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SENIOR THESIS

«THE SPEED OF MEAN REVERSION IN INTERNATIONAL STOCK MARKETS»

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Abstract

Given the widespread belief that stock index prices are ever-changing, this study offers proof of mean reversion and volatility in important emerging and developed financial markets. It seeks to determine a connection between these variations and the performance of indexes of the world's financial indices. The findings indicate that prices do not systematically change over time in the presence of stability. Conversely, trends and random fluctuations may exist if the Index is not stationary. According to the analysis, only 10 out of the 46 countries in the sample exhibit mean reversion behavior. The interpretation of this behavior is explained through mean reversion and the Hurst exponent.

Keywords: *mean reversion, stock markets, returns, developed emerging stock markets, stationarity, indices, half-life, hurst exponent*

Περίληψη

Με τη γενική πεποίθηση ότι οι τιμές των χρηματιστηριακών δεικτών μεταβάλλονται συνεχώς, η μελέτη αυτή παρέχει στοιχεία μέσης αναστροφής και διακυμάνσεων μεταξύ σημαντικών αναδυόμενων και ανεπτυγμένων χρηματοπιστωτικών αγορών. Στόχος της είναι να δημιουργήσει μια σχέση μεταξύ αυτών των διακυμάνσεων και της απόδοσης των δεικτών των παγκόσμιων χρηματοπιστωτικών αγορών. Τα ευρήματα δείχνουν ότι οι τιμές δεν μεταβάλλονται συστηματικά με την πάροδο του χρόνου παρουσία σταθερότητας. Αντιστρόφως, τάσεις και τυχαίες διακυμάνσεις μπορεί να υπάρχουν εάν ο δείκτης δεν είναι στάσιμος. Σύμφωνα με την ανάλυση, μόνο 10 από τις 46 χώρες του δείγματος παρουσιάζουν μέση συμπεριφορά αναστροφής. Η ερμηνεία αυτής της συμπεριφοράς εξηγείται μέσω της μέσης αναστροφής και του εκθέτη Hurst.

Λέξεις-κλειδιά: *μέση αναστροφή, χρηματιστηριακές αγορές, αποδόσεις, ανεπτυγμένες αναδυόμενες χρηματιστηριακές αγορές, στασιμότητα, δείκτες, half-life, εκθέτης Hurst*

1. Introduction

1.1 Background of the study.

Since the 1970s, a central proposition in asset pricing models has gained prominence in determining market prices. This widely accepted assertion, which is recognized as a fundamental concept in finance, is known as the efficient market hypothesis. Considering this theory, all the information necessary for assessing a firm is reflected in its prices, making it nearly impossible for any individual to achieve higher-than-average returns consistently. Nevertheless, many investors believe that by carefully examining securities, they can identify those that have previously underperformed but have the potential for better returns in the future. As a result, these investors employ various techniques to identify undervalued stocks.

In spite of the random walk theory and the efficient market hypothesis, investors' opinions can also be explained by the idea of mean reversion. So, “Mean reversion” describes the process by which prices, having reached extreme values, return to their average values (Palwasha R.I. et al., 2017). The subject of mean reversion in stock market prices has drawn increasing attention in the literature on financial economics. Certain studies examine the predictability of stock price returns by examining whether they exhibit random walk or mean reversion trends (Liew, V. K., and Kim, K. (2007). This hypothesis gives rise to the idea of mean reversion in relation to stock prices, which holds that an increase in price is typically followed by a decline in price. However, a drop in price typically occurs first.

1.2 Explanation of Mean Reversion.

Mean reversion is the term used in finance to describe an asset price or financial indicator's tendency to eventually return to its historical mean or average. Stated differently, a financial variable that exhibits mean reversion tends to revert to its long-term average or central tendency following a deviation from it.

A variety of financial instruments and economic indicators, including stock prices, exchange rates, interest rates, commodity prices, and more, can be impacted by mean reversion. It implies that moves in the opposite direction are likely to occur after significant departures from the mean, bringing the variable closer to its average value. For instance, mean reversion in the context of stock prices suggests that a certain stock may be expected to eventually return to its historical average if it has gone through a

period of tremendous price growth and is now much higher than that average. Similarly, suppose a currency exchange rate is significantly overvalued or undervalued compared to its historical average. In that case, mean reversion suggests it may adjust to its long-term average exchange rate.

Mean reversion is critical in various financial strategies and trading approaches, such as contrarian investing. In this approach, investors may buy assets that have recently underperformed in the expectation that they will revert to their historical mean, potentially providing opportunities for profit. However, mean reversion is not guaranteed to occur in every case, and market conditions and other factors can influence whether and how quickly mean reversion takes place.

