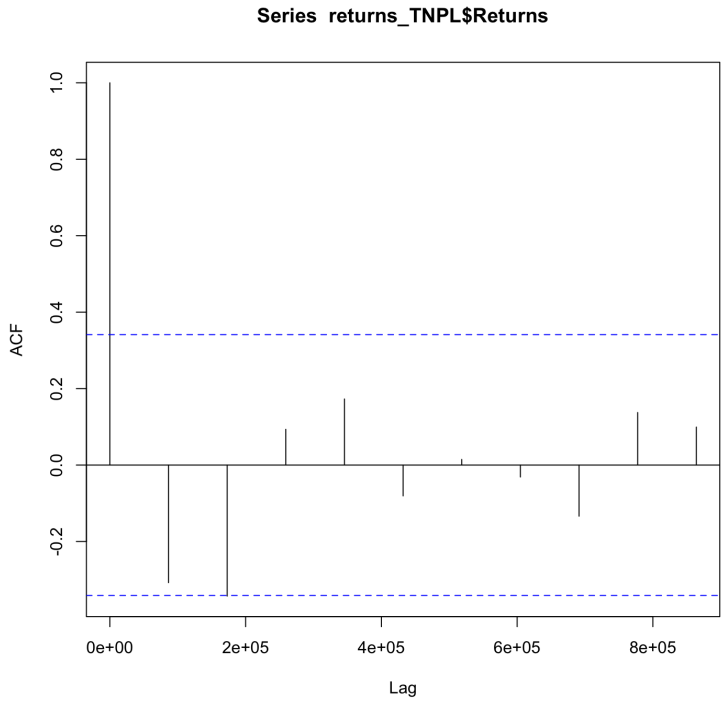
Since the series is not stationary, we use differencing.

```
returns_TNPL$Returns<- diff(returns_TNPL$Returns)
returns_TNPL<- na.omit(returns_TNPL)
adf.test(returns_TNPL$Returns , alternative = "stationary")
```

Post differencing, ADF test is passed as shown below.

```
        Augmented Dickey-Fuller Test

data:  returns_TNPL$Returns
Dickey-Fuller = -4.109, Lag order = 3, p-value = 0.0176
alternative hypothesis: stationary
```

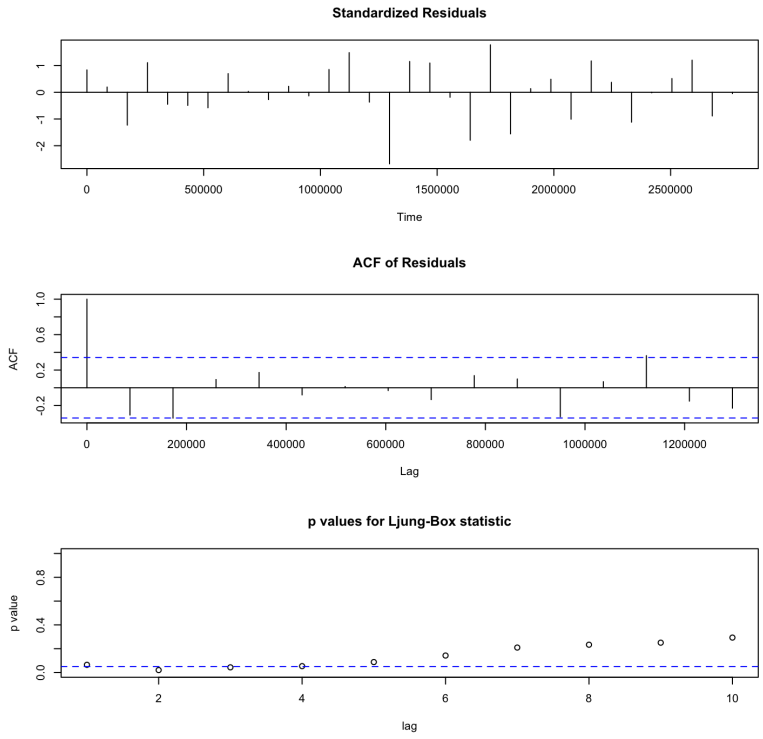




Above two graphs suggest, MA(1) ORDER AND AR(0) ORDER.

```
Series: returns_TNPL$Returns
ARIMA(0,0,0) with zero mean

sigma^2 = 0.02237:  log likelihood = 15.87
AIC=-29.75   AICc=-29.62   BIC=-28.25
>
```

Auto-ARIMA suggest ARIMA(0,0,0). Since AIC of arima_final>auto.arima we go with order c(0,0,1) and zero mean.



```
$pred
Time Series:
Start = 2851201
End = 3628801
Frequency = 1.15740740740741e-05
 [1] 0 0 0 0 0 0 0 0 0 0

$se
Time Series:
Start = 2851201
End = 3628801
Frequency = 1.15740740740741e-05
 [1] 0.1495716 0.1495716 0.1495716 0.1495716 0.1495716 0.1495716 0.1495716 0.1495716
 [9] 0.1495716 0.1495716
```

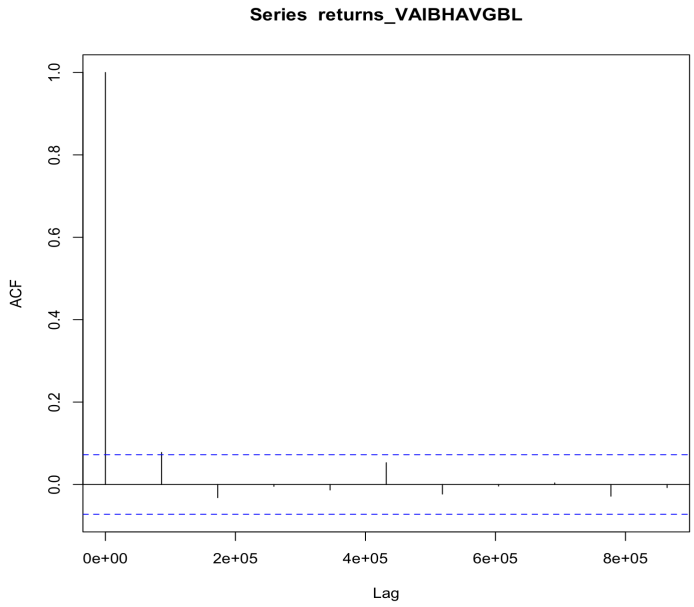
Since all forecast returns are positive, it suggests that the stock price will increase in the coming days.

3.6 Vaibhav Global Ltd

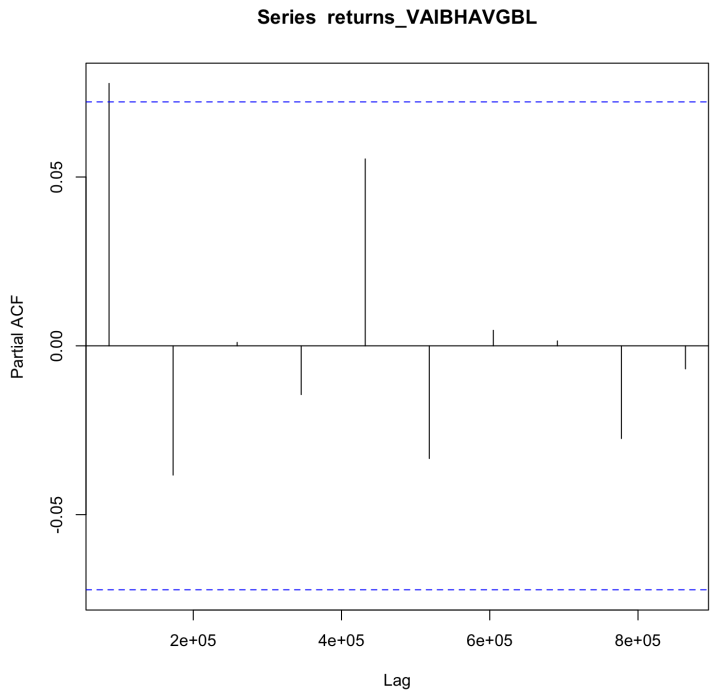
3.6.1 Vaibhav (Daily)

```
        Augmented Dickey-Fuller Test

data:  returns_no_missing_2
Dickey-Fuller = -8.6809, Lag order = 9, p-value = 0.01
alternative hypothesis: stationary
```

Series is stationary.



From observing the lags in the figure, we can say that it's an MA(1) order.



From observing the lags in the figure, we can say that it's an AR(0) order.

```
Series: returns_VAIBHAVGBL
ARIMA(0,0,1) with zero mean

Coefficients:
         ma1
      0.0837
s.e.  0.0379

sigma^2 = 0.0007429:  log likelihood = 1607.56
AIC=-3211.12   AICc=-3211.11   BIC=-3201.92
```

The best model, auto.arima() function of R can be used which turns to be ARIMA(0,0,1).

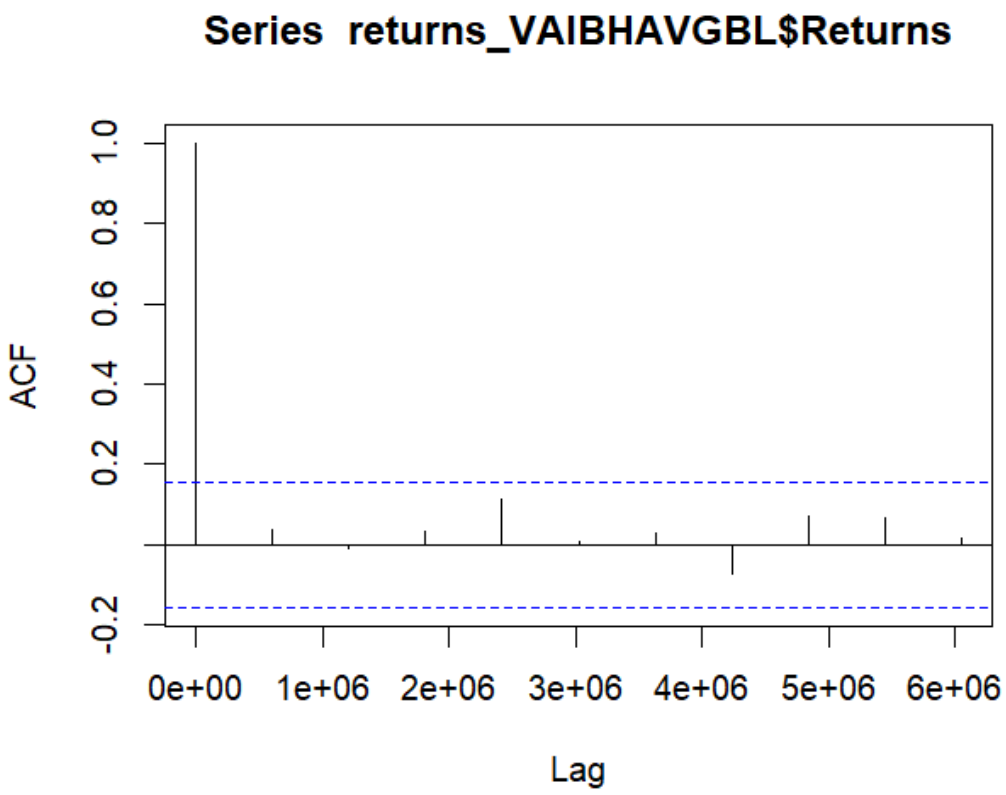
```
Time Series:
Start = 63590401
End = 64368001
Frequency = 1.15740740740741e-05
 [1] -0.0009448049  0.0000000000  0.0000000000  0.0000000000  0.0000000000  0.0000000000
 [7]  0.0000000000  0.0000000000  0.0000000000  0.0000000000

$se
Time Series:
Start = 63590401
End = 64368001
Frequency = 1.15740740740741e-05
 [1] 0.02725686 0.02735222 0.02735222 0.02735222 0.02735222 0.02735222 0.02735222 0.02735222
 [9] 0.02735222 0.02735222
```

Since all forecast returns are positive, it suggests that the stock price will increase in the coming days.

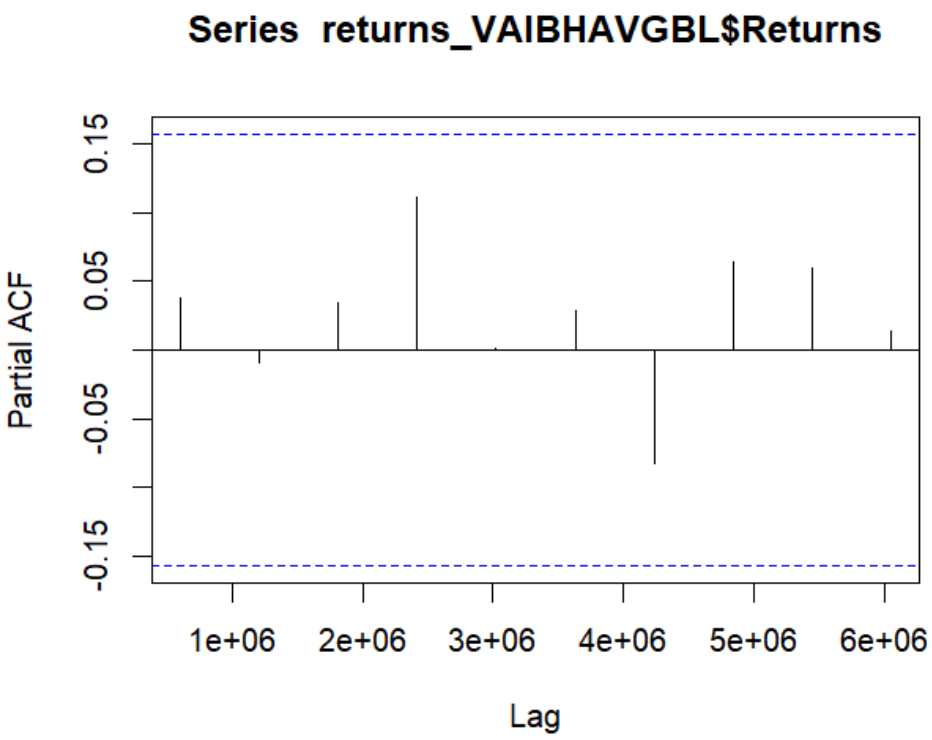
3.6.2 VAIBHAV ARIMA (Weekly)

```
        Augmented Dickey-Fuller Test

data:  returns_VAIBHAVGBL$Returns
Dickey-Fuller = -4.2301, Lag order = 5, p-value = 0.01
alternative hypothesis: stationary
```

ADF Test suggests that series is stationary.



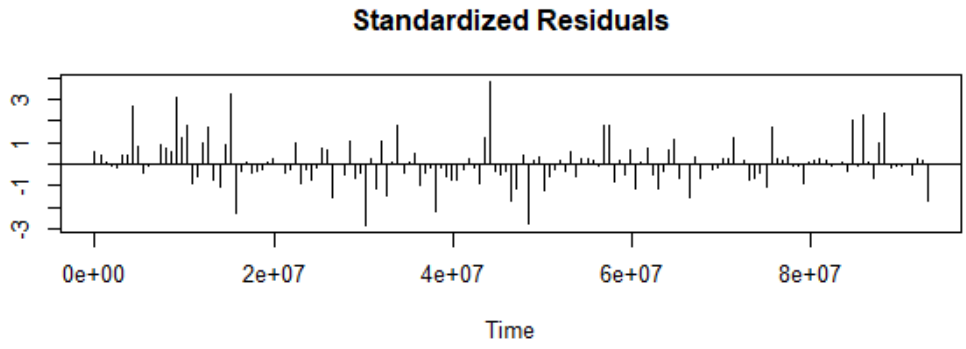
From observing the lags in the figure, we can say that it's an MA(0) order.

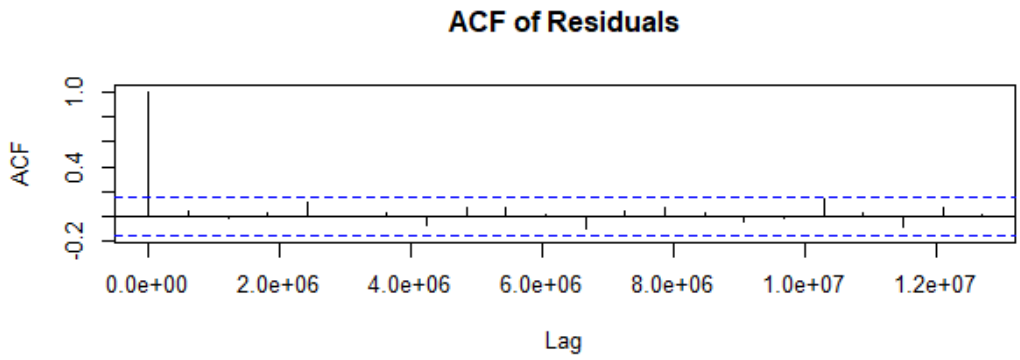


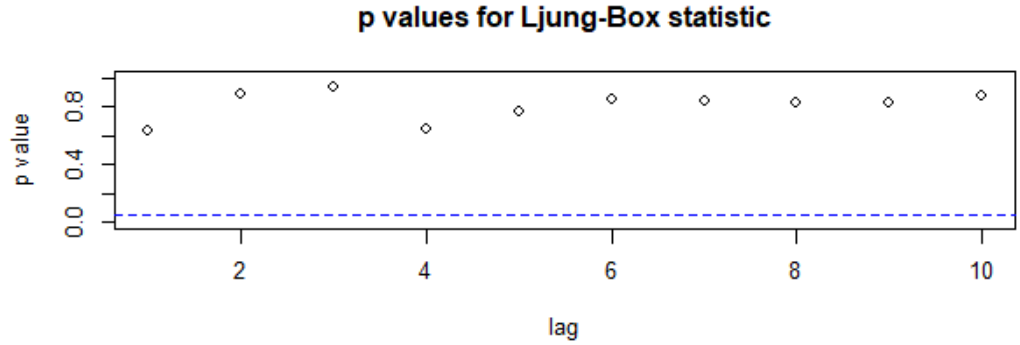
From observing the lags in the figure, we can say that it's an AR(0) order.

```
> auto.arima(returns_VAIBHAVGBL$Returns)
Series: returns_VAIBHAVGBL$Returns
ARIMA(0,0,0) with zero mean

sigma^2 = 0.003699:  log likelihood = 214.04
AIC=-426.09   AICc=-426.06   BIC=-423.04
>
```

Since order of arima_final same as auto.arima we go with order c(0,0,0)







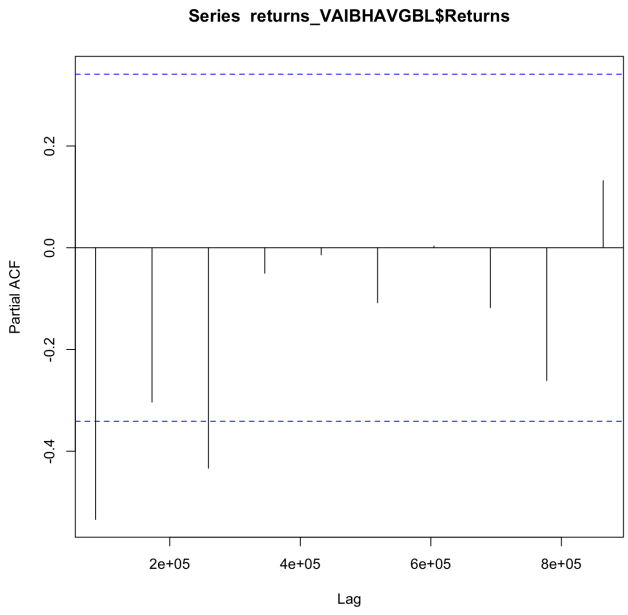

```
$pred
Time Series:
Start = c(93744001, 1)
End = c(99187201, 1)
Frequency = 1.65343915343915e-06
 [1] 0 0 0 0 0 0 0 0 0 0 0

$se
Time Series:
Start = c(93744001, 1)
End = c(99187201, 1)
Frequency = 1.65343915343915e-06
 [1] 0.06081853 0.06081853 0.06081853 0.06081853 0.06081853 0.06081853 0.06081853 0.06081853 0.06081853 0.06081853 0.06081853
```

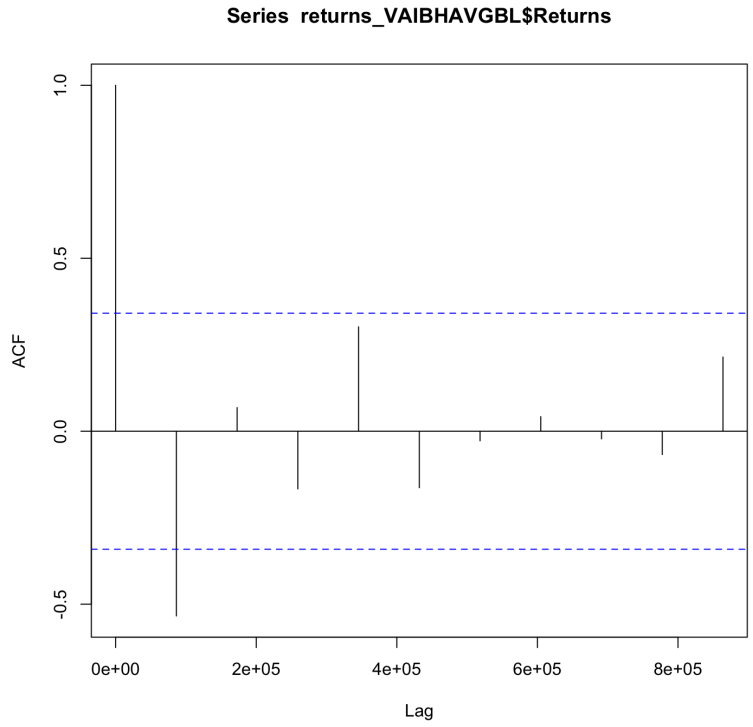
Since all forecast returns are positive, it suggests that the stock price will increase in the coming days.