A number of variables, such as market efficiency, investor sentiment, economic fundamentals, and market liquidity, might affect the rate of mean reversion. In more efficient markets, mean reversion tends to happen more quickly because prices swiftly adjust to incorporate all available information. Conversely, in less efficient or speculative markets, mean reversion can be slower, with prices deviating from their averages for extended periods due to behavioral biases or irrational market behavior.
Furthermore, mean reversion speed can vary across international stock markets. Factors like market structure, regulatory frameworks, and cultural influences contribute to the differing rates of mean reversion observed worldwide. Consequently, studying the pace of mean reversion in international stock markets offers insights into how local and global factors shape market dynamics.

The speed of mean reversion in global stock markets is analyzed and estimated by researchers and practitioners using a variety of statistical and econometric models, including vector error correction models (VECM), autoregressive integrated moving averages (ARIMA), and stochastic volatility models. These models help capture the underlying patterns in asset prices and provide quantitative measures of mean reversion speed, which can enhance risk management and investment strategies.

1.3 The goal and explanation of the problem.

The purpose of the study is to determine whether the COVID-19 pandemic has caused mean reversion in global stock markets. Consequently, the study aims to achieve the following goals precisely:

- Determine the existence of mean reversion in international stock market indices before and after the pandemic.

- Measure the Speed of mean reversion in international stock market indices before and after the pandemic.
- Compare the pace of mean reversion in international stock market indices before and after the pandemic.

The study aims to help investors determine the rate at which prices revert to their mean value by accomplishing the aforementioned goal. Investors may be better able to plan their trade entry and exit, and they will be able to identify and steer clear of comparable stocks.

1.4 The significance of this research.

In international stock markets, the speed at which stock values return to their long-term average following a deviation or shock is known as the "Speed of Mean Reversion". According to mean reversion, stock prices eventually tend to return to their average or equilibrium level.

Based on Hyun-Jin, C. & Kim, S. W.'s (2022) perspective concerning the COVID-19 pandemic's impact on capital markets: When the epidemic first appeared in early 2020, it had a major and pervasive impact on stock markets throughout the world. Initially, stock markets saw steep drops and considerable volatility as the virus spread and lockdown measures were put in place in numerous nations. Investors responded to the pandemic's uncertainties and its possible effects on companies and the world economy.

Nevertheless, as governments and central banks implemented diverse fiscal and monetary measures to alleviate the economic repercussions of the pandemic, stock markets began to rebound. Massive stimulus packages, interest rate cuts, and other interventions supported financial markets. Additionally, the development and distribution of vaccines played a crucial role in improving investor sentiment and restoring confidence in the global economy.

It is important to note that the Speed of mean reversion during and after the COVID-19 pandemic varied across countries and stock markets. Some markets rebounded relatively quickly, while others took more time to recover. Factors such as the outbreak's severity, government policies' effectiveness, and each market's industry composition influenced the Speed and extent of the mean reversion process.

All things considered, the COVID-19 pandemic had a major effect on global financial markets, resulting in a time of increased volatility and notable price fluctuations. However, the subsequent recovery and mean reversion in stock prices were influenced by government actions, economic indicators, investor sentiment, and the overall progress in containing the virus.

1.5 Hypotheses Development

Based on the comprehensive discussion, the goals of this research, and the existing literature, two hypotheses are the major concerns:

- **H_1**: The stock prices of indices observe mean reversion.
- **H_2:** The stock prices of indices tend to revert to their average price over time.

2. Literature review

There is evidence supporting the mean reversion in stock prices, despite some research finding substantial evidence against it. Many theories have been proposed to explain the phenomena of mean reversion in stock prices, which is closely related to the issue of market efficiency. The "Efficient Market Hypothesis" states that the value of a stock is a reflection of all available information (Fama, 1991).

The idea of mean reversion in stock prices could indicate inefficiencies in the market (Fongwa et al., 2015). As per Poterba and Summers (1988), this phenomenon can stem from the irrational actions of noise traders, leading to substantial deviations in stock prices from their intrinsic worth. Conversely, mean reversion in pricing might also result from trends (McQueen, 1992; Summers, 1986), excessive reactions to economic developments (De Bondt & Thaler 1985;1987), or collective behavior such as herding (Poterba & Summers, 1988).

Stock prices in efficient marketplaces can also exhibit mean reversion. The value of a stock is defined by the anticipated earnings per share, assuming that all relevant information has already been factored into the stock prices. Mean reversion occurs when anticipated earnings tend to return to their average value over time, as noted by Summers in 1986. Conrad and Kaul (1988) discovered that alterations in anticipated returns exhibit stability, indicating that they tend to recover to their average value over time.