3.5.3 VAIBHAV ARIMA (Monthly)

```
        Augmented Dickey-Fuller Test

data:  returns_VAIBHAVGBL$Returns
Dickey-Fuller = -3.0928, Lag order = 3, p-value = 0.1496
alternative hypothesis: stationary
```

The series is Stationary.

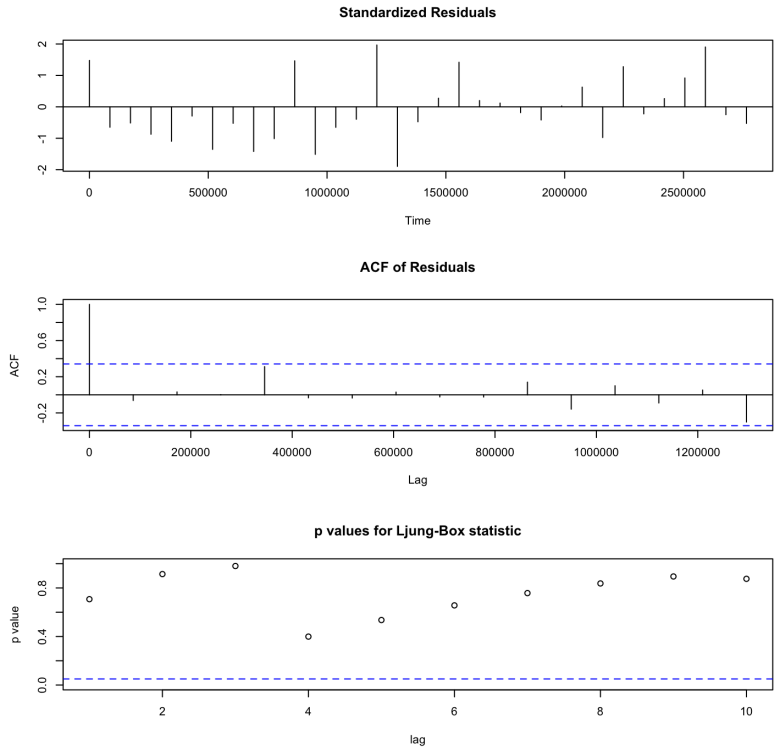




Above two graphs suggest, MA(1) ORDER AND AR(0) ORDER.

```
Series: returns_VAIBHAVGBL$Returns
ARIMA(0,0,1) with non-zero mean

Coefficients:
          ma1     mean
      -0.8889  -0.0006
s.e.   0.3327   0.0048

sigma^2 = 0.02284:  log likelihood = 15.78
AIC=-25.56   AICc=-24.74   BIC=-21.07
```

AutoARIMA suggests ARIMA(0,0,1). Since AIC of arima_final < auto.arima we go with order c(0,0,1).




```
Time Series:
Start = 2851201
End = 3628801
Frequency = 1.15740740740741e-05
 [1]  0.0679988696 -0.0005568217 -0.0005568217 -0.0005568217 -0.0005568217 -0.0005568217
 [7] -0.0005568217 -0.0005568217 -0.0005568217 -0.0005568217

$se
Time Series:
Start = 2851201
End = 3628801
Frequency = 1.15740740740741e-05
 [1] 0.1464919 0.1959923 0.1959923 0.1959923 0.1959923 0.1959923 0.1959923 0.1959923
 [9] 0.1959923 0.1959923
```

Since all forecast returns are positive, it suggests that the stock price will increase in the coming days.

Section 4: GARCH AND EGARCH MODEL

GARCH and EGARCH Model on Daily Returns

GARCH and EGARCH Model on Weekly Returns

GARCH and EGARCH Model on Monthly Returns

A statistical modelling method called GARCH is used to forecast the volatility of returns on financial assets. When an autoregressive moving average process is followed by serial autocorrelation in the error term's variance, GARCH analysis is suitable. An innovative process's conditional heteroscedasticity, also known as volatility clustering, is addressed by a dynamic model called the EGARCH model.

4.1 Rico Auto Industries Ltd

4.1.1Rico Auto Industries Ltd (Daily)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.001925    0.000969  1.9868e+00 0.046949
ar1     0.786873    0.226193  3.4788e+00 0.000504
ma1    -0.820187    0.209554 -3.9140e+00 0.000091
omega   0.000001    0.000000  1.3334e+01 0.000000
alpha1  0.000000    0.000182  2.9000e-05 0.999977
beta1   0.999000    0.000005  1.9105e+05 0.000000

Robust Standard Errors:
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.001925    0.000948  2.0309e+00 0.042265
ar1     0.786873    0.184154  4.2729e+00 0.000019
ma1    -0.820187    0.170767 -4.8030e+00 0.000002
omega   0.000001    0.000000  3.2037e+01 0.000000
alpha1  0.000000    0.000171  3.1000e-05 0.999975
beta1   0.999000    0.000046  2.1576e+04 0.000000

LogLikelihood : 1512.339
```

```
Information Criteria
-------------------------------------

Akaike       -4.0822
Bayes        -4.0448
Shibata      -4.0823
Hannan-Quinn -4.0678

Weighted Ljung-Box Test on Standardized Residuals
-------------------------------------
                        statistic p-value
Lag[1]                     0.1673  0.6826
Lag[2*(p+q)+(p+q)-1][5]    1.1566  0.9999
Lag[4*(p+q)+(p+q)-1][9]    5.9994  0.2566
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
-------------------------------------
                        statistic p-value
Lag[1]                      1.442 0.22981
Lag[2*(p+q)+(p+q)-1][5]     5.775 0.10159
Lag[4*(p+q)+(p+q)-1][9]     9.359 0.06852
d.o.f=2

Weighted ARCH LM Tests
-------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.4435 0.500 2.000  0.5055
ARCH Lag[5]    4.4892 1.440 1.667  0.1347
ARCH Lag[7]    6.3128 2.315 1.543  0.1216
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  134.7557
Individual Statistics:
mu     0.07928
ar1    0.07086
ma1    0.07997
omega  5.84455
alpha1 0.09757
beta1  0.09629

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value    prob sig
Sign Bias           0.8261 0.40899
Negative Sign Bias  1.6670 0.09595   *
Positive Sign Bias  0.2365 0.81311
Joint Effect        2.8780 0.41083


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     82.92    5.803e-10
2    30     97.61    2.352e-09
3    40    109.70    1.215e-08
4    50    133.27    1.002e-09


Elapsed time : 0.07217979
```

The model has a log-likelihood of 1512.339. For daily returns, GARCH (1,1) and corresponding ARFIMA (1,0,1) are optimal for RICO AUTO. All parameters, with the exception of alpha1, are deemed significant due to their p-values being less than 0.05. Alpha1 is deemed insignificant within the context of robust standard errors due to the fact that its p-values exceed 0.05. As a result, there is no evidence of serial autocorrelation, which is a favourable condition for the model. All p-values in the Adjusted Pearson goodness-of-fit portion are below 0.05, indicating that the null hypothesis can be rejected and that, in this case, the observed values and expected values are distinct.

Model Forecast GARCH:

```
*-----------------------------------*
*       GARCH Model Forecast        *
*-----------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-25]:
       Series  Sigma
T+1  0.003188 0.0318
T+2  0.002919 0.0318
T+3  0.002707 0.0318
T+4  0.002540 0.0318
T+5  0.002409 0.0318
T+6  0.002306 0.0318
T+7  0.002225 0.0318
T+8  0.002161 0.0318
T+9  0.002111 0.0318
T+10 0.002071 0.0318
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 3.18%.

Model Spec EGARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : eGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

The above result shows that EGARCH (1,1) is the resulting model, and the corresponding ARFIMA (1,0,1) is taken.

Model Fit EGARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
-----------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.001701    0.000878  1.93624 0.052838
ar1     0.773706    0.106224  7.28370 0.000000
ma1    -0.808593    0.095698 -8.44944 0.000000
omega  -2.112852    1.009606 -2.09275 0.036372
alpha1  0.006668    0.040041  0.16653 0.867736
beta1   0.694246    0.145559  4.76952 0.000002
gamma1  0.127980    0.058646  2.18226 0.029090

Robust Standard Errors:
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.001701    0.000842   2.01898 0.043490
ar1     0.773706    0.060782  12.72920 0.000000
ma1    -0.808593    0.056544 -14.30012 0.000000
omega  -2.112852    0.827216  -2.55417 0.010644
alpha1  0.006668    0.063769   0.10457 0.916719
beta1   0.694246    0.119589   5.80526 0.000000
gamma1  0.127980    0.088093   1.45278 0.146285

LogLikelihood : 1515.288

Information Criteria
-----------------------------------

Akaike       -4.0875
Bayes        -4.0438
Shibata      -4.0877
Hannan-Quinn -4.0707

Weighted Ljung-Box Test on Standardized Residuals
-----------------------------------
                        statistic p-value
Lag[1]                   0.002479  0.9603
Lag[2*(p+q)+(p+q)-1][5]  0.967197  1.0000
Lag[4*(p+q)+(p+q)-1][9]  6.025115  0.2524
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
-----------------------------------
                        statistic p-value
Lag[1]                   0.006403  0.9362
Lag[2*(p+q)+(p+q)-1][5]  1.376196  0.7703
Lag[4*(p+q)+(p+q)-1][9]  4.921695  0.4410
d.o.f=2

Weighted ARCH LM Tests
-----------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]   0.01218 0.500 2.000  0.9121
ARCH Lag[5]   3.77112 1.440 1.667  0.1958
ARCH Lag[7]   6.09244 2.315 1.543  0.1351
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  0.9878
Individual Statistics:
mu     0.08262
ar1    0.08325
ma1    0.09161
omega  0.16628
alpha1 0.03609
beta1  0.16918
gamma1 0.39791

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.69 1.9 2.35
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                    t-value   prob sig
Sign Bias           0.7674 0.4431
Negative Sign Bias  0.5511 0.5817
Positive Sign Bias  0.6025 0.5470
Joint Effect        0.7304 0.8660


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     73.71    2.202e-08
2    30    110.37    2.007e-11
3    40    111.86    5.847e-09
4    50    124.47    1.704e-08


Elapsed time : 0.1306069
```

The log-likelihood of the model is 1515.288. RICO AUTO optimizes daily returns using eGARCH (1,1) and the corresponding ARFIMA (1,0,1). With the exception of mu and alpha1, all other parameters are deemed significant as their p-values are below 0.05. Mu and Alpha1 are deemed insignificant in the context of robust standard errors as their corresponding p-values surpass the threshold of 0.05. Consequently, serial autocorrelation is not supported by evidence, which is a positive circumstance for the model. The adjusted Pearson goodness-of-fit portion contains p-values, all of which are less than 0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast EGARCH:

```
*-------------------------------------*
*       GARCH Model Forecast          *
*-------------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-25]:
       Series   Sigma
T+1  0.002995 0.03224
T+2  0.002702 0.03204
T+3  0.002476 0.03190
T+4  0.002300 0.03180
T+5  0.002165 0.03173
T+6  0.002060 0.03169
T+7  0.001978 0.03166
T+8  0.001916 0.03163
T+9  0.001867 0.03162
T+10 0.001829 0.03161
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 3.161%.

4.1.2 Rico Auto Industries Ltd (Weekly)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model      : sGARCH(1,1)
Mean Model       : ARFIMA(1,0,1)
Distribution     : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.008733    0.004801   1.819069 0.068901
ar1    -0.820426    0.173969  -4.715927 0.000002
ma1     0.768657    0.188051   4.087499 0.000044
omega   0.000009    0.000008   1.120063 0.262687
alpha1  0.000000    0.002500   0.000006 0.999995
beta1   0.999000    0.001405 710.982444 0.000000

Robust Standard Errors:
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.008733    0.004312   2.025069 0.042860
ar1    -0.820426    0.081856 -10.022765 0.000000
ma1     0.768657    0.079928   9.616903 0.000000
omega   0.000009    0.000004   2.416353 0.015677
alpha1  0.000000    0.000879   0.000016 0.999987
beta1   0.999000    0.000931 1073.449663 0.000000

LogLikelihood : 211.9253
```

```
Information Criteria
------------------------------------

Akaike       -2.6571
Bayes        -2.5393
Shibata      -2.6600
Hannan-Quinn -2.6092

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.05858  0.8088
Lag[2*(p+q)+(p+q)-1][5]   1.24032  0.9998
Lag[4*(p+q)+(p+q)-1][9]   3.12017  0.8716
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                      0.3343  0.5631
Lag[2*(p+q)+(p+q)-1][5]     3.8256  0.2766
Lag[4*(p+q)+(p+q)-1][9]     6.5802  0.2369
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]     3.020 0.500 2.000 0.08225
ARCH Lag[5]     5.398 1.440 1.667 0.08308
ARCH Lag[7]     5.643 2.315 1.543 0.16710
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  7.443
Individual Statistics:
mu     0.07395
ar1    0.13498
ma1    0.14466
omega  0.10968
alpha1 0.08863
beta1  0.10621

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                    t-value   prob sig
Sign Bias           1.2948 0.1974
Negative Sign Bias  1.3575 0.1767
Positive Sign Bias  0.1218 0.9032
Joint Effect        2.4444 0.4854


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     25.77       0.1366
2    30     34.48       0.2220
3    40     36.74       0.5733
4    50     58.87       0.1578


Elapsed time : 0.109503
```

211.9253 is the logarithm of the model's probability. ARFIMA (1,0,1) and GARCH (1,1) are the optimal daily return models in the case of RICO AUTO. Except for mu, omega, and alpha1, the p-values of all other parameters are less than 0.05, thus establishing their significance. When considering robust standard errors, the significance of ar1, ma1, and beta1 is compromised because their p-values exceed the threshold of 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying a discrepancy between the observed and expected values in this case.

Model Forecast GARCH:

```
> ugforecast_RICOAUTO = ugarchforecast(ugfit_RICOAUTO, n.ahead = 10)
> ugforecast_RICOAUTO

*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.017236 0.06733
T+2  0.001756 0.06736
T+3  0.014457 0.06739
T+4  0.004037 0.06742
T+5  0.012585 0.06746
T+6  0.005572 0.06749
T+7  0.011326 0.06752
T+8  0.006605 0.06755
T+9  0.010478 0.06758
T+10 0.007301 0.06761
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 6.761%.

Model Spec EGARCH:

```
*----------------------------------*
*        GARCH Model Spec          *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : eGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above result, it can be seen that EGARCH (1,1) is the resulting model, and the corresponding ARFIMA (1,0,1) is taken.

Model Fit EGARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error    t value Pr(>|t|)
mu      0.008453    0.004597    1.83904 0.065910
ar1    -0.813184    0.224122   -3.62831 0.000285
ma1     0.769942    0.237545    3.24125 0.001190
omega  -0.867637    0.033244  -26.09887 0.000000
alpha1  0.158973    0.068589    2.31774 0.020463
beta1   0.844997    0.007200  117.35447 0.000000
gamma1  0.043445    0.054483    0.79739 0.425224

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.008453    0.004980   1.6974 0.089612
ar1    -0.813184    0.116530  -6.9783 0.000000
ma1     0.769942    0.113814   6.7649 0.000000
omega  -0.867637    0.057800 -15.0110 0.000000
alpha1  0.158973    0.082489   1.9272 0.053954
beta1   0.844997    0.007555 111.8425 0.000000
gamma1  0.043445    0.043321   1.0029 0.315930

LogLikelihood : 214.0128
```

```
Information Criteria
------------------------------------

Akaike       -2.6711
Bayes        -2.5337
Shibata      -2.6750
Hannan-Quinn -2.6153

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.1967  0.6574
Lag[2*(p+q)+(p+q)-1][5]    1.2447  0.9998
Lag[4*(p+q)+(p+q)-1][9]    3.1881  0.8601
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.01602  0.8993
Lag[2*(p+q)+(p+q)-1][5]   1.56055  0.7250
Lag[4*(p+q)+(p+q)-1][9]   3.09874  0.7426
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.3637 0.500 2.000  0.5465
ARCH Lag[5]    1.6438 1.440 1.667  0.5553
ARCH Lag[7]    1.8018 2.315 1.543  0.7592
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  1.0966
Individual Statistics:
mu     0.1378
ar1    0.1439
ma1    0.1511
omega  0.2689
alpha1 0.1274
beta1  0.2677
gamma1 0.2539

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.69 1.9 2.35
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                    t-value   prob sig
Sign Bias           0.7592 0.4489
Negative Sign Bias  1.2507 0.2130
Positive Sign Bias  0.1778 0.8591
Joint Effect        1.5967 0.6601


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     14.42       0.7587
2    30     29.45       0.4417
3    40     46.03       0.2040
4    50     56.29       0.2208


Elapsed time : 0.1818819
```