Therefore, market efficiency and mean reversion in stock prices are not at odds (Fama & French, 1988b). Uncertainty over the economy's existence brought on by a worldwide conflict or recession can account for fluctuations in predicted earnings (Kim et al., 1991). According to McQueen (1992), variations in predicted earnings can also be caused by rational bubbles and uncertainty regarding a company's future.

Scholars have addressed established stock markets in a number of scholarly publications. Taiwan, Hong Kong, Shanghai, and Shenzhen are among the emerging markets that Hu et al. (1997) looked at with reference to the American and Japanese equities markets. They found unmistakable proof of returns and shock transmission between the American and Hong Kong equities markets. According to Chou et al. (1999), there is probable evidence of volatility and stock correlations between the US and Taiwanese equity markets, as well as gradual mean reversion in both markets. The model, also known as the BEKK model, was studied by Engle and Kroner (1995), who found evidence for mean reversion as well as the spread of variance and returns between the US and Taiwan equity markets. Hoque and Chiou (2011) examined the US, UK, and Japanese equities markets from 1997 to 2007, finding a lag in the recognized equity markets. Research verifying the integration of US equities markets with EU stock markets—specifically, US equity markets and EU stock markets, such as the UK, Germany, Italy, and France—was presented by Savva et al. (2009). Research on the volatility movement between the US and EU markets was conducted by Baele (2005). They used GARCH and GEKK models to analyze weekly stock returns from 13 European equities markets. According to their research, there has been volatility transmission from US stock markets to equity markets in Switzerland, Sweden, and the United Kingdom (2018). The study examined mean reversion, volatility, and stock returns in developed and emerging financial markets. The journal Technological and Economic Development of Economy published this research. Differentiating between market returns and figuring out whether they follow a mean reversion process or a random walk internationally has drawn a lot of attention from researchers and financial gurus. One of the main reasons for these studies is that if stock returns follow mean reversion, it is possible to predict future returns using historical data (Gulaya & Emec, 2017). A constrained trading strategy allows investors to purchase stocks at lower prices and sell them when they become more profitable, as stated by Mohammadi (2017), Chaves and Viswanathan (2016), Hart et al. (2015), Tsekrekos and Yannacopoulos (2016), Lubnau and Todorova (2015), and Balvers, Wu, and Gilliland (2000). This

means that the mean reversion process offers a greater chance of profit (Chen et al., 2012). Important studies on the mean reversion behavior of stock markets in Middle Eastern and North African nations were done by Neaime (2015) and Hakim and Neaime (2003) (Khalifa, A., Alsarhan, A. A., & Bertuccelli, P., 2017). According to their research, the markets in Jordan, Turkey, Egypt, and Morocco show fast mean reversion processes, which also have an impact on these markets' volatility.

In a similar vein, Kuttu (2017) suggested that the diverse behaviors seen in the stock market can be explained by mean reversion phenomenon. As for the relationship between stocks and volatility, researchers Ribeiro et al. (2017), Ahmad et al. (2016), and Kim, Morley, and Nelson (2001) all came to the same conclusion: there is a clear link between stock returns and volatility. In order to maximize gains attributable to the mean reversion process, investors should use a limited trading strategy, according to Arefin and Ahkam (2017), Chen et al. (2012), and Balsara, Chen, and Zheng (2007). After examining the performance of stock returns across 17 emerging markets, Chaudhuri and Wu (2003) discovered evidence of the mean reversion phenomena and used the half-life approach to determine the speed of mean reversion. They discovered that in emerging markets, equities returns recover to their mean levels over a period of 30 months. The random walk hypothesis was refuted by Poshakwale (2003), Malliaropulos and Priestley (1996), Riaz (2014), and Mustafa and Ahmed (2013), who instead confirmed the existence of mean reversion in a variety of international financial markets (2018).

Overall, relevant literature review sets the stage for the research by explaining the context in which mean reversion has gained prominence as a theory for understanding stock market behavior, and it highlights the significance of the study in the context of the evolving financial landscape.

3. Data and methodology

Examining the propensity of stock prices to return to their long-term average after brief deviations is necessary to determine the speed of mean reversion in global stock

markets. Here are some methodologies that can be utilized to investigate this phenomenon:

1. 1. Stock Market Classification: Analyzing the national stock market indexes obtained from respectable stock exchanges, as categorized by Morgan Stanley Capital International, is the main goal of this study (MSCI). In addition to GDP and GDP per capita, perceived investment risk, local and government regulations limiting foreign ownership and economic authority, and other variables are utilized to classify stock markets. Compared to global equity markets, the MSCI Emerging Markets Index measures the performance of emerging market stocks. MSCI indices are widely recognized as benchmarks utilized by global portfolio managers and are regarded as standards for measuring performance in global stock markets. The stock market indices of individual nations are comprised of a compilation of equities that serve as a comprehensive representation of the stock characteristics of that country.
2. Data Collection: This research is based on a dataset covering the period from June 3rd, 2002, to June 5th, 2023. The study period spans 21 years of data to provide a comprehensive analysis. The data utilized in this study related to both developed and emerging markets was obtained from the Refinitiv DataStream database, which is hosted in the university laboratory. Real-time data acquisition from Refinitiv DataStream and direct export to Microsoft Excel files constitute the most significant benefit. The observations comprise financial indices' daily closing values. Pakistan and India are identified as developing nations from South Asia in the study, whereas Korea, Japan, China, Hong Kong, Malaysia, and Indonesia represent East Asia and Far East Asia. Brazil is chosen from the Latin American region. At the same time, industrialized countries from Europe and the Middle East are considered to be Austria, Denmark, Finland, France, Germany, Ireland, Israel, Italy, the Netherlands, Portugal, Spain, Greece, Sweden, and Switzerland. North America consists of the United States and Canada.
3. Change in stock exchange indices: The returns for developed and emerging indices are computed using the natural log difference method. To achieve the

objective, the following equation is utilized to calculate the market returns: $SubscriptSP_{(t)} = \ln\left(\frac{C_t}{C_{t-1}}\right)^{-1}$

4. Time Series Analysis: This technique looks for mean reversion trends in past stock price data. It analyzes the behavior of stock prices over time using techniques such as exponential smoothing, autoregressive integrated moving average (ARIMA) models, and other time series models.
5. Cointegration Analysis: A statistical method for evaluating the long-term relationship between two or more time series variables is cointegration. By applying cointegration analysis to international stock market indices or individual stocks, researchers can determine whether there is a long-term equilibrium relationship and whether mean reversion occurs.
6. Panel Data Analysis: Panel data analysis involves studying data sets containing cross-sectional and time series observations. Through simultaneous analysis of stock market data from several nations or regions, researchers can look at the Speed of Mean Reversion in various markets and determine what factors affect the pace of reversion.
7. Mean reversion: Mean reversion is a theory that an index has a long-term average price (often called the “Long Run Mean” or “LRM” for short) and that its price at a given point in time will tend toward that LRM.
8. Hurst Exponent: The Hurst exponent measures the degree of persistence in a time series across various time scales, essentially gauging the strength of the "long-term memory" inherent in the time series. A value less than 0.5 suggests that a commodity tends to revert to its mean (mean-reverting), while a value greater than 0.5 indicates trending behavior.
9. Half-Life: The half-life calculates the amount of time that a time series needs to undergo a deviation before halfway returning to its mean. Greater pronounced mean-reverting characteristics are implied by a shorter half-life.

When studying the Speed of mean reversion, it is essential to consider each method's limitations and combine multiple approaches to understand the phenomenon comprehensively. Data quality, sample selection, and other factors should also be considered to ensure robust and reliable analysis.

Table 1

List of countries by group

Developing Countries	Index	Emerging Countries	Index	Developed Countries	Index
1. Jordan	@MSJORD	1. Brazil	@BRBOVES	1. Australia	@MSAUSTL
2. Pakistan	@KSE 100	2. Bulgaria	@BSSOFIX	2. Austria	@MSASTRL
3. Peru	@MSPERU	3. Colombia	@MSCOLML	3. Belgium	@MSBELGL
4. Philippines	@MSPHLFL	4. China	@MSNCNAL	4. Canada	@MSCNDAL
5. Sri Lanka	@MSSRILL	5. Egypt	@EGCSE30	5. Denmark	@MSDNMKL
6. Tunisia	@TUTUNIN	6. India	@NSEINDX	6. Finland	@MSFINDL
		7. Indonesia	@MSINDFL	7. France	@MSFRNCL
		8. Jamaica	@JAMSEIN	8. Greece	@GRAGENL
		9. Malaysia	@MSMALFL	9. Germany	@MSGERML
		10. Mexico	@MSMEXFL	10. Hungary	@MSHUNGL
		11. Morocco	@MSMORCL	11. Ireland	@MSEIREL
		12. Poland	@MSPLNDL	12. Italy	@FTSEMIB
		13. South Korea	@KOR200I	13. Japan	@MSJPANL
		14. South Africa	@MSSARFL	14. Netherlands	@MSNETHL
		15. Thailand	@MSTHAFL	15. New Zealand	@MSNZEAL
		16. Turkey	@MSTURKL	16. Norway	@MSNWAYL
				17. Portugal	@MSPORDL
				18. Spain	@MSSPANL
				19. Czech Republic	@MSCZCHL
				20. Sweden	@MSSWDNL
				21. Slovenia	@MSSLVN
				22. Switzerland	@MSSWITL
				23. United States	@NASA100
				24. United Kingdom	@MSUTDKL

3.1 Below is the analysis of the selected indices for the research.

I. Developing Countries

1) The "MSCI Jordan Index" is intended to assess the Peruvian market's major and mid-cap sectors' performance. Comprising three parts, the Index encompasses around 85% of the whole Peruvian stock market.