The log-likelihood of the model is 214.1028. RICO AUTO optimizes weekly returns using eGARCH (1,1) and the corresponding ARFIMA (1,0,1). With the exception of mu and alpha1, all other parameters are deemed significant as their p-values are below 0.05. Mu and Alpha1 are deemed insignificant in the context of robust standard errors as their corresponding p-values surpass the threshold of 0.05. Consequently, serial autocorrelation is not supported by evidence, which is a positive circumstance for the model. The adjusted Pearson goodness-of-fit portion contains p-values, all of which are less than 0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast EGARCH:

```
> egforecast_RICOAUTO = ugarchforecast(egfit_I
> egforecast_RICOAUTO

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.015574 0.05771
T+2  0.002663 0.05819
T+3  0.013162 0.05860
T+4  0.004624 0.05895
T+5  0.011567 0.05925
T+6  0.005921 0.05950
T+7  0.010512 0.05971
T+8  0.006779 0.05989
T+9  0.009815 0.06004
T+10 0.007346 0.06017
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 6.017%

4.1.3 Rico Auto Industries Ltd (Monthly)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model      : sGARCH(1,1)
Mean Model       : ARFIMA(1,0,1)
Distribution     : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error    t value Pr(>|t|)
mu      0.008733    0.004801   1.819069 0.068901
ar1    -0.820426    0.173969  -4.715927 0.000002
ma1     0.768657    0.188051   4.087499 0.000044
omega   0.000009    0.000008   1.120063 0.262687
alpha1  0.000000    0.002500   0.000006 0.999995
beta1   0.999000    0.001405 710.982444 0.000000

Robust Standard Errors:
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.008733    0.004312    2.025069 0.042860
ar1    -0.820426    0.081856  -10.022765 0.000000
ma1     0.768657    0.079928    9.616903 0.000000
omega   0.000009    0.000004    2.416353 0.015677
alpha1  0.000000    0.000879    0.000016 0.999987
beta1   0.999000    0.000931 1073.449663 0.000000

LogLikelihood : 211.9253
```

```
Information Criteria
------------------------------------

Akaike       -2.6571
Bayes        -2.5393
Shibata      -2.6600
Hannan-Quinn -2.6092

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.05858  0.8088
Lag[2*(p+q)+(p+q)-1][5]   1.24032  0.9998
Lag[4*(p+q)+(p+q)-1][9]   3.12017  0.8716
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.3343  0.5631
Lag[2*(p+q)+(p+q)-1][5]    3.8256  0.2766
Lag[4*(p+q)+(p+q)-1][9]    6.5802  0.2369
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]     3.020 0.500 2.000 0.08225
ARCH Lag[5]     5.398 1.440 1.667 0.08308
ARCH Lag[7]     5.643 2.315 1.543 0.16710
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  7.443
Individual Statistics:
mu     0.07395
ar1    0.13498
ma1    0.14466
omega  0.10968
alpha1 0.08863
beta1  0.10621

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias          1.2948 0.1974
Negative Sign Bias 1.3575 0.1767
Positive Sign Bias 0.1218 0.9032
Joint Effect       2.4444 0.4854


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     25.77       0.1366
2    30     34.48       0.2220
3    40     36.74       0.5733
4    50     58.87       0.1578


Elapsed time : 0.109503
```

211.9253 is the logarithm of the model's probability. ARFIMA (1,0,1) and GARCH (1,1) are the optimal daily return models in the case of RICO AUTO. Except for mu, omega, and alpha1, the p-values of all other parameters are less than 0.05, thus establishing their significance. When considering robust standard errors, the significance of ar1, ma1, and beta1 is compromised because their p-values exceed the threshold of 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
> ugforecast_RICOAUTO = ugarchforecast(ugfit_RICOAUTO, n.ahead = 10)
> ugforecast_RICOAUTO

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.017236 0.06733
T+2  0.001756 0.06736
T+3  0.014457 0.06739
T+4  0.004037 0.06742
T+5  0.012585 0.06746
T+6  0.005572 0.06749
T+7  0.011326 0.06752
T+8  0.006605 0.06755
T+9  0.010478 0.06758
T+10 0.007301 0.06761
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 6.761%.

Model Spec EGARCH:

```
*----------------------------------*
*        GARCH Model Spec          *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : eGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above result, it can be seen that EGARCH (1,1) is the resulting model, and the corresponding ARFIMA (1,0,1) is taken.

Model Fit EGARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model      : eGARCH(1,1)
Mean Model       : ARFIMA(1,0,1)
Distribution     : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.008453    0.004597   1.83904 0.065910
ar1    -0.813184    0.224122  -3.62831 0.000285
ma1     0.769942    0.237545   3.24125 0.001190
omega  -0.867637    0.033244 -26.09887 0.000000
alpha1  0.158973    0.068589   2.31774 0.020463
beta1   0.844997    0.007200 117.35447 0.000000
gamma1  0.043445    0.054483   0.79739 0.425224

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.008453    0.004980   1.6974 0.089612
ar1    -0.813184    0.116530  -6.9783 0.000000
ma1     0.769942    0.113814   6.7649 0.000000
omega  -0.867637    0.057800 -15.0110 0.000000
alpha1  0.158973    0.082489   1.9272 0.053954
beta1   0.844997    0.007555 111.8425 0.000000
gamma1  0.043445    0.043321   1.0029 0.315930

LogLikelihood : 214.0128

Information Criteria
------------------------------------

Akaike       -2.6711
Bayes        -2.5337
Shibata      -2.6750
Hannan-Quinn -2.6153

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.1967  0.6574
Lag[2*(p+q)+(p+q)-1][5]    1.2447  0.9998
Lag[4*(p+q)+(p+q)-1][9]    3.1881  0.8601
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.01602  0.8993
Lag[2*(p+q)+(p+q)-1][5]   1.56055  0.7250
Lag[4*(p+q)+(p+q)-1][9]   3.09874  0.7426
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.3637 0.500 2.000  0.5465
ARCH Lag[5]    1.6438 1.440 1.667  0.5553
ARCH Lag[7]    1.8018 2.315 1.543  0.7592
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  1.0966
Individual Statistics:
mu     0.1378
ar1    0.1439
ma1    0.1511
omega  0.2689
alpha1 0.1274
beta1  0.2677
gamma1 0.2539

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.69 1.9 2.35
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           0.7592 0.4489
Negative Sign Bias  1.2507 0.2130
Positive Sign Bias  0.1778 0.8591
Joint Effect        1.5967 0.6601


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     14.42       0.7587
2    30     29.45       0.4417
3    40     46.03       0.2040
4    50     56.29       0.2208


Elapsed time : 0.1818819
```

The log-likelihood of the model is 214.1028. RICO AUTO optimizes weekly returns using eGARCH (1,1) and the corresponding ARFIMA (1,0,1). With the exception of mu and alpha1, all other parameters are deemed significant as their p-values are below 0.05. Mu and Alpha1 are deemed insignificant in the context of robust standard errors as their corresponding p-values surpass the threshold of 0.05. Consequently, serial autocorrelation is not supported by evidence, which is a positive circumstance for the model. The adjusted Pearson goodness-of-fit portion contains p-values, all of which are less than 0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast EGARCH:

```
> egforecast_RICOAUTO = ugarchforecast(egfit_I
> egforecast_RICOAUTO

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.015574 0.05771
T+2  0.002663 0.05819
T+3  0.013162 0.05860
T+4  0.004624 0.05895
T+5  0.011567 0.05925
T+6  0.005921 0.05950
T+7  0.010512 0.05971
T+8  0.006779 0.05989
T+9  0.009815 0.06004
T+10 0.007346 0.06017
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 6.017%

4.2 Selan Exploration Technology Ltd.

4.2.1SELAN (Daily)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
> ugfit_SELAN = ugarchfit(spec= ug_spec , data = r_SELAN)
> ugfit_SELAN

*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error    t value Pr(>|t|)
mu      0.002490    0.001243    2.00297  0.04518
ar1    -0.131430    0.343290   -0.38286  0.70183
ma1     0.202952    0.334928    0.60596  0.54454
omega   0.000004    0.000000  358.87382  0.00000
alpha1  0.000017    0.000532    0.03114  0.97516
beta1   0.996235    0.000342 2916.09642  0.00000

Robust Standard Errors:
        Estimate  Std. Error    t value Pr(>|t|)
mu      0.002490    0.001057    2.35453 0.018546
ar1    -0.131430    0.237085   -0.55436 0.579332
ma1     0.202952    0.225590    0.89965 0.368305
omega   0.000004    0.000000  178.36092 0.000000
alpha1  0.000017    0.000975    0.01700 0.986437
beta1   0.996235    0.000590 1687.41169 0.000000

LogLikelihood : 1497.92

Information Criteria
------------------------------------

Akaike       -4.0431
Bayes        -4.0057
Shibata      -4.0433
Hannan-Quinn -4.0287

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                  0.0001362  0.9907
Lag[2*(p+q)+(p+q)-1][5] 3.2730154  0.3124
Lag[4*(p+q)+(p+q)-1][9] 7.2917624  0.1024
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.8209  0.3649
Lag[2*(p+q)+(p+q)-1][5]    3.7391  0.2884
Lag[4*(p+q)+(p+q)-1][9]    4.6997  0.4748
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]   0.03166 0.500 2.000  0.8588
ARCH Lag[5]   0.65588 1.440 1.667  0.8369
ARCH Lag[7]   1.14614 2.315 1.543  0.8887
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  23.3216
Individual Statistics:
mu      0.0323
ar1     0.1245
ma1     0.1017
omega   2.6414
alpha1 0.1878
beta1   0.2058

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:          1.49 1.68 2.12
Individual Statistic:     0.35 0.47 0.75

Sign Bias Test
------------------------------------
                    t-value   prob sig
Sign Bias           0.8576 0.3914
Negative Sign Bias  0.8493 0.3960
Positive Sign Bias  0.7838 0.4334
Joint Effect        2.4161 0.4906


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     105.1    6.208e-14
2    30     121.6    2.641e-13
3    40     125.2    5.695e-11
4    50     142.6    4.447e-11


Elapsed time : 0.04777002
```

1497.92 is the logarithm of the model's probability. The ARFIMA (1,0,1) and GARCH (1,1) are the optimal daily return models in the context of SELAN. Aside from ar1, ma1, and alpha1, the p-values of all other parameters are less than 0.05, thus classifying them as significant. When considering robust standard errors, the significance of mu, omega,

and beta1 is compromised when their p-values exceed the threshold of 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
> ugforecast_SELAN = ugarchforecast(ugfit_SELAN, n.ahead = 10)
> ugforecast_SELAN

*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-25]:
       Series   Sigma
T+1  0.004811 0.03206
T+2  0.002185 0.03206
T+3  0.002530 0.03206
T+4  0.002484 0.03206
T+5  0.002490 0.03206
T+6  0.002490 0.03206
T+7  0.002490 0.03206
T+8  0.002490 0.03206
T+9  0.002490 0.03206
T+10 0.002490 0.03206
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 3.206%.

Model Spec EGARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : eGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above result, it can be seen that EGARCH (1,1) is the resulting model, and the corresponding ARFIMA (1,0,1) is taken.

Model Fit EGARCH:

```
> egfit_SELAN = ugarchfit(spec= eg_spec , data = r_SELAN)
> egfit_SELAN

*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.002002    0.001277  1.56740 0.117022
ar1     0.036011    0.263767  0.13653 0.891406
ma1     0.064503    0.260511  0.24760 0.804442
omega  -4.059720    0.951141 -4.26826 0.000020
alpha1  0.095556    0.053861  1.77414 0.076040
beta1   0.409508    0.137375  2.98094 0.002874
gamma1  0.229584    0.073659  3.11685 0.001828

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.002002    0.001118  1.79003 0.073449
ar1     0.036011    0.236265  0.15242 0.878858
ma1     0.064503    0.224730  0.28702 0.774093
omega  -4.059720    1.377417 -2.94734 0.003205
alpha1  0.095556    0.097900  0.97606 0.329034
beta1   0.409508    0.198366  2.06441 0.038979
gamma1  0.229584    0.134985  1.70082 0.088977

LogLikelihood : 1505.762

Information Criteria
------------------------------------

Akaike       -4.0617
Bayes        -4.0180
Shibata      -4.0619
Hannan-Quinn -4.0448

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.01269 0.91031
Lag[2*(p+q)+(p+q)-1][5]   3.45133 0.22657
Lag[4*(p+q)+(p+q)-1][9]   7.46577 0.08934
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.01903  0.8903
Lag[2*(p+q)+(p+q)-1][5]   0.46808  0.9625
Lag[4*(p+q)+(p+q)-1][9]   1.49195  0.9562
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]   0.07596 0.500 2.000  0.7829
ARCH Lag[5]   0.72994 1.440 1.667  0.8144
ARCH Lag[7]   1.65823 2.315 1.543  0.7891

Nyblom stability test
------------------------------------
Joint Statistic:  0.866
Individual Statistics:
mu     0.1379
ar1    0.1454
ma1    0.1040
omega  0.1131
alpha1 0.1323
beta1  0.1127
gamma1 0.1017

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:          1.69 1.9 2.35
Individual Statistic:     0.35 0.47 0.75

Sign Bias Test
------------------------------------
                    t-value   prob sig
Sign Bias           1.3209 0.1869
Negative Sign Bias  0.5832 0.5599
Positive Sign Bias  0.8146 0.4155
Joint Effect        1.8242 0.6097


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     101.4    2.980e-13
2    30     115.0    3.405e-12
3    40     141.1    1.733e-13
4    50     133.7    8.767e-10


Elapsed time : 0.0875051
```

The model's log-likelihood is calculated to be 1505.762. For SELAN weekly returns, GARCH (1,1) and its corresponding ARFIMA (1,0,1) are optimal. Each of the Optimal Parameters is deemed significant if its corresponding p-value is less than 0.05. Each robust standard error is deemed statistically significant if its corresponding p-value is less

than 0.05. As a result, there is no evidence of serial autocorrelation, which is a favorable condition for the model. All the p-values in the Adjusted Pearson goodness-of-fit section are extremely high, indicating that the null hypothesis cannot be rejected and that the difference between the observed and expected values is not significant.

Model Forecast EGARCH:

```
> egforecast_SELAN = ugarchforecast(egfit_SELAN, n.ahead = 10)
> egforecast_SELAN

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-25]:
       Series   Sigma
T+1  0.004707 0.03364
T+2  0.002099 0.03275
T+3  0.002006 0.03239
T+4  0.002002 0.03224
T+5  0.002002 0.03218
T+6  0.002002 0.03216
T+7  0.002002 0.03215
T+8  0.002002 0.03215
T+9  0.002002 0.03214
T+10 0.002002 0.03214
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 3.214%.

4.2.2 SELAN (Weekly)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model      : sGARCH(1,1)
Mean Model       : ARFIMA(1,0,1)
Distribution     : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.011232    0.004377  2.56621 0.010282
ar1    -0.452248    0.363883 -1.24284 0.213928
ma1     0.302591    0.387895  0.78009 0.435341
omega   0.000067    0.000088  0.76492 0.444318
alpha1  0.000000    0.040078  0.00000 1.000000
beta1   0.985851    0.063593 15.50262 0.000000

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.011232    0.007669  1.46459 0.143033
ar1    -0.452248    0.246104 -1.83762 0.066118
ma1     0.302591    0.255665  1.18354 0.236594
omega   0.000067    0.000426  0.15839 0.874152
alpha1  0.000000    0.120866  0.00000 1.000000
beta1   0.985851    0.205917  4.78763 0.000002

LogLikelihood : 200.917
```

```
Information Criteria
------------------------------------

Akaike       -2.5151
Bayes        -2.3972
Shibata      -2.5179
Hannan-Quinn -2.4672

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                   0.001379  0.9704
Lag[2*(p+q)+(p+q)-1][5]  0.917113  1.0000
Lag[4*(p+q)+(p+q)-1][9]  5.280618  0.3920
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                      1.555  0.2124
Lag[2*(p+q)+(p+q)-1][5]     1.965  0.6267
Lag[4*(p+q)+(p+q)-1][9]     2.675  0.8111
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]   0.06529 0.500 2.000  0.7983
ARCH Lag[5]   0.71890 1.440 1.667  0.8177
ARCH Lag[7]   1.16300 2.315 1.543  0.8857
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  3.9469
Individual Statistics:
mu     0.04349
ar1    0.07915
ma1    0.10681
omega  0.09578
alpha1 0.07448
beta1  0.09667

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           0.7973 0.4265
Negative Sign Bias  1.0785 0.2825
Positive Sign Bias  1.0446 0.2979
Joint Effect        3.4020 0.3337


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     23.97       0.19739
2    30     41.06       0.06798
3    40     41.90       0.34604
4    50     46.61       0.57043


Elapsed time : 0.141793
```

The model has a log-likelihood of 200.917. ARFIMA (1,0,1) and GARCH (1,1) are the optimal daily return models in the case of SELAN. All parameters, apart from ar1, ma1, and omega, are considered significant due to the fact that their p-values are all less than 0.05. The robustness of standard errors compromises the significance of mu, alpha1, and beta1 when their p-values exceed the threshold of 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that

the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
> ugforecast_SELAN = ugarchforecast(ugfit_SELAN, n.ahead = 10)
> ugforecast_SELAN

*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.015029 0.06876
T+2  0.009514 0.06877
T+3  0.012008 0.06877
T+4  0.010880 0.06878
T+5  0.011390 0.06878
T+6  0.011160 0.06878
T+7  0.011264 0.06879
T+8  0.011217 0.06879
T+9  0.011238 0.06880
T+10 0.011229 0.06880
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 6.880%.