2) "Pakistan Stock Market (KSE100)": An important stock market indicator, the Karachi Stock Exchange 100 Index tracks the performance of the biggest firms in every area of the Pakistani economy according to market capitalization, as reported on The Karachi Stock Exchange. It operates as a free-float index as of October 15, 2012. As of November 1991, the KSE 100 has a base value of 1000.
3) MSCI Peru Index: The MSCI Jordan Index evaluates the way the Jordanian market's large- and mid-cap sectors performed. With its seven components, the Index represents approximately 85% of the Jordanian equity market.
4) "MSCI Philippines Index (PHP)": The "MSCI Philippines Index" is designed to evaluate the performance of the Philippine market's large- and mid-cap categories. With its fourteen components, the Index represents about 85% of the entire Philippine equity market.
5) "MSCI Sri Lanka Index": The "MSCI Sri Lanka Index" is set up to evaluate the performance of big and mid-sized businesses operating in Sri Lanka. It consists of three components and encompasses about 85% of the Sri Lankan equity universe.
6) TUNINDEX Index: The TUNINDEX Index of the Tunis Stock Exchange is a well-known indicator of the stock market that follows the performance of every company listed on the exchange. As of December 31, 1997, the base value of the index, which serves as a free-float, capitalization-weighted benchmark, was set at 1000.

II. Emerging Countries

1) "Brazil Stock Market": The IBOVESPA is a significant stock market benchmark that monitors the performance of approximately 50 of the most liquid stocks traded.

2) "Bulgaria Stock Market": The SOFIX is a notable gauge of the Bulgaria Stock Exchange, tracking the performance of highly liquid companies. Inclusion

criteria require companies to exceed a market capitalization of BGN 50 million, have an annual turnover surpassing BGN 2 million, and boast over 500 shareholders. Founded on October 20, 2000, it functions as a free-float market capitalization-weighted index with a base value of BGN 100.

3) "MSCI Colombia Index": The "MSCI Colombia Index" assesses the Colombian market's large- and mid-cap sectors' performance. It is made up of three components and accounts for over 85% of the Colombian stock market.

4) "MSCI China Index": The "MSCI China" is an Onshore Index represents the trading activity of Chinese large- and mid-cap stocks that are traded on the Shenzhen and Shanghai exchanges.

5) Egypt Stock Market: The EGX 30 serves as a prominent benchmark for the Egyptian Exchange, tracking the performance of 30 highly liquid stocks. It operates as a free-float capitalization-weighted index, with a base value 1000, established on January 1st, 1998.

6) NSE INDIA: The NIFTY 50 is the primary Index. It comprises blue-chip companies listed on the NSE and domiciled in India. The Index utilizes a float-adjusted, market capitalization-weighted methodology to monitor its performance.

7) MSCI Indonesia Index: The MSCI Indonesia Index tracks the financial performance of prominent Indonesian companies that have both big and mid-cap market capitalizations, with 22 constituents representing approximately 85% of the Indonesian equity market.

8) "Jamaica Stock Market": The "Jamaica Stock Exchange (JSE) Market Index" is an important metric used by the JSE to track the performance of all regular listed companies.

9) "MSCI Malaysia Index": "The MSCI Malaysia Index" evaluates the performance of major and mid-cap companies in the Malaysian market; its 32 members account for over 85% of the country's equities market.
10) "MSCI Mexico Index": The "MSCI Mexico Index" assesses the profitability of the major and medium-sized sectors in the Mexican economy. The 23 constituents included in it represent around 85% of Mexico's market capitalization that has been adjusted for free float.
11) MSCI Morocco Index: The MSCI Morocco Index evaluates the Moroccan market's large- and mid-cap categories' performance. About 85% of Morocco's market value, adjusted for free float, is comprised of its 20 constituents.
12) "MSCI Poland Index": The "MSCI Poland Index" evaluates the Polish market's large- and mid-cap segments' performance. Its fifteen components account for over 85% of all Polish equity.
13) KOREA SE KOSPI 200: "The Korea Composite Stock Price Index", known as KOSPI, represents all ordinary stocks traded on the Stock Market Division of the Korea Exchange. It is a leading indicator for South Korea's stock market, established in 1983 with an initial base value of 100 as of January 4th, 1980.