Model Spec EGARCH:

```
*---------------------------------*
*       GARCH Model Spec          *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : eGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above result, it can be seen that EGARCH (1,1) is the resulting model, and the corresponding ARFIMA (1,0,1) is taken.

Model Fit EGARCH

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.010251    0.000003   3927.4        0
ar1     0.081087    0.000015   5422.4        0
ma1    -0.197175    0.000096  -2056.1        0
omega  -0.257785    0.000063  -4088.4        0
alpha1 -0.163451    0.000076  -2155.2        0
beta1   0.957849    0.000134   7173.8        0
gamma1 -0.262367    0.000212  -1237.8        0

Robust Standard Errors:
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.010251    0.000034   301.952        0
ar1     0.081087    0.000053  1544.070        0
ma1    -0.197175    0.000391  -504.756        0
omega  -0.257785    0.000257 -1003.949        0
alpha1 -0.163451    0.000085 -1923.669        0
beta1   0.957849    0.002555   374.862        0
gamma1 -0.262367    0.003237   -81.041        0

LogLikelihood : 212.53
```

```
Information Criteria
------------------------------------

Akaike       -2.6520
Bayes        -2.5146
Shibata      -2.6558
Hannan-Quinn -2.5962

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.04174  0.8381
Lag[2*(p+q)+(p+q)-1][5]   0.39875  1.0000
Lag[4*(p+q)+(p+q)-1][9]   3.36805  0.8273
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.02221  0.8815
Lag[2*(p+q)+(p+q)-1][5]   1.60852  0.7132
Lag[4*(p+q)+(p+q)-1][9]   2.97384  0.7633
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]   0.05418 0.500 2.000  0.8159
ARCH Lag[5]   2.42638 1.440 1.667  0.3845
ARCH Lag[7]   3.03836 2.315 1.543  0.5064
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  11.1885
Individual Statistics:
mu     0.05038
ar1    0.05061
ma1    0.05050
omega  0.04848
alpha1 0.04826
beta1  0.05379
gamma1 0.45978

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.69 1.9 2.35
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value    prob sig
Sign Bias           2.1955 0.02967  **
Negative Sign Bias  1.6810 0.09484   *
Positive Sign Bias  0.3419 0.73293
Joint Effect        5.8288 0.12025


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     25.77       0.13660
2    30     32.94       0.28035
3    40     50.16       0.10861
4    50     62.74       0.08977


Elapsed time : 0.3564699
```

The log-likelihood of the model is 212.53. SELAN optimizes weekly returns using eGARCH (1,1) and the corresponding ARFIMA (1,0,1). With the exception of mu and alpha1, all other parameters are deemed significant as their p-values are below 0.05. Mu and Alpha1 are deemed insignificant in the context of robust standard errors as their corresponding p-values surpass the threshold of 0.05. Consequently, serial autocorrelation is not supported by evidence, which is a positive circumstance for the model. The adjusted Pearson goodness-of-fit portion contains p-values, all of which are less than 0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast EGARCH

```
> egforecast_SELAN = ugarchforecast(egfit_SELAN, n.ahead = 10)
> egforecast_SELAN

*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
      Series Sigma
T+1  0.01692 0.047
T+2  0.01079 0.047
T+3  0.01029 0.047
T+4  0.01025 0.047
T+5  0.01025 0.047
T+6  0.01025 0.047
T+7  0.01025 0.047
T+8  0.01025 0.047
T+9  0.01025 0.047
T+10 0.01025 0.047
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 4.7%

4.2.3 SELAN (Monthly)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.011232    0.004377  2.56621 0.010282
ar1    -0.452248    0.363883 -1.24284 0.213928
ma1     0.302591    0.387895  0.78009 0.435341
omega   0.000067    0.000088  0.76492 0.444318
alpha1  0.000000    0.040078  0.00000 1.000000
beta1   0.985851    0.063593 15.50262 0.000000

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.011232    0.007669  1.46459 0.143033
ar1    -0.452248    0.246104 -1.83762 0.066118
ma1     0.302591    0.255665  1.18354 0.236594
omega   0.000067    0.000426  0.15839 0.874152
alpha1  0.000000    0.120866  0.00000 1.000000
beta1   0.985851    0.205917  4.78763 0.000002

LogLikelihood : 200.917
```

```
Information Criteria
------------------------------------

Akaike       -2.5151
Bayes        -2.3972
Shibata      -2.5179
Hannan-Quinn -2.4672

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                   0.001379  0.9704
Lag[2*(p+q)+(p+q)-1][5]  0.917113  1.0000
Lag[4*(p+q)+(p+q)-1][9]  5.280618  0.3920
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                      1.555  0.2124
Lag[2*(p+q)+(p+q)-1][5]     1.965  0.6267
Lag[4*(p+q)+(p+q)-1][9]     2.675  0.8111
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]   0.06529 0.500 2.000  0.7983
ARCH Lag[5]   0.71890 1.440 1.667  0.8177
ARCH Lag[7]   1.16300 2.315 1.543  0.8857
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  3.9469
Individual Statistics:
mu     0.04349
ar1    0.07915
ma1    0.10681
omega  0.09578
alpha1 0.07448
beta1  0.09667

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           0.7973 0.4265
Negative Sign Bias  1.0785 0.2825
Positive Sign Bias  1.0446 0.2979
Joint Effect        3.4020 0.3337


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     23.97       0.19739
2    30     41.06       0.06798
3    40     41.90       0.34604
4    50     46.61       0.57043


Elapsed time : 0.141793
```

The model has a log-likelihood of 200.917. ARFIMA (1,0,1) and GARCH (1,1) are the optimal daily return models in the case of SELAN. All parameters, apart from ar1, ma1, and omega, are considered significant due to the fact that their p-values are all less than 0.05. The robustness of standard errors compromises the significance of mu, alpha1, and

beta1 when their p-values exceed the threshold of 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
> ugforecast_SELAN = ugarchforecast(ugfit_SELAN, n.ahead = 10)
> ugforecast_SELAN

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.015029 0.06876
T+2  0.009514 0.06877
T+3  0.012008 0.06877
T+4  0.010880 0.06878
T+5  0.011390 0.06878
T+6  0.011160 0.06878
T+7  0.011264 0.06879
T+8  0.011217 0.06879
T+9  0.011238 0.06880
T+10 0.011229 0.06880
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 6.880%.

Model Spec EGARCH:

```
*---------------------------------*
*       GARCH Model Spec          *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model             : eGARCH(1,1)
Variance Targeting      : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model              : ARFIMA(1,0,1)
Include Mean            : TRUE
GARCH-in-Mean           : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above result, it can be seen that EGARCH (1,1) is the resulting model, and the corresponding ARFIMA (1,0,1) is taken.

Model Fit EGARCH

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.010251    0.000003   3927.4        0
ar1     0.081087    0.000015   5422.4        0
ma1    -0.197175    0.000096  -2056.1        0
omega  -0.257785    0.000063  -4088.4        0
alpha1 -0.163451    0.000076  -2155.2        0
beta1   0.957849    0.000134   7173.8        0
gamma1 -0.262367    0.000212  -1237.8        0

Robust Standard Errors:
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.010251    0.000034   301.952        0
ar1     0.081087    0.000053  1544.070        0
ma1    -0.197175    0.000391  -504.756        0
omega  -0.257785    0.000257 -1003.949        0
alpha1 -0.163451    0.000085 -1923.669        0
beta1   0.957849    0.002555   374.862        0
gamma1 -0.262367    0.003237   -81.041        0

LogLikelihood : 212.53
```

```
Information Criteria
------------------------------------

Akaike       -2.6520
Bayes        -2.5146
Shibata      -2.6558
Hannan-Quinn -2.5962

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.04174  0.8381
Lag[2*(p+q)+(p+q)-1][5]   0.39875  1.0000
Lag[4*(p+q)+(p+q)-1][9]   3.36805  0.8273
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.02221  0.8815
Lag[2*(p+q)+(p+q)-1][5]   1.60852  0.7132
Lag[4*(p+q)+(p+q)-1][9]   2.97384  0.7633
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]   0.05418 0.500 2.000  0.8159
ARCH Lag[5]   2.42638 1.440 1.667  0.3845
ARCH Lag[7]   3.03836 2.315 1.543  0.5064
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  11.1885
Individual Statistics:
mu     0.05038
ar1    0.05061
ma1    0.05050
omega  0.04848
alpha1 0.04826
beta1  0.05379
gamma1 0.45978

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:          1.69 1.9 2.35
Individual Statistic:     0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value    prob sig
Sign Bias           2.1955 0.02967  **
Negative Sign Bias  1.6810 0.09484   *
Positive Sign Bias  0.3419 0.73293
Joint Effect        5.8288 0.12025


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     25.77       0.13660
2    30     32.94       0.28035
3    40     50.16       0.10861
4    50     62.74       0.08977


Elapsed time : 0.3564699
```

The log-likelihood of the model is 212.53. SELAN optimizes weekly returns using eGARCH (1,1) and the corresponding ARFIMA (1,0,1). With the exception of mu and alpha1, all other parameters are deemed significant as their p-values are below 0.05. Mu and Alpha1 are deemed insignificant in the context of robust standard errors as their corresponding p-values surpass the threshold of 0.05. Consequently, serial autocorrelation

is not supported by evidence, which is a positive circumstance for the model. The adjusted Pearson goodness-of-fit portion contains p-values, all of which are less than 0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast EGARCH

```
> egforecast_SELAN = ugarchforecast(egfit_SELAN, n.ahead = 10)
> egforecast_SELAN

*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
      Series Sigma
T+1  0.01692 0.047
T+2  0.01079 0.047
T+3  0.01029 0.047
T+4  0.01025 0.047
T+5  0.01025 0.047
T+6  0.01025 0.047
T+7  0.01025 0.047
T+8  0.01025 0.047
T+9  0.01025 0.047
T+10 0.01025 0.047
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 4.7%

4.3 Somi Conveyor Beltings Ltd.

4.3.1 SOMICONVEY (Daily)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
> ugfit_SOMICONVEY = ugarchfit(spec= ug_spec , data = r_SOMICONVEY)
> ugfit_SOMICONVEY

*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model      : sGARCH(1,1)
Mean Model       : ARFIMA(1,0,1)
Distribution     : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.001066    0.001327  0.80294 0.422007
ar1    -0.365623    0.347620 -1.05179 0.292896
ma1     0.482622    0.325754  1.48155 0.138459
omega   0.000354    0.000093  3.80059 0.000144
alpha1  0.227856    0.048578  4.69049 0.000003
beta1   0.521846    0.091908  5.67793 0.000000

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.001066    0.001701  0.62640 0.531051
ar1    -0.365623    0.512692 -0.71314 0.475758
ma1     0.482622    0.487650  0.98969 0.322326
omega   0.000354    0.000183  1.93249 0.053299
alpha1  0.227856    0.061574  3.70053 0.000215
beta1   0.521846    0.136015  3.83669 0.000125

LogLikelihood : 1436.115

Information Criteria
------------------------------------

Akaike       -3.8809
Bayes        -3.8434
Shibata      -3.8810
Hannan-Quinn -3.8665

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.6341  0.4259
Lag[2*(p+q)+(p+q)-1][5]    2.0491  0.9482
Lag[4*(p+q)+(p+q)-1][9]    3.8805  0.7187
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.3400  0.5598
Lag[2*(p+q)+(p+q)-1][5]    0.9458  0.8718
Lag[4*(p+q)+(p+q)-1][9]    1.4616  0.9587
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.4275 0.500 2.000  0.5132
ARCH Lag[5]    0.6660 1.440 1.667  0.8338
ARCH Lag[7]    1.0835 2.315 1.543  0.8996

Nyblom stability test
------------------------------------
Joint Statistic:  0.4359
Individual Statistics:
mu     0.13851
ar1    0.04820
ma1    0.04334
omega  0.07049
alpha1 0.02545
beta1  0.05339
```

```
Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           0.5652 0.5721
Negative Sign Bias  0.8042 0.4215
Positive Sign Bias  0.4082 0.6833
Joint Effect        0.8271 0.8430


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     84.52    3.055e-10
2    30     79.84    1.223e-06
3    40    106.80    3.192e-08
4    50    131.18    1.982e-09


Elapsed time : 0.0592041
```

The log-likelihood of the model is 1436.115. GARCH (1,1) and its corresponding ARFIMA (1,0,1) are the optimal daily return models for SOMICONVEY. With the exception of omega, alpha1, and beta1, all other parameters are deemed significant as their p-values are all below 0.05. The significance of mu, arl, and mal is compromised in the context of robust standard errors as its p-values surpass the threshold of 0.05. Consequently, serial autocorrelation is not supported by evidence, which is a positive circumstance for the model. The adjusted Pearson goodness-of-fit portion contains p-values all of which are less than 0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast GARCH:

```
> ugforecast_SOMICONVEY = ugarchforecast(ugfit_SOMICONVEY, n.ahead = 10)
> ugforecast_SOMICONVEY

*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-25]:
        Series   Sigma
T+1  -0.0180870 0.08276
T+2   0.0080682 0.07408
T+3  -0.0014947 0.06685
T+4   0.0020017 0.06087
T+5   0.0007233 0.05596
T+6   0.0011907 0.05198
T+7   0.0010198 0.04879
T+8   0.0010823 0.04625
T+9   0.0010595 0.04424
T+10  0.0010678 0.04268
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 4.268%.

Model Spec EGARCH:

```
*---------------------------------*
*       GARCH Model Spec          *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : eGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above result, it can be seen that EGARCH (1,1) is the resulting model, and the corresponding ARFIMA (1,0,1) is taken.

Model Fit EGARCH:

```
Information Criteria
------------------------------------

Akaike       -3.9044
Bayes        -3.8607
Shibata      -3.9046
Hannan-Quinn -3.8876

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                      2.131  0.1444
Lag[2*(p+q)+(p+q)-1][5]     3.544  0.1887
Lag[4*(p+q)+(p+q)-1][9]     5.314  0.3849
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.02847  0.8660
Lag[2*(p+q)+(p+q)-1][5]   0.82008  0.8989
Lag[4*(p+q)+(p+q)-1][9]   1.62514  0.9447
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.6357 0.500 2.000  0.4253
ARCH Lag[5]    0.8976 1.440 1.667  0.7635
ARCH Lag[7]    1.5776 2.315 1.543  0.8057

Nyblom stability test
------------------------------------
Joint Statistic:  0.5956
Individual Statistics:
mu     0.14352
ar1    0.05565
ma1    0.05666
omega  0.05002
alpha1 0.10363
beta1  0.05031
gamma1 0.08535
```

```
> egfit_SOMICONVEY = ugarchfit(spec= eg_spec , data = r_SOMI
> egfit_SOMICONVEY

*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.001055    0.000813   1.2979 0.194314
ar1    -0.455814    0.219227  -2.0792 0.037600
ma1     0.538224    0.201639   2.6692 0.007602
omega  -1.361718    0.325914  -4.1781 0.000029
alpha1  0.155323    0.034742   4.4707 0.000008
beta1   0.795079    0.048308  16.4584 0.000000
gamma1  0.331758    0.058425   5.6783 0.000000

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.001055    0.000823   1.2820 0.199836
ar1    -0.455814    0.173703  -2.6241 0.008688
ma1     0.538224    0.151087   3.5623 0.000368
omega  -1.361718    0.520227  -2.6175 0.008856
alpha1  0.155323    0.046379   3.3490 0.000811
beta1   0.795079    0.076806  10.3518 0.000000
gamma1  0.331758    0.110851   2.9928 0.002764

LogLikelihood : 1445.788


Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:          1.69 1.9 2.35
Individual Statistic:     0.35 0.47 0.75

Sign Bias Test
-------------------------------------
                    t-value   prob sig
Sign Bias           0.5285 0.5973
Negative Sign Bias  0.2839 0.7766
Positive Sign Bias  0.1689 0.8659
Joint Effect        0.5400 0.9100


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     77.36    5.288e-09
2    30     87.00    1.046e-07
3    40     96.92    7.788e-07
4    50    114.09    4.163e-07


Elapsed time : 0.07118011
```

The model's log-likelihood is calculated to be 1445.788. For SOMICONVEY weekly returns, GARCH (1,1) and its corresponding ARFIMA (1,0,1) are optimal. Each of the Optimal Parameters is deemed significant if its corresponding p-value is less than 0.05. Each robust standard error is deemed statistically significant if its corresponding p-value

is less than 0.05. As a result, there is no evidence of serial autocorrelation, which is a favorable condition for the model. All the p-values in the Adjusted Pearson goodness-of-fit section are extremely high, indicating that the null hypothesis cannot be rejected and that the difference between the observed and expected values is not significant.

Model Forecast EGARCH:

```
> egforecast_SOMICONVEY = ugarchforecast(egfit_SOMICONVEY, n.ahead = 10)
> egforecast_SOMICONVEY

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-25]:
        Series   Sigma
T+1  -0.0132736 0.08790
T+2   0.0075865 0.07323
T+3  -0.0019218 0.06334
T+4   0.0024122 0.05643
T+5   0.0004367 0.05148
T+6   0.0013372 0.04786
T+7   0.0009267 0.04516
T+8   0.0011138 0.04313
T+9   0.0010285 0.04157
T+10  0.0010674 0.04038
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 4.038%

4.3.2 SOMICONVEY (Weekly)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
> ugfit_SOMICONVEY = ugarchfit(spec= ug_spec , data = r_SOMICONVEY)
> ugfit_SOMICONVEY

*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.012814    0.006305   2.03221 0.042132
ar1     0.593898    0.440713   1.34758 0.177793
ma1    -0.671135    0.403982  -1.66130 0.096654
omega   0.000044    0.000085   0.52409 0.600216
alpha1  0.000000    0.011701   0.00000 1.000000
beta1   0.993398    0.004974 199.72038 0.000000

Robust Standard Errors:
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.012814    0.007607   1.68454 0.092077
ar1     0.593898    0.295512   2.00972 0.044461
ma1    -0.671135    0.277685  -2.41690 0.015654
omega   0.000044    0.000138   0.32147 0.747858
alpha1  0.000000    0.017630   0.00000 1.000000
beta1   0.993398    0.001558 637.78858 0.000000

LogLikelihood : 147.3222

Information Criteria
------------------------------------

Akaike       -1.8235
Bayes        -1.7057
Shibata      -1.8264
Hannan-Quinn -1.7757

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.3924  0.5311
Lag[2*(p+q)+(p+q)-1][5]    2.9169  0.5248
Lag[4*(p+q)+(p+q)-1][9]    4.6445  0.5366
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.05533  0.8140
Lag[2*(p+q)+(p+q)-1][5]   0.58691  0.9435
Lag[4*(p+q)+(p+q)-1][9]   1.47051  0.9579
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.4623 0.500 2.000  0.4965
ARCH Lag[5]    0.7580 1.440 1.667  0.8058
ARCH Lag[7]    1.2110 2.315 1.543  0.8770

Nyblom stability test
------------------------------------
Joint Statistic:  3.8348
Individual Statistics:
mu      0.15336
ar1     0.01987
ma1     0.01984
omega   0.05949
alpha1 0.09542
beta1   0.05983

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           1.3461 0.1803
Negative Sign Bias  0.3966 0.6922
Positive Sign Bias  0.2096 0.8342
Joint Effect        5.0097 0.1711


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     45.13    6.575e-04
2    30     67.00    7.713e-05
3    40     61.52    1.222e-02
4    50     79.52    3.783e-03


Elapsed time : 0.201036
```

The model has a log-likelihood of 147.3222. GARCH (1,1) and ARFIMA (1,0,1) are the daily return models that are deemed optimal for SOMICONVEY. All parameters, excluding mu, ma1, alpha1, and omega, are considered significant due to their p-values being less than 0.05. When considering robust standard errors, the significance of ar1 and beta1 is compromised when their p-values exceed the threshold of 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
> ugforecast_SOMICONVEY = ugarchforecast
> ugforecast_SOMICONVEY

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
        Series   Sigma
T+1  -0.013059 0.08636
T+2  -0.002552 0.08633
T+3   0.003688 0.08631
T+4   0.007394 0.08628
T+5   0.009595 0.08625
T+6   0.010902 0.08622
T+7   0.011679 0.08619
T+8   0.012140 0.08617
T+9   0.012413 0.08614
T+10  0.012576 0.08611
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 8.611%

Model Spec EGARCH:

```
*---------------------------------*
*       GARCH Model Spec          *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model             : eGARCH(1,1)
Variance Targeting      : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model              : ARFIMA(1,0,1)
Include Mean            : TRUE
GARCH-in-Mean           : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above result, it can be seen that EGARCH (1,1) is the resulting model, and the corresponding ARFIMA (1,0,1) is taken.

Model Fit EGARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.011047    0.000002  5743.22        0
ar1     0.466632    0.000075  6222.75        0
ma1    -0.627854    0.000068 -9283.97        0
omega  -0.530346    0.000067 -7894.42        0
alpha1 -0.018356    0.000027  -669.24        0
beta1   0.897035    0.000105  8555.18        0
gamma1 -0.393122    0.000050 -7876.16        0

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.011047    0.000367  30.0903        0
ar1     0.466632    0.018625  25.0547        0
ma1    -0.627854    0.017075 -36.7699        0
omega  -0.530346    0.008652 -61.2947        0
alpha1 -0.018356    0.002096  -8.7595        0
beta1   0.897035    0.030892  29.0373        0
gamma1 -0.393122    0.014011 -28.0582        0

LogLikelihood : 165.3581
```

```
Information Criteria
------------------------------------

Akaike       -2.0433
Bayes        -1.9059
Shibata      -2.0472
Hannan-Quinn -1.9875

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                      1.036  0.3089
Lag[2*(p+q)+(p+q)-1][5]     3.672  0.1444
Lag[4*(p+q)+(p+q)-1][9]     6.591  0.1725
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.03273  0.8564
Lag[2*(p+q)+(p+q)-1][5]   1.11179  0.8339
Lag[4*(p+q)+(p+q)-1][9]   1.83550  0.9237
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.4881 0.500 2.000  0.4848
ARCH Lag[5]    0.7498 1.440 1.667  0.8083
ARCH Lag[7]    0.9646 2.315 1.543  0.9193
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  2.3756
Individual Statistics:
mu      0.03004
ar1     0.02975
ma1     0.02969
omega   0.02353
alpha1  0.02991
beta1   0.43515
gamma1  0.03000

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:          1.69 1.9 2.35
Individual Statistic:     0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias          1.40141 0.1632
Negative Sign Bias 0.09795 0.9221
Positive Sign Bias 0.43624 0.6633
Joint Effect       2.94769 0.3998


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     27.84       0.08658
2    30     42.61       0.04942
3    40     54.81       0.04785
4    50     57.58       0.18747


Elapsed time : 0.6651111
```