14) "MSCI South Africa Index": The "MSCI South Africa Index" assesses the South African market's major and mid-sized segments' performance. Approximately 85% of the nation's free float-adjusted market value is comprised of its 34 members.
15) "MSCI Thailand Index": The "MSCI Thailand Index" assesses the performance of Thai market-based large and mid-cap corporations. Approximately 85% of the entire value of the Thai equity market is comprised of its 41 constituents.

16) MSCI Turkey Index: The "MSCI Turkey Index" evaluates the Turkish market's large- and mid-cap sectors' performance. It includes 18 constituents, covering around 85% of Turkey's equity market.

III. Developed Countries

1) "MSCI Australia Index": The "MSCI Australia Index" examines the effectiveness of the leading and medium-sized sectors in the Australian market.

With 58 constituents, it encompasses about 85% of Australia's free float-adjusted market capitalization.

2) "MSCI Austria Index": The "MSCI Austria Index" assesses the performance of large and mid-cap sectors in the Austrian market. It comprises four constituents and covers approximately 85% of Austria's free float-adjusted market capitalization.

3) "MSCI Belgium Index": The "MSCI Belgium Index" evaluates the performance of the large and mid-cap sectors in the Belgian equity market. Comprising 13 constituents, it represents approximately 85% of Belgium's free float-adjusted market capitalization.

4) MSCI Canada Index: The MSCI Canada Index evaluates the Canadian market's large- and mid-cap sectors' performance. It has 88 components and accounts for around 85% of the market capitalization adjusted for free float in Canada.

5) "MSCI Denmark Index": The "MSCI Denmark Index" evaluates the Danish market's large- and mid-cap sectors' performance. With 16 constituents, it represents approximately 85% of Denmark's free float-adjusted market capitalization.

6) "MSCI Finland Index": The "MSCI Finland Index" evaluates the performance of the large and mid-cap sectors in the Finnish equity market. It comprises 12 constituents and represents approximately 85% of Finland's free float-adjusted market capitalization.

7) MSCI France Index: The MSCI France Index monitors the performance of French market large- and mid-cap enterprises. With 63 members, it accounts for almost 85% of the French equities market.

8) Athex Composite Share Price Index: The Athens Exchange collaborates with reputable international index providers to compute and distribute more than 30 indices globally, either in real-time or at the end of the day. It provides market

participants, whether professionals or not, with a dependable benchmark for making investment decisions. Moreover, it is a valuable tool in licensing a wide range of financial products, including futures, options, ETFs, and structured products. The range of indices examined is comprehensive, including sector and standard indices, total return indices, and associate indices encompassing foreign markets and the Greek market.

9) MSCI Germany Index: The "MSCI Germany Index" assesses the German market's performance of large and mid-cap corporations. Its 59 constituents represent about 85% of the equity market in Germany.

10) "MSCI Hungary Index": The "MSCI Hungary Index" evaluates the Hungarian market's large- and mid-cap sectors' performance. Its three components account for over 85% of the Hungarian equity market.

11) "MSCI Ireland Index": The "MSCI Ireland Index" evaluates the performance of large and mid-cap sectors in the Irish equity market. With six constituents, it represents approximately 85% of Ireland's free float-adjusted market capitalization.

12) MSCI Italy Index: The MSCI Italy Index evaluates the performance of the Italian market's large and mid-cap sectors. It includes 23 components and accounts for roughly 85% of Italy's equities market.

13) "MSCI Japan Index": The "MSCI Japan Index" evaluates the performance of large and mid-cap sectors in the Japanese market. With Two hundred thirty-six constituents represent approximately 85% of Japan's free float-adjusted market capitalization.

14) "MSCI Netherlands Index": The "MSCI Netherlands Index" assesses the performance of large and mid-cap sectors in the Dutch market. Comprising 26 constituents, it covers about 85% of the free float-adjusted market capitalization in the Netherlands.

15) "MSCI New Zealand Index": The "MSCI New Zealand Index" evaluates the performance of large and mid-cap sectors in the New Zealand market. With six constituents, it represents approximately 85% of the free float-adjusted market capitalization in New Zealand.

16) MSCI Norway Index: The MSCI Norway Index evaluates the performance of the Norwegian market's major and mid-cap sectors. It has twelve components and accounts for approximately 85 percent of Norway's market value adjusted for free float.

17) "MSCI Portugal Index": The "MSCI Portugal Index" assesses the performance of large and mid-cap sectors in the Portuguese market. With four constituents, it represents approximately 85% of the country's free float-adjusted market capitalization.

18) "MSCI Spain Index": The "MSCI Spain Index" assesses the Spanish market's large- and mid-cap sectors' performance. It includes 19 components and accounts for approximately 85% of the Spanish equity market.