The log-likelihood of the model is 165.3581. SOMICONVEY optimizes weekly returns using eGARCH (1,1) and the corresponding ARFIMA (1,0,1). With the exception of mu and alpha1, all other parameters are deemed significant as their p-values are below 0.05. Mu and Alpha1 are deemed insignificant in the context of robust standard errors as their corresponding p-values surpass the threshold of 0.05. Consequently, serial autocorrelation is not supported by evidence, which is a positive circumstance for the model. The adjusted Pearson goodness-of-fit portion contains p-values, all of which are less than

0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast EGARCH:

```
> egforecast_SOMICONVEY = ugarchforecast(egfit_
> egforecast_SOMICONVEY

*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
        Series   Sigma
T+1  -0.0438859 0.07565
T+2  -0.0145865 0.07570
T+3  -0.0009145 0.07574
T+4   0.0054654 0.07578
T+5   0.0084424 0.07582
T+6   0.0098316 0.07585
T+7   0.0104798 0.07588
T+8   0.0107823 0.07590
T+9   0.0109234 0.07593
T+10  0.0109893 0.07595
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 7.595%

4.3.3 SOMICONVEY (Monthly)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
> ugfit_SOMICONVEY = ugarchfit(spec= ug_spec , data = r_SOMICONVEY)
> ugfit_SOMICONVEY

*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.012814    0.006305   2.03221 0.042132
ar1     0.593898    0.440713   1.34758 0.177793
ma1    -0.671135    0.403982  -1.66130 0.096654
omega   0.000044    0.000085   0.52409 0.600216
alpha1  0.000000    0.011701   0.00000 1.000000
beta1   0.993398    0.004974 199.72038 0.000000

Robust Standard Errors:
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.012814    0.007607   1.68454 0.092077
ar1     0.593898    0.295512   2.00972 0.044461
ma1    -0.671135    0.277685  -2.41690 0.015654
omega   0.000044    0.000138   0.32147 0.747858
alpha1  0.000000    0.017630   0.00000 1.000000
beta1   0.993398    0.001558 637.78858 0.000000

LogLikelihood : 147.3222

Information Criteria
------------------------------------

Akaike       -1.8235
Bayes        -1.7057
Shibata      -1.8264
Hannan-Quinn -1.7757

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.3924  0.5311
Lag[2*(p+q)+(p+q)-1][5]    2.9169  0.5248
Lag[4*(p+q)+(p+q)-1][9]    4.6445  0.5366
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.05533  0.8140
Lag[2*(p+q)+(p+q)-1][5]   0.58691  0.9435
Lag[4*(p+q)+(p+q)-1][9]   1.47051  0.9579
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.4623 0.500 2.000  0.4965
ARCH Lag[5]    0.7580 1.440 1.667  0.8058
ARCH Lag[7]    1.2110 2.315 1.543  0.8770

Nyblom stability test
------------------------------------
Joint Statistic:  3.8348
Individual Statistics:
mu     0.15336
ar1    0.01987
ma1    0.01984
omega  0.05949
alpha1 0.09542
beta1  0.05983

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           1.3461 0.1803
Negative Sign Bias  0.3966 0.6922
Positive Sign Bias  0.2096 0.8342
Joint Effect        5.0097 0.1711


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     45.13    6.575e-04
2    30     67.00    7.713e-05
3    40     61.52    1.222e-02
4    50     79.52    3.783e-03


Elapsed time : 0.201036
```

The model has a log-likelihood of 147.3222. GARCH (1,1) and ARFIMA (1,0,1) are the daily return models that are deemed optimal for SOMICONVEY. All parameters, excluding mu, ma1, alpha1, and omega, are considered significant due to their p-values being less than 0.05. When considering robust standard errors, the significance of ar1 and beta1 is compromised when their p-values exceed the threshold of 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
> ugforecast_SOMICONVEY = ugarchforecast
> ugforecast_SOMICONVEY

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
        Series   Sigma
T+1  -0.013059 0.08636
T+2  -0.002552 0.08633
T+3   0.003688 0.08631
T+4   0.007394 0.08628
T+5   0.009595 0.08625
T+6   0.010902 0.08622
T+7   0.011679 0.08619
T+8   0.012140 0.08617
T+9   0.012413 0.08614
T+10  0.012576 0.08611
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 8.611%

Model Spec EGARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : eGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above result, it can be seen that EGARCH (1,1) is the resulting model, and the corresponding ARFIMA (1,0,1) is taken.

Model Fit EGARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.011047    0.000002  5743.22        0
ar1     0.466632    0.000075  6222.75        0
ma1    -0.627854    0.000068 -9283.97        0
omega  -0.530346    0.000067 -7894.42        0
alpha1 -0.018356    0.000027  -669.24        0
beta1   0.897035    0.000105  8555.18        0
gamma1 -0.393122    0.000050 -7876.16        0

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.011047    0.000367  30.0903        0
ar1     0.466632    0.018625  25.0547        0
ma1    -0.627854    0.017075 -36.7699        0
omega  -0.530346    0.008652 -61.2947        0
alpha1 -0.018356    0.002096  -8.7595        0
beta1   0.897035    0.030892  29.0373        0
gamma1 -0.393122    0.014011 -28.0582        0

LogLikelihood : 165.3581
```

```
Information Criteria
------------------------------------

Akaike       -2.0433
Bayes        -1.9059
Shibata      -2.0472
Hannan-Quinn -1.9875

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                      1.036  0.3089
Lag[2*(p+q)+(p+q)-1][5]     3.672  0.1444
Lag[4*(p+q)+(p+q)-1][9]     6.591  0.1725
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.03273  0.8564
Lag[2*(p+q)+(p+q)-1][5]   1.11179  0.8339
Lag[4*(p+q)+(p+q)-1][9]   1.83550  0.9237
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.4881 0.500 2.000  0.4848
ARCH Lag[5]    0.7498 1.440 1.667  0.8083
ARCH Lag[7]    0.9646 2.315 1.543  0.9193
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  2.3756
Individual Statistics:
mu      0.03004
ar1     0.02975
ma1     0.02969
omega   0.02353
alpha1 0.02991
beta1   0.43515
gamma1 0.03000

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.69 1.9 2.35
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias          1.40141 0.1632
Negative Sign Bias 0.09795 0.9221
Positive Sign Bias 0.43624 0.6633
Joint Effect       2.94769 0.3998


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     27.84       0.08658
2    30     42.61       0.04942
3    40     54.81       0.04785
4    50     57.58       0.18747


Elapsed time : 0.6651111
```

The log-likelihood of the model is 165.3581. SOMICONVEY optimizes weekly returns using eGARCH (1,1) and the corresponding ARFIMA (1,0,1). With the exception of mu and alpha1, all other parameters are deemed significant as their p-values are below 0.05. Mu and Alpha1 are deemed insignificant in the context of robust standard errors as their corresponding p-values surpass the threshold of 0.05. Consequently, serial autocorrelation is not supported by evidence, which is a positive circumstance for the model. The adjusted Pearson goodness-of-fit portion contains p-values, all of which are less than 0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast EGARCH:

```
> egforecast_SOMICONVEY = ugarchforecast(egfit_
> egforecast_SOMICONVEY

*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
         Series   Sigma
T+1  -0.0438859 0.07565
T+2  -0.0145865 0.07570
T+3  -0.0009145 0.07574
T+4   0.0054654 0.07578
T+5   0.0084424 0.07582
T+6   0.0098316 0.07585
T+7   0.0104798 0.07588
T+8   0.0107823 0.07590
T+9   0.0109234 0.07593
T+10  0.0109893 0.07595
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 7.595%

4.4 TAJ GVK Hotels and Resorts Ltd.

4.4.1 TAJGVK (Daily)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
> ugfit_TAJGVK = ugarchfit(spec= ug_spec , data = r_TAJGVK)
> ugfit_TAJGVK

*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.001036    0.000849  1.2211e+00  0.22203
ar1    -0.072767    0.590601 -1.2321e-01  0.90194
ma1     0.098582    0.588373  1.6755e-01  0.86694
omega   0.000001    0.000000  6.8566e+00  0.00000
alpha1  0.000000    0.000185  6.0000e-05  0.99995
beta1   0.999000    0.000008  1.2831e+05  0.00000

Robust Standard Errors:
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.001036    0.000783   1.324003  0.18550
ar1    -0.072767    0.221322  -0.328783  0.74232
ma1     0.098582    0.213110   0.462586  0.64366
omega   0.000001    0.000000  14.165908  0.00000
alpha1  0.000000    0.000031   0.000354  0.99972
beta1   0.999000    0.000113 8846.190460  0.00000

LogLikelihood : 1751.865

Information Criteria
------------------------------------

Akaike       -4.7313
Bayes        -4.6939
Shibata      -4.7315
Hannan-Quinn -4.7169

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                  0.0001414  0.9905
Lag[2*(p+q)+(p+q)-1][5] 1.9766110  0.9623
Lag[4*(p+q)+(p+q)-1][9] 4.8419913  0.4900
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic   p-value
Lag[1]                      18.12 2.076e-05
Lag[2*(p+q)+(p+q)-1][5]     20.83 1.146e-05
Lag[4*(p+q)+(p+q)-1][9]     24.65 1.218e-05
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]     2.061 0.500 2.000  0.1511
ARCH Lag[5]     2.897 1.440 1.667  0.3050
ARCH Lag[7]     6.114 2.315 1.543  0.1338

Nyblom stability test
------------------------------------
Joint Statistic:  160.8912
Individual Statistics:
mu      0.0440
ar1     0.0371
ma1     0.0395
omega  13.9712
alpha1  0.1120
beta1   0.1222

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75
```

```
Sign Bias Test
------------------------------------
                    t-value      prob sig
Sign Bias           1.47208 1.414e-01
Negative Sign Bias  5.30789 1.471e-07 ***
Positive Sign Bias  0.08496 9.323e-01
Joint Effect       31.42033 6.933e-07 ***


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     67.42    2.456e-07
2    30     75.25    5.610e-06
3    40    105.36    5.134e-08
4    50    102.11    1.324e-05


Elapsed time : 0.04636192
```

The model has a log-likelihood of 1751.865. The ARFIMA (1,0,1) and GARCH (1,1) are the optimal daily return models in the context of TAJGVK. Except for mu, ar1, ma1, and alpha1, the p-values of all other parameters are less than 0.05, thus establishing their significance. When considering robust standard errors, the significance of omega and beta1 is compromised when their p-values exceed the threshold of 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
> ugforecast_TAJGVK = ugarchforecast(ugfit_TAJGVK, n.ahead = 10)
> ugforecast_TAJGVK

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-25]:
       Series   Sigma
T+1  0.001321 0.02329
T+2  0.001016 0.02329
T+3  0.001038 0.02329
T+4  0.001036 0.02329
T+5  0.001036 0.02329
T+6  0.001036 0.02329
T+7  0.001036 0.02329
T+8  0.001036 0.02329
T+9  0.001036 0.02329
T+10 0.001036 0.02329
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 2.329%.

Model Spec EGARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : eGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above result, it can be seen that EGARCH (1,1) is the resulting model, and the corresponding ARFIMA (1,0,1) is taken.

Model Fit EGARCH:

```
> egfit_TAJGVK = ugarchfit(spec= eg_spec , data = r_TAJGVK)
> egfit_TAJGVK

*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.001188    0.000759  1.56640 0.117255
ar1     0.591420    0.087694  6.74413 0.000000
ma1    -0.616291    0.085083 -7.24337 0.000000
omega  -7.372635    1.784882 -4.13060 0.000036
alpha1 -0.176454    0.049303 -3.57897 0.000345
beta1   0.030600    0.234380  0.13056 0.896125
gamma1  0.199081    0.079155  2.51508 0.011901

Robust Standard Errors:
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.001188    0.000779   1.52584 0.127049
ar1     0.591420    0.020012  29.55274 0.000000
ma1    -0.616291    0.018482 -33.34572 0.000000
omega  -7.372635    2.281510  -3.23147 0.001232
alpha1 -0.176454    0.068764  -2.56609 0.010285
beta1   0.030600    0.297498   0.10286 0.918076
gamma1  0.199081    0.083907   2.37262 0.017662

LogLikelihood : 1765.497

Information Criteria
------------------------------------

Akaike       -4.7656
Bayes        -4.7219
Shibata      -4.7658
Hannan-Quinn -4.7487

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                      1.037  0.3085
Lag[2*(p+q)+(p+q)-1][5]     1.944  0.9677
Lag[4*(p+q)+(p+q)-1][9]     4.420  0.5907
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.2881  0.5914
Lag[2*(p+q)+(p+q)-1][5]    0.7202  0.9190
Lag[4*(p+q)+(p+q)-1][9]    3.8421  0.6157
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.0451 0.500 2.000  0.8318
ARCH Lag[5]    0.8301 1.440 1.667  0.7839
ARCH Lag[7]    3.7693 2.315 1.543  0.3811

Nyblom stability test
------------------------------------
Joint Statistic:  0.9757
Individual Statistics:
mu     0.12939
ar1    0.09154
ma1    0.09045
omega  0.11811
alpha1 0.41385
beta1  0.11055
gamma1 0.04786
```

```
Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.69 1.9 2.35
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                    t-value   prob sig
Sign Bias           0.3650 0.7152
Negative Sign Bias  0.8052 0.4209
Positive Sign Bias  0.1520 0.8792
Joint Effect        0.7011 0.8729


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     56.58    1.327e-05
2    30     69.64    3.393e-05
3    40     85.31    2.644e-05
4    50     95.60    7.681e-05


Elapsed time : 0.133637
```

The model's log-likelihood is calculated to be 1505.762. For TAJGVK weekly returns, GARCH (1,1) and its corresponding ARFIMA (1,0,1) are optimal. Each of the Optimal Parameters is deemed significant if its corresponding p-value is less than 0.05. Each robust standard error is deemed statistically significant if its corresponding p-value is less than 0.05. As a result, there is no evidence of serial autocorrelation, which is a favorable condition for the model. All the p-values in the Adjusted Pearson goodness-of-fit section are extremely high, indicating that the null hypothesis cannot be rejected and that the difference between the observed and expected values is not significant.

Model Forecast EGARCH:

```
> egforecast_TAJGVK = ugarchforecast(egfit_TAJGVK, n.ahead = 10)
> egforecast_TAJGVK

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-25]:
       Series   Sigma
T+1  0.002038 0.02083
T+2  0.001691 0.02226
T+3  0.001485 0.02231
T+4  0.001364 0.02231
T+5  0.001292 0.02231
T+6  0.001250 0.02231
T+7  0.001225 0.02231
T+8  0.001210 0.02231
T+9  0.001201 0.02231
T+10 0.001196 0.02231
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 2.231%

4.4.2 TAJGVK (Weekly)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model      : sGARCH(1,1)
Mean Model       : ARFIMA(1,0,1)
Distribution     : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error    t value Pr(>|t|)
mu      0.004664    0.003637   1.282312 0.199733
ar1    -0.690107    0.281858  -2.448420 0.014348
ma1     0.585627    0.313529   1.867853 0.061783
omega   0.000005    0.000018   0.271949 0.785661
alpha1  0.000001    0.001845   0.000488 0.999610
beta1   0.998595    0.003052 327.164688 0.000000

Robust Standard Errors:
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.004664    0.003712  1.256543 0.208919
ar1    -0.690107    0.174322 -3.958795 0.000075
ma1     0.585627    0.201799  2.902030 0.003708
omega   0.000005    0.000047  0.104383 0.916866
alpha1  0.000001    0.006968  0.000129 0.999897
beta1   0.998595    0.011267 88.632531 0.000000

LogLikelihood : 249.8472
```

```
LogLikelihood : 249.8472

Information Criteria
------------------------------------

Akaike       -3.1464
Bayes        -3.0286
Shibata      -3.1493
Hannan-Quinn -3.0986

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.2424  0.6225
Lag[2*(p+q)+(p+q)-1][5]    1.3162  0.9996
Lag[4*(p+q)+(p+q)-1][9]    3.1519  0.8663
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic  p-value
Lag[1]                      7.531 0.006064
Lag[2*(p+q)+(p+q)-1][5]     8.657 0.020192
Lag[4*(p+q)+(p+q)-1][9]     9.912 0.052390
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.3492 0.500 2.000  0.5545
ARCH Lag[5]    0.5113 1.440 1.667  0.8803
ARCH Lag[7]    1.6010 2.315 1.543  0.8009
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  19.1391
Individual Statistics:
mu     0.06262
ar1    0.16887
ma1    0.16814
omega  0.06423
alpha1 0.06616
beta1  0.07244

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                    t-value     prob sig
Sign Bias           1.6909 0.092928   *
Negative Sign Bias  2.6225 0.009629 ***
Positive Sign Bias  0.8801 0.380236
Joint Effect        8.9691 0.029705  **


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     15.71       0.6766
2    30     24.81       0.6883
3    40     30.03       0.8482
4    50     33.71       0.9529


Elapsed time : 0.1135619
```

249.8472 is the logarithm of the model's probability. GARCH (1,1) and ARFIMA (1,0,1) are the daily return models that are deemed optimal for TAJGVK. All parameters, excluding mu, alpha1, and omega, are considered significant due to the fact that their p-values are all less than 0.05. When considering robust standard errors, the significance of ar1, ma1, and beta1 is compromised because their p-values exceed the threshold of 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.006445 0.05060
T+2  0.003435 0.05062
T+3  0.005512 0.05063
T+4  0.004078 0.05064
T+5  0.005068 0.05065
T+6  0.004385 0.05067
T+7  0.004856 0.05068
T+8  0.004531 0.05069
T+9  0.004755 0.05071
T+10 0.004601 0.05072
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 5.072%.

Model Spec EGARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : eGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

Model Fit GARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.005058    0.001185  4.268916 0.000020
ar1     0.532191    0.061183  8.698295 0.000000
ma1    -0.350641    0.065210 -5.377066 0.000000
omega  -6.193817    1.327956 -4.664174 0.000003
alpha1  0.213275    0.107094  1.991476 0.046429
beta1   0.006964    0.205927  0.033818 0.973023
gamma1  1.076561    0.195107  5.517809 0.000000

Robust Standard Errors:
        Estimate  Std. Error    t value Pr(>|t|)
mu      0.005058    0.000400  12.647157 0.000000
ar1     0.532191    0.028937  18.391295 0.000000
ma1    -0.350641    0.016542 -21.197304 0.000000
omega  -6.193817    1.879861  -3.294827 0.000985
alpha1  0.213275    0.113213   1.883831 0.059588
beta1   0.006964    0.301507   0.023097 0.981573
gamma1  1.076561    0.281072   3.830191 0.000128

LogLikelihood : 265.3577

Information Criteria
------------------------------------

Akaike       -3.3336
Bayes        -3.1962
Shibata      -3.3375
Hannan-Quinn -3.2778

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                      1.568  0.2104
Lag[2*(p+q)+(p+q)-1][5]     3.540  0.1905
Lag[4*(p+q)+(p+q)-1][9]     4.669  0.5307
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.1753  0.6755
Lag[2*(p+q)+(p+q)-1][5]    1.2388  0.8037
Lag[4*(p+q)+(p+q)-1][9]    3.5272  0.6697
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]   0.05288 0.500 2.000  0.8181
ARCH Lag[5]   1.67843 1.440 1.667  0.5467
ARCH Lag[7]   3.48024 2.315 1.543  0.4277
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  1.7239
Individual Statistics:
mu      0.09758
ar1     0.20649
ma1     0.12631
omega   0.08677
alpha1 0.09050
beta1   0.10045
gamma1 0.20054

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:          1.69 1.9 2.35
Individual Statistic:     0.35 0.47 0.75

Sign Bias Test
------------------------------------
                    t-value   prob sig
Sign Bias           0.2033 0.8392
Negative Sign Bias  0.6218 0.5350
Positive Sign Bias  0.6568 0.5123
Joint Effect        0.9370 0.8165


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     19.06       0.4527
2    30     25.19       0.6682
3    40     37.26       0.5495
4    50     52.42       0.3428


Elapsed time : 0.552459
```