19) "MSCI Czech Republic Index": The "MSCI Czech Republic Index" assesses the performance of large and mid-cap sectors in the Czech Republic market. Including three constituents, it covers approximately 85% of the Czech Republic's free float-adjusted market capitalization.

20) "MSCI Sweden Index": The "MSCI Sweden Index" evaluates the performance of the Swedish market's large and mid-cap sectors. Its 43 members account for over 85% of the Swedish equities market.

21) "MSCI Slovenia Index": The "MSCI Slovenia Index" evaluates the Slovenian market's large- and mid-cap sectors' performance. With its six components, it accounts for over 85% of the Slovenian equity market.

22) "MSCI Switzerland Index": The "MSCI Switzerland Index" assesses the Swiss market's major and mid-sized sectors' performance. It makes up around 85% of Switzerland's market capitalization adjusted for free float, with 45 constituents.

23) Nasdaq-100 Index: The Nasdaq-100 index consists of 101 stock securities chosen from the top 100 non-financial firms that are listed on the Nasdaq stock exchange. It operates as a modified capitalization-weighted index, assigning weights to individual stocks based on their market capitalizations. Specific regulations mitigate the influence of the most prominent components. This Index exclusively features companies from the Nasdaq exchange and excludes any financial entities, which are instead part of a separate index called the Nasdaq Financial-100.

24) "MSCI United Kingdom Index": The "MSCI United Kingdom Index" is created to evaluate the performance of major and medium-sized market sectors in the United Kingdom. Its 83 components account for almost 85% of the UK's free-float adjusted market value.

4. The 22-year study of long-term mean reversion

Numerous studies have shown evidence both in favor of and against mean reversion in stock prices. Theoretically, mean reversion has been studied in great detail, and the topic of market efficiency is closely related to these theories. The efficient market hypothesis is applied to determine a stock's value by taking into account all available information (Fama, 1991). The mean reversion of stock prices may be a sign of inefficiency in the market. According to Poterba and Summers (1988), mean reversion may be caused by the abnormal behavior of noise traders and appear as

significant fluctuations in stock prices that are significantly out of line with their intrinsic worth. Various variables, such as investor opportunism (Poterba & Summers, 1988), overreaction to financial news (De Bondt & Thaler, 1985, 1987), and trends (McQueen, 1992), can be ascribed to irrational pricing behavior.

Anticipated returns per share are used to determine the value of a company's shares, assuming that the market prices accurately reflect all relevant facts. As a result, mean reversion is recognized when projected returns show a propensity to return to the mean (Summers, 1986). Uncertainty regarding the sustainability of the economy, brought about by events such as a global pandemic, a recession, or a world conflict, could result in variations in anticipated returns (Kim et al., 1991). Conversely, these variations may result from logical speculative bubbles or unclear business opportunities (McQueen, 1992). Thus, mean reversion in stock prices does not necessarily contradict market efficiency (Fama & French, 1988).

4.1 Absolute Mean Reversion

Fama and French (1988b) were the first to provide significant evidence in favor of absolute mean reversion over prolonged time horizons. Over a range of investment horizons from one to 10 years, strong mean reversion was found to account for 25–40% of the volatility in US stock returns over three to five-year intervals. Poterba and Summers (1988) applied a preset random walk characteristic to generate suggestive data in favor of the mean reversion. They proved long-term mean reversion in the US and other developed economies. The absence of more reliable statistical tests for null hypothesis rejection accounts for the lack of significance in their results.

Fama and French (1988) and Poterba and Summers (1988) use annual stock returns to increase the amount of observations in their analysis of the period from 1926 to 1985. The solution to the dependence issue is to apply the strategy that Hansen and Hodrick suggested in 1980. Richardson and Smith (1991), who also address the problem of small sample bias, are against the procedure. They demonstrate that the evidence in favor of long-term mean reversion vanishes when a small sample bias is removed. Moreover, Richardson and Stock (1990) argue that greater sample sizes over longer investment horizons strengthen the statistical tests used to evaluate the random walk hypothesis (Spierdijk et al., P. V. D. 2012). However, their stronger statistical measure does not lead to the rejection of the random walk hypothesis (S. J. Taylor, 1980).

The problem of seasonality brought on the monthly stock returns is brought up by Jegadeesh (1991). Apart from criticisms regarding the use of monthly stock returns, there are additional possible areas of criticism for Fama and French's (1988b) approach. The issue of heteroskedasticity during the period in question is examined by McQueen (1992). Long-term uncertainty tends to have larger weights and hence affect outcomes more significantly. McQueen (1992) posits that periods of heightened ambiguity are correlated with more conspicuous tendencies toward mean reversion, leading to an overestimation of the collective evidence supporting mean reversion. Kim and Nelson (1998) and Kim et al. (1998) critique Poterba and Summers (1988) and Fama and French (1988) for similar grounds. Events with high degrees of uncertainty may not accurately reflect the current behavior of stock prices. Poterba and Summers (1988) note that the parameter estimates of mean reversion were greatly affected by the Great Depression. The strength of the evidence in favor of mean reversion is diminished when this time is excluded. Furthermore, the post-war era is characterized by mean aversion, which indicates a fundamental shift in the trend of stock prices.