The log-likelihood of the model is 265.3577. TAJGVK optimizes weekly returns using eGARCH (1,1) and the corresponding ARFIMA (1,0,1). With the exception of mu and alpha1, all other parameters are deemed significant as their p-values are below 0.05. Mu and Alpha1 are deemed insignificant in the context of robust standard errors as their corresponding p-values surpass the threshold of 0.05. In the Ljung-box test result portion, the null hypothesis cannot be rejected because all p-values for standard deviations and standard squared residuals are substantially greater than 0.05. Consequently, serial autocorrelation is not supported by evidence, which is a positive circumstance for the model. The adjusted Pearson goodness-of-fit portion contains p-values, all of which are less than 0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast GARCH:

```
> egforecast_TAJGVK = ugarchforecast(egf
> egforecast_TAJGVK

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
        Series   Sigma
T+1  -0.008332 0.03821
T+2  -0.002068 0.04417
T+3   0.001266 0.04422
T+4   0.003040 0.04422
T+5   0.003984 0.04422
T+6   0.004487 0.04422
T+7   0.004754 0.04422
T+8   0.004896 0.04422
T+9   0.004972 0.04422
T+10  0.005012 0.04422
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 4.422%

4.4.3 TAJGVK (Monthly)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model             : sGARCH(1,1)
Variance Targeting      : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model              : ARFIMA(1,0,1)
Include Mean            : TRUE
GARCH-in-Mean           : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error    t value Pr(>|t|)
mu      0.004664    0.003637   1.282312 0.199733
ar1    -0.690107    0.281858  -2.448420 0.014348
ma1     0.585627    0.313529   1.867853 0.061783
omega   0.000005    0.000018   0.271949 0.785661
alpha1  0.000001    0.001845   0.000488 0.999610
beta1   0.998595    0.003052 327.164688 0.000000

Robust Standard Errors:
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.004664    0.003712  1.256543 0.208919
ar1    -0.690107    0.174322 -3.958795 0.000075
ma1     0.585627    0.201799  2.902030 0.003708
omega   0.000005    0.000047  0.104383 0.916866
alpha1  0.000001    0.006968  0.000129 0.999897
beta1   0.998595    0.011267 88.632531 0.000000

LogLikelihood : 249.8472
```

```
LogLikelihood : 249.8472

Information Criteria
------------------------------------

Akaike       -3.1464
Bayes        -3.0286
Shibata      -3.1493
Hannan-Quinn -3.0986

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.2424  0.6225
Lag[2*(p+q)+(p+q)-1][5]    1.3162  0.9996
Lag[4*(p+q)+(p+q)-1][9]    3.1519  0.8663
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic  p-value
Lag[1]                      7.531 0.006064
Lag[2*(p+q)+(p+q)-1][5]     8.657 0.020192
Lag[4*(p+q)+(p+q)-1][9]     9.912 0.052390
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.3492 0.500 2.000  0.5545
ARCH Lag[5]    0.5113 1.440 1.667  0.8803
ARCH Lag[7]    1.6010 2.315 1.543  0.8009
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  19.1391
Individual Statistics:
mu      0.06262
ar1     0.16887
ma1     0.16814
omega   0.06423
alpha1 0.06616
beta1   0.07244

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:          1.49 1.68 2.12
Individual Statistic:     0.35 0.47 0.75

Sign Bias Test
------------------------------------
                    t-value     prob sig
Sign Bias           1.6909 0.092928   *
Negative Sign Bias  2.6225 0.009629 ***
Positive Sign Bias  0.8801 0.380236
Joint Effect        8.9691 0.029705  **


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     15.71       0.6766
2    30     24.81       0.6883
3    40     30.03       0.8482
4    50     33.71       0.9529


Elapsed time : 0.1135619
```

249.8472 is the logarithm of the model's probability. GARCH (1,1) and ARFIMA (1,0,1) are the daily return models that are deemed optimal for TAJGVK. All parameters, excluding mu, alpha1, and omega, are considered significant due to the fact that their p-values are all less than 0.05. When considering robust standard errors, the significance of ar1, ma1, and beta1 is compromised because their p-values exceed the threshold of 0.05. The null hypothesis cannot be rejected in the Ljung-box test result portion due to the fact that all p-values associated with standard deviations and standard squared residuals are significantly larger than 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
*-------------------------------------*
*       GARCH Model Forecast          *
*-------------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.006445 0.05060
T+2  0.003435 0.05062
T+3  0.005512 0.05063
T+4  0.004078 0.05064
T+5  0.005068 0.05065
T+6  0.004385 0.05067
T+7  0.004856 0.05068
T+8  0.004531 0.05069
T+9  0.004755 0.05071
T+10 0.004601 0.05072
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 5.072%.

Model Spec EGARCH:

```
*---------------------------------*
*       GARCH Model Spec          *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model             : eGARCH(1,1)
Variance Targeting      : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model              : ARFIMA(1,0,1)
Include Mean            : TRUE
GARCH-in-Mean           : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

Model Fit GARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.005058    0.001185  4.268916 0.000020
ar1     0.532191    0.061183  8.698295 0.000000
ma1    -0.350641    0.065210 -5.377066 0.000000
omega  -6.193817    1.327956 -4.664174 0.000003
alpha1  0.213275    0.107094  1.991476 0.046429
beta1   0.006964    0.205927  0.033818 0.973023
gamma1  1.076561    0.195107  5.517809 0.000000

Robust Standard Errors:
        Estimate  Std. Error    t value Pr(>|t|)
mu      0.005058    0.000400  12.647157 0.000000
ar1     0.532191    0.028937  18.391295 0.000000
ma1    -0.350641    0.016542 -21.197304 0.000000
omega  -6.193817    1.879861  -3.294827 0.000985
alpha1  0.213275    0.113213   1.883831 0.059588
beta1   0.006964    0.301507   0.023097 0.981573
gamma1  1.076561    0.281072   3.830191 0.000128

LogLikelihood : 265.3577
```

```
Information Criteria
------------------------------------

Akaike       -3.3336
Bayes        -3.1962
Shibata      -3.3375
Hannan-Quinn -3.2778

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                      1.568  0.2104
Lag[2*(p+q)+(p+q)-1][5]     3.540  0.1905
Lag[4*(p+q)+(p+q)-1][9]     4.669  0.5307
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.1753  0.6755
Lag[2*(p+q)+(p+q)-1][5]    1.2388  0.8037
Lag[4*(p+q)+(p+q)-1][9]    3.5272  0.6697
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]   0.05288 0.500 2.000  0.8181
ARCH Lag[5]   1.67843 1.440 1.667  0.5467
ARCH Lag[7]   3.48024 2.315 1.543  0.4277
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  1.7239
Individual Statistics:
mu     0.09758
ar1    0.20649
ma1    0.12631
omega  0.08677
alpha1 0.09050
beta1  0.10045
gamma1 0.20054

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.69 1.9 2.35
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           0.2033 0.8392
Negative Sign Bias  0.6218 0.5350
Positive Sign Bias  0.6568 0.5123
Joint Effect        0.9370 0.8165


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     19.06       0.4527
2    30     25.19       0.6682
3    40     37.26       0.5495
4    50     52.42       0.3428


Elapsed time : 0.552459
```

The log-likelihood of the model is 265.3577. TAJGVK optimizes weekly returns using eGARCH (1,1) and the corresponding ARFIMA (1,0,1). With the exception of mu and alpha1, all other parameters are deemed significant as their p-values are below 0.05. Mu and Alpha1 are deemed insignificant in the context of robust standard errors as their corresponding p-values surpass the threshold of 0.05. In the Ljung-box test result portion, the null hypothesis cannot be rejected because all p-values for standard deviations and standard squared residuals are substantially greater than 0.05. Consequently, serial

autocorrelation is not supported by evidence, which is a positive circumstance for the model. The adjusted Pearson goodness-of-fit portion contains p-values, all of which are less than 0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast GARCH:

```
> egforecast_TAJGVK = ugarchforecast(egf
> egforecast_TAJGVK

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
        Series   Sigma
T+1  -0.008332 0.03821
T+2  -0.002068 0.04417
T+3   0.001266 0.04422
T+4   0.003040 0.04422
T+5   0.003984 0.04422
T+6   0.004487 0.04422
T+7   0.004754 0.04422
T+8   0.004896 0.04422
T+9   0.004972 0.04422
T+10  0.005012 0.04422
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 4.422%

4.5 Tamilnadu Newsprint & Papers Ltd.

4.5.1 TNPL (Daily)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
> ugfit_TNPL = ugarchfit(spec= ug_spec , data = r_TNPL)
> ugfit_TNPL

*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model      : sGARCH(1,1)
Mean Model       : ARFIMA(1,0,1)
Distribution     : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.001312    0.000833  1.57393 0.115503
ar1     0.454722    0.682169  0.66658 0.505039
ma1    -0.489189    0.667731 -0.73262 0.463793
omega   0.000032    0.000015  2.14448 0.031995
alpha1  0.055593    0.023045  2.41236 0.015850
beta1   0.898040    0.040074 22.40936 0.000000

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.001312    0.000883  1.48537  0.13745
ar1     0.454722    0.533341  0.85259  0.39389
ma1    -0.489189    0.514476 -0.95085  0.34168
omega   0.000032    0.000025  1.25014  0.21125
alpha1  0.055593    0.030930  1.79735  0.07228
beta1   0.898040    0.059203 15.16880  0.00000

LogLikelihood : 1678.082

Information Criteria
------------------------------------

Akaike       -4.5314
Bayes        -4.4940
Shibata      -4.5315
Hannan-Quinn -4.5170
```

```
Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.04575  0.8306
Lag[2*(p+q)+(p+q)-1][5]   1.28491  0.9997
Lag[4*(p+q)+(p+q)-1][9]   3.19915  0.8582
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.4736  0.4913
Lag[2*(p+q)+(p+q)-1][5]    2.0061  0.6170
Lag[4*(p+q)+(p+q)-1][9]    3.0717  0.7471
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]     1.097 0.500 2.000  0.2950
ARCH Lag[5]     2.782 1.440 1.667  0.3230
ARCH Lag[7]     3.142 2.315 1.543  0.4871

Nyblom stability test
------------------------------------
Joint Statistic:  0.7403
Individual Statistics:
mu     0.09924
ar1    0.10386
ma1    0.09342
omega  0.08193
alpha1 0.08726
beta1  0.09508

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75
```

```
Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           1.2296 0.2192
Negative Sign Bias  0.7754 0.4383
Positive Sign Bias  0.6225 0.5338
Joint Effect        3.6373 0.3034


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     78.21    3.782e-09
2    30     92.89    1.297e-08
3    40    106.55    3.464e-08
4    50    112.14    7.443e-07


Elapsed time : 0.04960489
```

The model has a log-likelihood of 1678.082. GARCH (1,1) and ARFIMA (1,0,1) are the daily return models that are considered optimal for TNPL. Except for mu, ar1, and ma1, the p-values of all other parameters are less than 0.05, thus indicating their significance. The robustness of standard errors compromises the significance of omega, alpha1, and beta1 when their p-values exceed the threshold of 0.05. The null hypothesis cannot be rejected in the Ljung-box test result portion due to the fact that all p-values associated with standard deviations and standard squared residuals are significantly larger than 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
> ugforecast_TNPL = ugarchforecast(ugfit_TNPL, n.ahead = 10)
> ugforecast_TNPL

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-25]:
       Series   Sigma
T+1  0.002236 0.02914
T+2  0.001732 0.02901
T+3  0.001503 0.02888
T+4  0.001399 0.02875
T+5  0.001351 0.02863
T+6  0.001330 0.02852
T+7  0.001320 0.02841
T+8  0.001315 0.02831
T+9  0.001313 0.02821
T+10 0.001312 0.02811
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 2.811%.

Model Spec EGARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : eGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above result, it can be seen that EGARCH (1,1) is the resulting model, and the corresponding ARFIMA (1,0,1) is taken.

Model Fit EGARCH:

```
> egfit_TNPL = ugarchfit(spec= eg_spec , data = r_TNPL)
> egfit_TNPL

*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.001662    0.001365    1.2178  0.22329
ar1     0.607260    0.063345    9.5866  0.00000
ma1    -0.651595    0.061962  -10.5161  0.00000
omega  -0.373481    0.006856  -54.4729  0.00000
alpha1  0.079236    0.015311    5.1753  0.00000
beta1   0.948560    0.000132 7204.0504  0.00000
gamma1  0.075628    0.014848    5.0936  0.00000

Robust Standard Errors:
        Estimate  Std. Error    t value Pr(>|t|)
mu      0.001662    0.002514    0.66098 0.508624
ar1     0.607260    0.041942   14.47843 0.000000
ma1    -0.651595    0.028950  -22.50743 0.000000
omega  -0.373481    0.012288  -30.39308 0.000000
alpha1  0.079236    0.031898    2.48408 0.012989
beta1   0.948560    0.000230 4128.89302 0.000000
gamma1  0.075628    0.031141    2.42852 0.015160

LogLikelihood : 1681.725

Information Criteria
------------------------------------

Akaike       -4.5386
Bayes        -4.4949
Shibata      -4.5387
Hannan-Quinn -4.5217

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.06128  0.8045
Lag[2*(p+q)+(p+q)-1][5]   1.67498  0.9928
Lag[4*(p+q)+(p+q)-1][9]   3.81202  0.7342
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                      1.195  0.2742
Lag[2*(p+q)+(p+q)-1][5]     2.439  0.5189
Lag[4*(p+q)+(p+q)-1][9]     3.324  0.7045
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.7976 0.500 2.000  0.3718
ARCH Lag[5]    2.0064 1.440 1.667  0.4698
ARCH Lag[7]    2.2767 2.315 1.543  0.6589

Nyblom stability test
------------------------------------
Joint Statistic:  0.6339
Individual Statistics:
mu     0.18558
ar1    0.03026
ma1    0.02876
omega  0.13229
alpha1 0.05710
beta1  0.12450
gamma1 0.05322

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.69 1.9 2.35
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                    t-value   prob sig
Sign Bias           1.3810 0.1677
Negative Sign Bias  1.6274 0.1041
Positive Sign Bias  0.2452 0.8064
Joint Effect        3.5943 0.3087


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     87.15    1.057e-10
2    30    103.22    2.968e-10
3    40    113.38    3.491e-09
4    50    122.43    3.227e-08


Elapsed time : 0.06765604
```

The model's log-likelihood is calculated to be 1681.725. For TNPL weekly returns, GARCH (1,1) and its corresponding ARFIMA (1,0,1) are optimal. Each of the Optimal Parameters is deemed significant if its corresponding p-value is less than 0.05. Each robust standard error is deemed statistically significant if its corresponding p-value is less than 0.05. The null hypothesis cannot be rejected in the Ljung-box test result portion due to the fact that all p-values for both standardized results and standard squared residuals are significantly greater than 0.05. As a result, there is no evidence of serial autocorrelation, which is a favorable condition for the model. All the p-values in the

Adjusted Pearson goodness-of-fit section are extremely high, indicating that the null hypothesis cannot be rejected and that the difference between the observed and expected values is not significant.

Model Forecast EGARCH:

```
> egforecast_TNPL = ugarchforecast(egfit_TNPL, n.ahead = 10)
> egforecast_TNPL

*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-25]:
      Series   Sigma
T+1  0.003444 0.02733
T+2  0.002744 0.02729
T+3  0.002319 0.02725
T+4  0.002061 0.02721
T+5  0.001904 0.02717
T+6  0.001809 0.02714
T+7  0.001751 0.02710
T+8  0.001716 0.02707
T+9  0.001695 0.02704
T+10 0.001682 0.02702
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 2.702%

4.5.2 TNPL (Weekly)

Model Spec GARCH:

```
*----------------------------------*
*        GARCH Model Spec          *
*----------------------------------*

Conditional Variance Dynamics
------------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
------------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
------------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
> ugfit_TNPL = ugarchfit(spec= ug_spec , data = r_
> ugfit_TNPL

*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.007906    0.004519  1.749417 0.080219
ar1     0.607148    0.370921  1.636865 0.101659
ma1    -0.565310    0.380578 -1.485398 0.137438
omega   0.000041    0.000064  0.649044 0.516310
alpha1  0.000001    0.065896  0.000009 0.999992
beta1   0.984559    0.077225 12.749176 0.000000

Robust Standard Errors:
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.007906    0.005820  1.358510 0.174302
ar1     0.607148    0.146311  4.149723 0.000033
ma1    -0.565310    0.111247 -5.081598 0.000000
omega   0.000041    0.000102  0.405632 0.685013
alpha1  0.000001    0.285305  0.000002 0.999998
beta1   0.984559    0.319658  3.080041 0.002070

LogLikelihood : 242.5098

Information Criteria
------------------------------------

Akaike       -3.0517
Bayes        -2.9339
Shibata      -3.0546
Hannan-Quinn -3.0039

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.2453  0.6204
Lag[2*(p+q)+(p+q)-1][5]    1.3467  0.9995
Lag[4*(p+q)+(p+q)-1][9]    3.8937  0.7157
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                      1.165 0.28053
Lag[2*(p+q)+(p+q)-1][5]     6.137 0.08351
Lag[4*(p+q)+(p+q)-1][9]    12.567 0.01345
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]     1.402 0.500 2.000 0.23647
ARCH Lag[5]     5.548 1.440 1.667 0.07664
ARCH Lag[7]     9.504 2.315 1.543 0.02396
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  0.7005
Individual Statistics:
mu     0.05376
ar1    0.06264
ma1    0.06238
omega  0.13215
alpha1 0.11879
beta1  0.13174

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                    t-value    prob sig
Sign Bias             1.073 0.28497
Negative Sign Bias    1.265 0.20780
Positive Sign Bias    1.243 0.21594
Joint Effect          6.264 0.09943   *


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     30.16     0.049781
2    30     51.13     0.006806
3    40     55.84     0.039304
4    50     66.61     0.047708


Elapsed time : 0.115335
```

The model has a log-likelihood of 242.5098. GARCH (1,1) and ARFIMA (1,0,1) are the daily return models that are considered optimal for TNPL. All parameters, excluding mu, ar1, ma1, alpha1, and omega, are considered significant due to their p-values being less than 0.05. The robustness of standard errors compromises the significance of beta1 when its p-values exceed the threshold of 0.05. The null hypothesis cannot be rejected in the Ljung-box test result portion due to the fact that all p-values associated with standard deviations and standard squared residuals are significantly larger than 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below

0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.008348 0.05163
T+2  0.008174 0.05163
T+3  0.008069 0.05163
T+4  0.008005 0.05163
T+5  0.007966 0.05163
T+6  0.007943 0.05163
T+7  0.007928 0.05163
T+8  0.007920 0.05164
T+9  0.007914 0.05164
T+10 0.007911 0.05164
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 5.164%.

Model Spec EGARCH:

```
*---------------------------------*
*       GARCH Model Spec          *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model             : eGARCH(1,1)
Variance Targeting      : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model              : ARFIMA(1,0,1)
Include Mean            : TRUE
GARCH-in-Mean           : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

Model Fit GARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model      : eGARCH(1,1)
Mean Model       : ARFIMA(1,0,1)
Distribution     : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.008422    0.003336  2.5248e+00 0.011578
ar1     0.510932    0.638782  7.9985e-01 0.423796
ma1    -0.484619    0.655951 -7.3880e-01 0.460026
omega  -0.798117    0.020058 -3.9791e+01 0.000000
alpha1  0.273753    0.064649  4.2344e+00 0.000023
beta1   0.867422    0.000002  4.0976e+05 0.000000
gamma1 -0.136450    0.075906 -1.7976e+00 0.072236

Robust Standard Errors:
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.008422    0.004474      1.8825 0.059774
ar1     0.510932    0.172943      2.9543 0.003133
ma1    -0.484619    0.173721     -2.7896 0.005277
omega  -0.798117    0.029099    -27.4276 0.000000
alpha1  0.273753    0.064664      4.2334 0.000023
beta1   0.867422    0.000001 635427.1719 0.000000
gamma1 -0.136450    0.096439     -1.4149 0.157099

LogLikelihood : 249.6764
```

```
Information Criteria
------------------------------------

Akaike       -3.1313
Bayes        -2.9939
Shibata      -3.1352
Hannan-Quinn -3.0755

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.01668  0.8972
Lag[2*(p+q)+(p+q)-1][5]   0.95683  1.0000
Lag[4*(p+q)+(p+q)-1][9]   3.60333  0.7799
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                      0.617  0.4321
Lag[2*(p+q)+(p+q)-1][5]     2.283  0.5531
Lag[4*(p+q)+(p+q)-1][9]     6.524  0.2424
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.7067 0.500 2.000  0.4005
ARCH Lag[5]    3.8341 1.440 1.667  0.1895
ARCH Lag[7]    6.3794 2.315 1.543  0.1177
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  0.7121
Individual Statistics:
mu      0.09375
ar1     0.02429
ma1     0.02433
omega   0.13905
alpha1 0.05361
beta1   0.13202
gamma1 0.13789

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:          1.69 1.9 2.35
Individual Statistic:     0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           1.3056 0.1937
Negative Sign Bias  0.7166 0.4747
Positive Sign Bias  1.9332 0.0551   *
Joint Effect        5.2732 0.1529


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     28.61       0.07232
2    30     46.10       0.02295
3    40     47.58       0.16292
4    50     57.58       0.18747


Elapsed time : 0.1519399
```

The log-likelihood of the model is 249.6764. TNPL optimizes weekly returns using eGARCH (1,1) and the corresponding ARFIMA (1,0,1). With the exception of mu and alpha1, all other parameters are deemed significant as their p-values are below 0.05. Mu and Alpha1 are deemed insignificant in the context of robust standard errors as their corresponding p-values surpass the threshold of 0.05. In the Ljung-box test result portion, the null hypothesis cannot be rejected because all p-values for standard deviations and standard squared residuals are substantially greater than 0.05. Consequently, serial autocorrelation is not supported by evidence, which is a positive circumstance for the model. The adjusted Pearson goodness-of-fit portion contains p-values, all of which are

less than 0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast GARCH:

```
*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.008548 0.06013
T+2  0.008486 0.05857
T+3  0.008455 0.05724
T+4  0.008439 0.05612
T+5  0.008431 0.05516
T+6  0.008426 0.05435
T+7  0.008424 0.05365
T+8  0.008423 0.05305
T+9  0.008423 0.05253
T+10 0.008422 0.05209
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 5.209%

4.5.3 TNPL (Monthly)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
> ugfit_TNPL = ugarchfit(spec= ug_spec , data = r_
> ugfit_TNPL

*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model      : sGARCH(1,1)
Mean Model       : ARFIMA(1,0,1)
Distribution     : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.007906    0.004519  1.749417 0.080219
ar1     0.607148    0.370921  1.636865 0.101659
ma1    -0.565310    0.380578 -1.485398 0.137438
omega   0.000041    0.000064  0.649044 0.516310
alpha1  0.000001    0.065896  0.000009 0.999992
beta1   0.984559    0.077225 12.749176 0.000000

Robust Standard Errors:
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.007906    0.005820  1.358510 0.174302
ar1     0.607148    0.146311  4.149723 0.000033
ma1    -0.565310    0.111247 -5.081598 0.000000
omega   0.000041    0.000102  0.405632 0.685013
alpha1  0.000001    0.285305  0.000002 0.999998
beta1   0.984559    0.319658  3.080041 0.002070

LogLikelihood : 242.5098

Information Criteria
------------------------------------

Akaike       -3.0517
Bayes        -2.9339
Shibata      -3.0546
Hannan-Quinn -3.0039

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.2453  0.6204
Lag[2*(p+q)+(p+q)-1][5]    1.3467  0.9995
Lag[4*(p+q)+(p+q)-1][9]    3.8937  0.7157
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                      1.165 0.28053
Lag[2*(p+q)+(p+q)-1][5]     6.137 0.08351
Lag[4*(p+q)+(p+q)-1][9]    12.567 0.01345
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]     1.402 0.500 2.000 0.23647
ARCH Lag[5]     5.548 1.440 1.667 0.07664
ARCH Lag[7]     9.504 2.315 1.543 0.02396
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  0.7005
Individual Statistics:
mu     0.05376
ar1    0.06264
ma1    0.06238
omega  0.13215
alpha1 0.11879
beta1  0.13174

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                    t-value    prob sig
Sign Bias             1.073 0.28497
Negative Sign Bias    1.265 0.20780
Positive Sign Bias    1.243 0.21594
Joint Effect          6.264 0.09943   *


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     30.16     0.049781
2    30     51.13     0.006806
3    40     55.84     0.039304
4    50     66.61     0.047708


Elapsed time : 0.115335
```

The model has a log-likelihood of 242.5098. GARCH (1,1) and ARFIMA (1,0,1) are the daily return models that are considered optimal for TNPL. All parameters, excluding mu, ar1, ma1, alpha1, and omega, are considered significant due to their p-values being less than 0.05. The robustness of standard errors compromises the significance of beta1 when its p-values exceed the threshold of 0.05. The null hypothesis cannot be rejected in the Ljung-box test result portion due to the fact that all p-values associated with standard deviations and standard squared residuals are significantly larger than 0.05. As a result,

the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.008348 0.05163
T+2  0.008174 0.05163
T+3  0.008069 0.05163
T+4  0.008005 0.05163
T+5  0.007966 0.05163
T+6  0.007943 0.05163
T+7  0.007928 0.05163
T+8  0.007920 0.05164
T+9  0.007914 0.05164
T+10 0.007911 0.05164
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 5.164%.

Model Spec EGARCH:

```
*---------------------------------*
*       GARCH Model Spec          *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model             : eGARCH(1,1)
Variance Targeting      : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model              : ARFIMA(1,0,1)
Include Mean            : TRUE
GARCH-in-Mean           : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

Model Fit GARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.008422    0.003336  2.5248e+00 0.011578
ar1     0.510932    0.638782  7.9985e-01 0.423796
ma1    -0.484619    0.655951 -7.3880e-01 0.460026
omega  -0.798117    0.020058 -3.9791e+01 0.000000
alpha1  0.273753    0.064649  4.2344e+00 0.000023
beta1   0.867422    0.000002  4.0976e+05 0.000000
gamma1 -0.136450    0.075906 -1.7976e+00 0.072236

Robust Standard Errors:
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.008422    0.004474      1.8825 0.059774
ar1     0.510932    0.172943      2.9543 0.003133
ma1    -0.484619    0.173721     -2.7896 0.005277
omega  -0.798117    0.029099    -27.4276 0.000000
alpha1  0.273753    0.064664      4.2334 0.000023
beta1   0.867422    0.000001 635427.1719 0.000000
gamma1 -0.136450    0.096439     -1.4149 0.157099

LogLikelihood : 249.6764
```

```
Information Criteria
------------------------------------

Akaike       -3.1313
Bayes        -2.9939
Shibata      -3.1352
Hannan-Quinn -3.0755

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                    0.01668  0.8972
Lag[2*(p+q)+(p+q)-1][5]   0.95683  1.0000
Lag[4*(p+q)+(p+q)-1][9]   3.60333  0.7799
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                      0.617  0.4321
Lag[2*(p+q)+(p+q)-1][5]     2.283  0.5531
Lag[4*(p+q)+(p+q)-1][9]     6.524  0.2424
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.7067 0.500 2.000  0.4005
ARCH Lag[5]    3.8341 1.440 1.667  0.1895
ARCH Lag[7]    6.3794 2.315 1.543  0.1177
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  0.7121
Individual Statistics:
mu      0.09375
ar1     0.02429
ma1     0.02433
omega   0.13905
alpha1 0.05361
beta1   0.13202
gamma1 0.13789

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:          1.69 1.9 2.35
Individual Statistic:     0.35 0.47 0.75

Sign Bias Test
------------------------------------
                    t-value   prob sig
Sign Bias           1.3056 0.1937
Negative Sign Bias  0.7166 0.4747
Positive Sign Bias  1.9332 0.0551   *
Joint Effect        5.2732 0.1529


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     28.61      0.07232
2    30     46.10      0.02295
3    40     47.58      0.16292
4    50     57.58      0.18747


Elapsed time : 0.1519399
```

The log-likelihood of the model is 249.6764. TNPL optimizes weekly returns using eGARCH (1,1) and the corresponding ARFIMA (1,0,1). With the exception of mu and alpha1, all other parameters are deemed significant as their p-values are below 0.05. Mu and Alpha1 are deemed insignificant in the context of robust standard errors as their corresponding p-values surpass the threshold of 0.05. In the Ljung-box test result portion, the null hypothesis cannot be rejected because all p-values for standard deviations and standard squared residuals are substantially greater than 0.05. Consequently, serial autocorrelation is not supported by evidence, which is a positive circumstance for the

model. The adjusted Pearson goodness-of-fit portion contains p-values, all of which are less than 0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast GARCH:

```
*-------------------------------------*
*       GARCH Model Forecast          *
*-------------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.008548 0.06013
T+2  0.008486 0.05857
T+3  0.008455 0.05724
T+4  0.008439 0.05612
T+5  0.008431 0.05516
T+6  0.008426 0.05435
T+7  0.008424 0.05365
T+8  0.008423 0.05305
T+9  0.008423 0.05253
T+10 0.008422 0.05209
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 5.209%

4.6 Vaibhav Global Ltd.

4.5.1 VAIBHAVGBL (Daily)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
> ugfit_VAIBHAVGBL = ugarchfit(spec= ug_spec , data = r_VAIBHAVGBL)
> ugfit_VAIBHAVGBL

*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.000435    0.000953  0.45628 0.648187
ar1    -0.096631    0.325379 -0.29698 0.766481
ma1     0.179762    0.320479  0.56092 0.574855
omega   0.000115    0.000045  2.52801 0.011471
alpha1  0.185342    0.053825  3.44344 0.000574
beta1   0.676186    0.094595  7.14823 0.000000

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.000435    0.000895  0.48594 0.627013
ar1    -0.096631    0.242267 -0.39886 0.689993
ma1     0.179762    0.234963  0.76507 0.444232
omega   0.000115    0.000093  1.24007 0.214951
alpha1  0.185342    0.095302  1.94480 0.051799
beta1   0.676186    0.186454  3.62656 0.000287

LogLikelihood : 1645.91

Information Criteria
------------------------------------

Akaike       -4.4502
Bayes        -4.4128
Shibata      -4.4504
Hannan-Quinn -4.4358

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                   0.004943  0.9440
Lag[2*(p+q)+(p+q)-1][5]  0.563044  1.0000
Lag[4*(p+q)+(p+q)-1][9]  0.956363  0.9998
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.4456  0.5045
Lag[2*(p+q)+(p+q)-1][5]    0.6062  0.9401
Lag[4*(p+q)+(p+q)-1][9]    1.0893  0.9823
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]   0.05113 0.500 2.000  0.8211
ARCH Lag[5]   0.39591 1.440 1.667  0.9138
ARCH Lag[7]   0.61752 2.315 1.543  0.9665

Nyblom stability test
------------------------------------
Joint Statistic:  0.9291
Individual Statistics:
mu     0.20416
ar1    0.03654
ma1    0.03481
omega  0.12488
alpha1 0.24381
beta1  0.14417

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75
```

```
Sign Bias Test
------------------------------------
                    t-value   prob sig
Sign Bias          0.60405 0.5460
Negative Sign Bias 0.04631 0.9631
Positive Sign Bias 0.80882 0.4189
Joint Effect       0.76759 0.8572


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     99.55    6.451e-13
2    30    117.53    1.284e-12
3    40    128.51    1.745e-11
4    50    131.86    1.589e-09


Elapsed time : 0.06069303
```

The model has a log-likelihood of 1654.91. GARCH (1,1) and ARFIMA (1,0,1) are the daily return models that are deemed optimal for VAIBHAVGBL. Except for mu, ar1, and ma1, the p-values of all other parameters are less than 0.05, thus indicating their significance. The robustness of standard errors compromises the significance of omega, alpha1, and beta1 when their p-values exceed the threshold of 0.05. The null hypothesis cannot be rejected in the Ljung-box test result portion due to the fact that all p-values associated with standard deviations and standard squared residuals are significantly larger than 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
> ugforecast_VAIBHAVGBL = ugarchforecast(ugfit_VAIBHAVGBL, n.ahead = 10)
> ugforecast_VAIBHAVGBL

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-25]:
         Series   Sigma
T+1  -0.0001462 0.02818
T+2   0.0004908 0.02827
T+3   0.0004293 0.02834
T+4   0.0004352 0.02840
T+5   0.0004346 0.02846
T+6   0.0004347 0.02850
T+7   0.0004347 0.02855
T+8   0.0004347 0.02858
T+9   0.0004347 0.02861
T+10  0.0004347 0.02864
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 2.864%.

Model Spec EGARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : eGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution     :  norm
Includes Skew    :  FALSE
Includes Shape   :  FALSE
Includes Lambda  :  FALSE
```

From the above result, it can be seen that EGARCH (1,1) is the resulting model, and the corresponding ARFIMA (1,0,1) is taken.

Model Fit EGARCH:

```
> egfit_VAIBHAVGBL = ugarchfit(spec= eg_spec , data = r_VAIBHAVGBL)
> egfit_VAIBHAVGBL

*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model      : eGARCH(1,1)
Mean Model       : ARFIMA(1,0,1)
Distribution     : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.000783    0.001010   0.77552 0.438034
ar1    -0.256377    0.023747 -10.79616 0.000000
ma1     0.339593    0.022222  15.28210 0.000000
omega  -1.064143    0.374536  -2.84123 0.004494
alpha1  0.020624    0.034125   0.60438 0.545592
beta1   0.850583    0.051753  16.43547 0.000000
gamma1  0.292895    0.067484   4.34024 0.000014

Robust Standard Errors:
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.000783    0.001092   0.71743 0.473110
ar1    -0.256377    0.014813 -17.30735 0.000000
ma1     0.339593    0.013348  25.44067 0.000000
omega  -1.064143    0.654839  -1.62505 0.104153
alpha1  0.020624    0.044664   0.46177 0.644246
beta1   0.850583    0.090392   9.40996 0.000000
gamma1  0.292895    0.124269   2.35694 0.018426

LogLikelihood : 1649.639

Information Criteria
------------------------------------

Akaike       -4.4576
Bayes        -4.4139
Shibata      -4.4578
Hannan-Quinn -4.4408

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                   0.007037  0.9331
Lag[2*(p+q)+(p+q)-1][5]  0.343472  1.0000
Lag[4*(p+q)+(p+q)-1][9]  0.687995  1.0000
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.1428  0.7056
Lag[2*(p+q)+(p+q)-1][5]    0.4663  0.9628
Lag[4*(p+q)+(p+q)-1][9]    1.1538  0.9790
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.1096 0.500 2.000  0.7406
ARCH Lag[5]    0.5503 1.440 1.667  0.8687
ARCH Lag[7]    0.8965 2.315 1.543  0.9298

Nyblom stability test
------------------------------------
Joint Statistic:  1.0717
Individual Statistics:
mu     0.12106
ar1    0.04103
ma1    0.04819
omega  0.10584
alpha1 0.21806
beta1  0.09927
gamma1 0.10582

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.69 1.9 2.35
Individual Statistic:    0.35 0.47 0.75
```

```
Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           0.1474 0.8828
Negative Sign Bias  0.1473 0.8829
Positive Sign Bias  0.3379 0.7355
Joint Effect        0.2480 0.9695


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     95.16    3.994e-12
2    30    109.88    2.423e-11
3    40    130.35    8.982e-12
4    50    143.12    3.756e-11


Elapsed time : 0.06279898
```

The model's log-likelihood is calculated to be 1649.639. For VAIBHAVGBL weekly returns, GARCH (1,1) and its corresponding ARFIMA (1,0,1) are optimal. Each of the Optimal Parameters is deemed significant if its corresponding p-value is less than 0.05. Each robust standard error is deemed statistically significant if its corresponding p-value is less than 0.05. The null hypothesis cannot be rejected in the Ljung-box test result portion due to the fact that all p-values for both standardized results and standard squared residuals are significantly greater than 0.05. As a result, there is no evidence of serial autocorrelation, which is a favorable condition for the model. All the p-values in the Adjusted Pearson goodness-of-fit section are extremely high, indicating that the null hypothesis cannot be rejected and that the difference between the observed and expected values is not significant.

Model Forecast EGARCH:

```
> egforecast_VAIBHAVGBL = ugarchforecast(egfit_VAIBHAVGBL, n.ahead = 10)
> egforecast_VAIBHAVGBL

*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-25]:
       Series   Sigma
T+1  0.0007734 0.02799
T+2  0.0007860 0.02805
T+3  0.0007827 0.02810
T+4  0.0007836 0.02815
T+5  0.0007834 0.02819
T+6  0.0007834 0.02822
T+7  0.0007834 0.02825
T+8  0.0007834 0.02827
T+9  0.0007834 0.02829
T+10 0.0007834 0.02831
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 2.831%

4.6.2 VAIBHAVGBL (Weekly)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
> ugfit_VAIBHAVGBL = ugarchfit(spec= ug_spec , data
> ugfit_VAIBHAVGBL

*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model      : sGARCH(1,1)
Mean Model       : ARFIMA(1,0,1)
Distribution     : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.002010    0.006811    0.295124  0.76790
ar1     0.919475    0.134426    6.840017  0.00000
ma1    -0.889092    0.153180   -5.804236  0.00000
omega   0.000000    0.000008    0.000001  1.00000
alpha1  0.000001    0.000317    0.002216  0.99823
beta1   0.998697    0.000368 2711.175772  0.00000

Robust Standard Errors:
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.002010    0.007748    0.259435   0.7953
ar1     0.919475    0.087198   10.544695   0.0000
ma1    -0.889092    0.081996  -10.843182   0.0000
omega   0.000000    0.000007    0.000001   1.0000
alpha1  0.000001    0.000431    0.001634   0.9987
beta1   0.998697    0.000251 3977.220721   0.0000

LogLikelihood : 215.096
```

```
Information Criteria
------------------------------------

Akaike       -2.6980
Bayes        -2.5802
Shibata      -2.7009
Hannan-Quinn -2.6502

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                  5.576e-05  0.9940
Lag[2*(p+q)+(p+q)-1][5] 6.947e-01  1.0000
Lag[4*(p+q)+(p+q)-1][9] 1.655e+00  0.9947
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                   0.008801  0.9253
Lag[2*(p+q)+(p+q)-1][5]  0.469312  0.9623
Lag[4*(p+q)+(p+q)-1][9]  1.470336  0.9580
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.1409 0.500 2.000  0.7074
ARCH Lag[5]    1.1338 1.440 1.667  0.6937
ARCH Lag[7]    1.6268 2.315 1.543  0.7956
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  6.7859
Individual Statistics:
mu      0.15946
ar1     0.08847
ma1     0.08942
omega   0.15438
alpha1 0.10934
beta1   0.12870

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
-------------------------------------
                    t-value    prob sig
Sign Bias           0.6444 0.52029
Negative Sign Bias  0.7833 0.43468
Positive Sign Bias  1.0290 0.30513
Joint Effect        6.4183 0.09294   *


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     31.19      0.03844
2    30     39.13      0.09922
3    40     45.52      0.21920
4    50     56.94      0.20368


Elapsed time : 0.5597119
```

The model has a log-likelihood of 215.096. GARCH (1,1) and ARFIMA (1,0,1) are the daily return models that are deemed optimal for VAIBHAVGBL. All parameters, excluding mu, alpha1, and omega, are considered significant due to the fact that their p-values are all less than 0.05. When considering robust standard errors, the significance of ar1, ma1, and beta1 is compromised because their p-values exceed the threshold of 0.05. The null hypothesis cannot be rejected in the Ljung-box test result portion due to the fact that all p-values associated with standard deviations and standard squared residuals are significantly larger than 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
> ugforecast_VAIBHAVGBL = ugarchforecas
> ugforecast_VAIBHAVGBL

*-----------------------------------*
*       GARCH Model Forecast        *
*-----------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.001589 0.05477
T+2  0.001623 0.05473
T+3  0.001654 0.05470
T+4  0.001683 0.05466
T+5  0.001709 0.05463
T+6  0.001733 0.05459
T+7  0.001756 0.05456
T+8  0.001776 0.05452
T+9  0.001795 0.05449
T+10 0.001812 0.05445
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 5.445%.

Model Spec EGARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model             : eGARCH(1,1)
Variance Targeting      : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model              : ARFIMA(1,0,1)
Include Mean            : TRUE
GARCH-in-Mean           : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

Model Fit EGARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : eGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.001146    0.003416   0.33539 0.737329
ar1     0.941978    0.057407  16.40876 0.000000
ma1    -0.936175    0.073890 -12.66979 0.000000
omega  -7.457771    0.860728  -8.66449 0.000000
alpha1  0.552423    0.109733   5.03425 0.000000
beta1  -0.295048    0.152421  -1.93574 0.052899
gamma1 -0.211376    0.067097  -3.15028 0.001631

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.001146    0.004592   0.2495 0.802972
ar1     0.941978    0.076258  12.3526 0.000000
ma1    -0.936175    0.080332 -11.6539 0.000000
omega  -7.457771    0.801015  -9.3104 0.000000
alpha1  0.552423    0.127901   4.3192 0.000016
beta1  -0.295048    0.140303  -2.1029 0.035471
gamma1 -0.211376    0.167004  -1.2657 0.205623

LogLikelihood : 225.1287
```

```
Information Criteria
------------------------------------

Akaike       -2.8146
Bayes        -2.6771
Shibata      -2.8184
Hannan-Quinn -2.7587

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.1911  0.6620
Lag[2*(p+q)+(p+q)-1][5]    0.7024  1.0000
Lag[4*(p+q)+(p+q)-1][9]    1.1642  0.9994
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                   0.007381  0.9315
Lag[2*(p+q)+(p+q)-1][5]  0.493195  0.9587
Lag[4*(p+q)+(p+q)-1][9]  1.378650  0.9649
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]   0.07369 0.500 2.000  0.7860
ARCH Lag[5]   0.43171 1.440 1.667  0.9036
ARCH Lag[7]   1.10725 2.315 1.543  0.8955
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  0.7986
Individual Statistics:
mu      0.12974
ar1     0.05464
ma1     0.05468
omega   0.06776
alpha1 0.22493
beta1   0.06963
gamma1 0.06526

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:          1.69 1.9 2.35
Individual Statistic:     0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           0.4549 0.6498
Negative Sign Bias  0.0477 0.9620
Positive Sign Bias  0.3347 0.7383
Joint Effect        0.2658 0.9663


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     36.35     0.009545
2    30     42.61     0.049415
3    40     59.97     0.017038
4    50     80.81     0.002844


Elapsed time : 0.504118
```

The log-likelihood of the model is 225.1287. VAIBHAVGBL optimizes weekly returns using eGARCH (1,1) and the corresponding ARFIMA (1,0,1). With the exception of mu and alpha1, all other parameters are deemed significant as their p-values are below 0.05. Mu and Alpha1 are deemed insignificant in the context of robust standard errors as their corresponding p-values surpass the threshold of 0.05. In the Ljung-box test result portion, the null hypothesis cannot be rejected because all p-values for standard deviations and standard squared residuals are substantially greater than 0.05. Consequently, serial autocorrelation is not supported by evidence, which is a positive circumstance for the model. The adjusted Pearson goodness-of-fit portion contains p-values, all of which are

less than 0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast EGARCH:

```
*-----------------------------------*
*       GARCH Model Forecast        *
*-----------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.001500 0.03063
T+2  0.001479 0.06718
T+3  0.001460 0.05328
T+4  0.001442 0.05705
T+5  0.001424 0.05591
T+6  0.001408 0.05625
T+7  0.001393 0.05615
T+8  0.001379 0.05618
T+9  0.001365 0.05617
T+10 0.001352 0.05617
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 5.617%

5.6.3 VAIBHAVGBL (Monthly)

Model Spec GARCH:

```
*----------------------------------*
*       GARCH Model Spec           *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model              : sGARCH(1,1)
Variance Targeting       : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model               : ARFIMA(1,0,1)
Include Mean             : TRUE
GARCH-in-Mean            : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

From the above specs, it can be seen that GARCH (1,1) is the best model, and the corresponding ARFIMA taken is (1,0,1).

Model Fit GARCH:

```
> ugfit_VAIBHAVGBL = ugarchfit(spec= ug_spec , data
> ugfit_VAIBHAVGBL

*---------------------------------*
*          GARCH Model Fit        *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model     : sGARCH(1,1)
Mean Model      : ARFIMA(1,0,1)
Distribution    : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.002010    0.006811    0.295124  0.76790
ar1     0.919475    0.134426    6.840017  0.00000
ma1    -0.889092    0.153180   -5.804236  0.00000
omega   0.000000    0.000008    0.000001  1.00000
alpha1  0.000001    0.000317    0.002216  0.99823
beta1   0.998697    0.000368 2711.175772  0.00000

Robust Standard Errors:
        Estimate  Std. Error     t value Pr(>|t|)
mu      0.002010    0.007748    0.259435   0.7953
ar1     0.919475    0.087198   10.544695   0.0000
ma1    -0.889092    0.081996  -10.843182   0.0000
omega   0.000000    0.000007    0.000001   1.0000
alpha1  0.000001    0.000431    0.001634   0.9987
beta1   0.998697    0.000251 3977.220721   0.0000

LogLikelihood : 215.096
```

```
Information Criteria
------------------------------------

Akaike       -2.6980
Bayes        -2.5802
Shibata      -2.7009
Hannan-Quinn -2.6502

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                  5.576e-05  0.9940
Lag[2*(p+q)+(p+q)-1][5] 6.947e-01  1.0000
Lag[4*(p+q)+(p+q)-1][9] 1.655e+00  0.9947
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                   0.008801  0.9253
Lag[2*(p+q)+(p+q)-1][5]  0.469312  0.9623
Lag[4*(p+q)+(p+q)-1][9]  1.470336  0.9580
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]    0.1409 0.500 2.000  0.7074
ARCH Lag[5]    1.1338 1.440 1.667  0.6937
ARCH Lag[7]    1.6268 2.315 1.543  0.7956
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  6.7859
Individual Statistics:
mu     0.15946
ar1    0.08847
ma1    0.08942
omega  0.15438
alpha1 0.10934
beta1  0.12870

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:         1.49 1.68 2.12
Individual Statistic:    0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value    prob sig
Sign Bias           0.6444 0.52029
Negative Sign Bias  0.7833 0.43468
Positive Sign Bias  1.0290 0.30513
Joint Effect        6.4183 0.09294   *


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     31.19      0.03844
2    30     39.13      0.09922
3    40     45.52      0.21920
4    50     56.94      0.20368


Elapsed time : 0.5597119
```

The model has a log-likelihood of 215.096. GARCH (1,1) and ARFIMA (1,0,1) are the daily return models that are deemed optimal for VAIBHAVGBL. All parameters, excluding mu, alpha1, and omega, are considered significant due to the fact that their p-values are all less than 0.05. When considering robust standard errors, the significance of ar1, ma1, and beta1 is compromised because their p-values exceed the threshold of 0.05. The null hypothesis cannot be rejected in the Ljung-box test result portion due to

the fact that all p-values associated with standard deviations and standard squared residuals are significantly larger than 0.05. As a result, the evidence does not support serial autocorrelation, which is advantageous for the model. Each of the p-values in the adjusted Pearson goodness-of-fit portion is below 0.05. This finding suggests that the null hypothesis can be refuted, implying that there is a discrepancy between the observed and expected values in this particular case.

Model Forecast GARCH:

```
> ugforecast_VAIBHAVGBL = ugarchforecas
> ugforecast_VAIBHAVGBL

*----------------------------------*
*       GARCH Model Forecast       *
*----------------------------------*
Model: sGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.001589 0.05477
T+2  0.001623 0.05473
T+3  0.001654 0.05470
T+4  0.001683 0.05466
T+5  0.001709 0.05463
T+6  0.001733 0.05459
T+7  0.001756 0.05456
T+8  0.001776 0.05452
T+9  0.001795 0.05449
T+10 0.001812 0.05445
```

The results show that the returns will be positive on average for the next 10 days with standard deviation of 5.445%.

Model Spec EGARCH:

```
*---------------------------------*
*       GARCH Model Spec          *
*---------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model             : eGARCH(1,1)
Variance Targeting      : FALSE

Conditional Mean Dynamics
-----------------------------------
Mean Model              : ARFIMA(1,0,1)
Include Mean            : TRUE
GARCH-in-Mean           : FALSE

Conditional Distribution
-----------------------------------
Distribution    :  norm
Includes Skew   :  FALSE
Includes Shape  :  FALSE
Includes Lambda :  FALSE
```

Model Fit EGARCH:

```
*----------------------------------*
*          GARCH Model Fit         *
*----------------------------------*

Conditional Variance Dynamics
-----------------------------------
GARCH Model      : eGARCH(1,1)
Mean Model       : ARFIMA(1,0,1)
Distribution     : norm

Optimal Parameters
------------------------------------
        Estimate  Std. Error   t value Pr(>|t|)
mu      0.001146    0.003416   0.33539 0.737329
ar1     0.941978    0.057407  16.40876 0.000000
ma1    -0.936175    0.073890 -12.66979 0.000000
omega  -7.457771    0.860728  -8.66449 0.000000
alpha1  0.552423    0.109733   5.03425 0.000000
beta1  -0.295048    0.152421  -1.93574 0.052899
gamma1 -0.211376    0.067097  -3.15028 0.001631

Robust Standard Errors:
        Estimate  Std. Error  t value Pr(>|t|)
mu      0.001146    0.004592   0.2495 0.802972
ar1     0.941978    0.076258  12.3526 0.000000
ma1    -0.936175    0.080332 -11.6539 0.000000
omega  -7.457771    0.801015  -9.3104 0.000000
alpha1  0.552423    0.127901   4.3192 0.000016
beta1  -0.295048    0.140303  -2.1029 0.035471
gamma1 -0.211376    0.167004  -1.2657 0.205623

LogLikelihood : 225.1287
```

```
Information Criteria
------------------------------------

Akaike       -2.8146
Bayes        -2.6771
Shibata      -2.8184
Hannan-Quinn -2.7587

Weighted Ljung-Box Test on Standardized Residuals
------------------------------------
                        statistic p-value
Lag[1]                     0.1911  0.6620
Lag[2*(p+q)+(p+q)-1][5]    0.7024  1.0000
Lag[4*(p+q)+(p+q)-1][9]    1.1642  0.9994
d.o.f=2
H0 : No serial correlation

Weighted Ljung-Box Test on Standardized Squared Residuals
------------------------------------
                        statistic p-value
Lag[1]                   0.007381  0.9315
Lag[2*(p+q)+(p+q)-1][5]  0.493195  0.9587
Lag[4*(p+q)+(p+q)-1][9]  1.378650  0.9649
d.o.f=2

Weighted ARCH LM Tests
------------------------------------
            Statistic Shape Scale P-Value
ARCH Lag[3]   0.07369 0.500 2.000  0.7860
ARCH Lag[5]   0.43171 1.440 1.667  0.9036
ARCH Lag[7]   1.10725 2.315 1.543  0.8955
```

```
Nyblom stability test
------------------------------------
Joint Statistic:  0.7986
Individual Statistics:
mu      0.12974
ar1     0.05464
ma1     0.05468
omega   0.06776
alpha1 0.22493
beta1   0.06963
gamma1 0.06526

Asymptotic Critical Values (10% 5% 1%)
Joint Statistic:          1.69 1.9 2.35
Individual Statistic:     0.35 0.47 0.75

Sign Bias Test
------------------------------------
                   t-value   prob sig
Sign Bias           0.4549 0.6498
Negative Sign Bias  0.0477 0.9620
Positive Sign Bias  0.3347 0.7383
Joint Effect        0.2658 0.9663


Adjusted Pearson Goodness-of-Fit Test:
------------------------------------
  group statistic p-value(g-1)
1    20     36.35     0.009545
2    30     42.61     0.049415
3    40     59.97     0.017038
4    50     80.81     0.002844


Elapsed time : 0.504118
```

The log-likelihood of the model is 225.1287. VAIBHAVGBL optimizes weekly returns using eGARCH (1,1) and the corresponding ARFIMA (1,0,1). With the exception of mu and alpha1, all other parameters are deemed significant as their p-values are below 0.05. Mu and Alpha1 are deemed insignificant in the context of robust standard errors as their corresponding p-values surpass the threshold of 0.05. In the Ljung-box test result portion, the null hypothesis cannot be rejected because all p-values for standard deviations and

standard squared residuals are substantially greater than 0.05. Consequently, serial autocorrelation is not supported by evidence, which is a positive circumstance for the model. The adjusted Pearson goodness-of-fit portion contains p-values, all of which are less than 0.05. This indicates that the null hypothesis can be rejected, suggesting that the observed values and expected values are distinct in this instance.

Model Forecast EGARCH:

```
*------------------------------------*
*       GARCH Model Forecast         *
*------------------------------------*
Model: eGARCH
Horizon: 10
Roll Steps: 0
Out of Sample: 0

0-roll forecast [T0=2023-10-22]:
       Series   Sigma
T+1  0.001500 0.03063
T+2  0.001479 0.06718
T+3  0.001460 0.05328
T+4  0.001442 0.05705
T+5  0.001424 0.05591
T+6  0.001408 0.05625
T+7  0.001393 0.05615
T+8  0.001379 0.05618
T+9  0.001365 0.05617
T+10 0.001352 0.05617
```

The results show that the returns will be positive on average for the next 10 days with a standard deviation of 5.617%

SECTION 5: Value at Risk

Portfolio of these 6 companies

5. Value at Risk

A financial risk management indicator called Value at Risk, or VaR, projects possible losses in a portfolio or investment over a certain period of time with a given degree of confidence. Computed through historical data or models, it quantifies the maximum loss with a given probability. VaR aids in setting risk limits and strategic portfolio decisions in financial institutions.

5.1 Our Portfolio

Stocks -

- Renaissance Global Ltd
- Seamec Limited
- Somany Ceramics Ltd
- Tainwala Chemicals and Plastics (India) Ltd
- Tamil Nadu Petroproducts Limited
- Vadilal Industries Ltd

Quantity-

- RGL-500
- SOMANYCERA-500
- SEAMECLTD-500
- TAINWALCHM-500
- TNPETRO-500
- VADILALIND-500

5.2 Confidence interval under observation - More than 75%.

To assess our portfolio's value at risk (VaR), we begin by determining the total invested capital. This involves multiplying the number of shares held by each firm by their respective stock prices. Subsequently, the VaR is employed to compute the maximum potential loss at various confidence intervals.

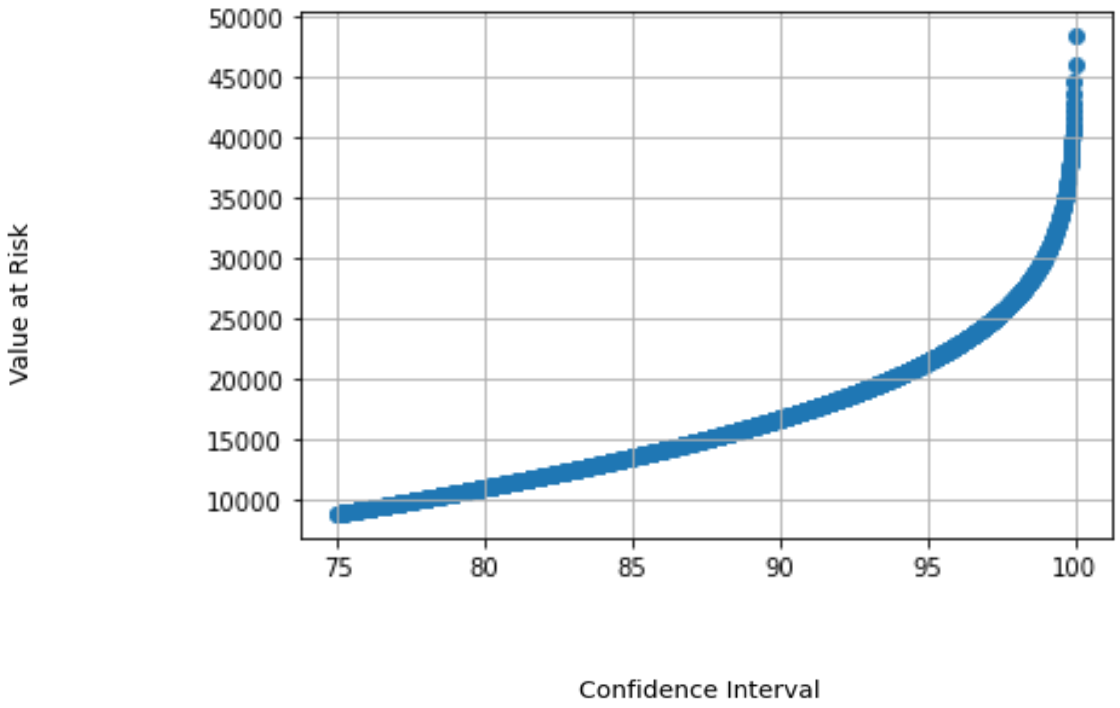


Figure 92: VaR vs Confidence Interval for the Portfolio

5.3 Graphical Interpretation

The graph in the above figure illustrates the different values at risk in relation to the confidence intervals. As an example, a maximum of approximately 22,864 Rs can be lost with confidence of around 95%.