4.2 Relative Mean Reversion

A different approach to forecasting future dividends would be to utilize earnings as an approximation of forthcoming cash disbursements to investors. Alternative methodologies encompass valuation ratios, such as the dividend yield. Campbell and Shiller (2001) look at how long it takes for the dividend yield and price-earnings ratio to return to the mean. Given their impact on stock prices, it is expected that these ratios will, in theory, return to their mean values. A predicted response to elevated stock prices relative to underlying company fundamentals is a subsequent adjustment to either the stock prices or the fundamentals. According to Campbell and Shiller (2001), stock prices have the biggest impact on how ratios adapt themselves towards equilibrium. The behavior of valuation ratios returning to their mean value is examined by Coakley and Fuertes (2006), who attribute this tendency to changes in investor mood. Finally, the researchers found that financial ratios re-align with their long-term mean value.

Fama and French (1988a) established a correlation between anticipated earnings of a stock and dividend yield in a previous study, discovering that these variables exhibit a tendency toward mean reversion. Asset pricing models serve as the cornerstone of a second specification of fundamental value. The Fama-French three-

factor model and the medium-term mean-reverting behavior of equities are related, according to Ho and Sears (2004). They come to the conclusion that these models fall short of adequately capturing the mean-reverting behavior of stock prices. Subsequent findings are documented by Gangopadhyay and Reinganum (1996). Conversely, they argue that mean reversion can be explained by the Capital Asset Pricing Model (CAPM) as long as the market risk premium is amenable to time fluctuation. The observed variability is in line with the mean-reversion inefficient markets theory (Summers, 1986), which postulates that expected returns follow a mean-reverting style of behavior.

5. Arima Model

Difference is used to the data in an autoregressive integrated moving average (ARIMA) model in order to achieve stationarity. When data is stationar, it means that its features remain constant across time. Since economic and market data often display trends, differencing is employed to eliminate these trends or seasonal patterns. After confirming or achieving stationarity through differencing, the next step is to fit Autoregressive Integrated Moving Average (ARIMA) models to each country's time series data. The ARIMA model equation is then determined. The ARIMA model equation

$$y_t=\phi_1 y_{t-1}+\phi_2 y_{t-2}+\cdots+\phi_p y_{t-p}+\epsilon_t+\theta_1\epsilon_{t-1}+\theta_2\epsilon_{t-2}+\cdots+\theta_q\epsilon_{t-q}$$

It incorporates autoregressive and moving average parameters, where ϵt denotes the error term. Following this, mean reversion analysis determines the half-life of mean reversion and the Hurst exponent. These measures offer valuable information on the durability and enduring memory of the time series data.

6. Mean reversion model

An analysis is conducted on the financial market indices of N countries, which were collected and measured in units over T years. It is anticipated that each index will revert to its initial value over time. The subsequent reorientation procedure is postulated for each country (Balvers et al. 2000):

$$\text{Subscript}rt^{i}{}_{t+1} = \alpha^{i} + \lambda^{i}\left(p^{*i}{}_{t+1} - p^{i}{}_{t}\right) + \varepsilon^{i}{}_{t+1}\,, \qquad (1)$$

Where $rt^{i}{}_{t+1}$ equals the continuously compounded real return on the stock index of the country I between time t and t+1, $p^{*i}{}_{t+1}$ is the natural logarithm of the intrinsic value of the actual stock price index of the country I at time t+1. The pit is the country I is natural logarithmic actual stock price index at time t. The error term $\varepsilon^{i}{}_{t+1}$ is assumed to be a country-specific stationary process with unconditional mean zero. Parameter α^{i} is a country-specific constant, and λ^{i} indicates the Speed of reversion of the index price process of country *i*. The relation between the index returns and the deviation from its fundamental value depends entirely on the parametermeter λ^{i}. Equation (1) is a mean-reverting process from $0 < \lambda^{i} < 1$. Mean aversion occurs for $\lambda^{i} <$ 0.

To estimate the parameter lambda to the i. directly, we must know the alpha to the i. and lambda to the i. directly; we must know the fundamental the i. directly, we must know the α^{i} and λ^{i} directly, we must know te fundamental value $p*^{i}{}_{t}$. Unfortunately, it canot be measured due to the difficulty of determining firms' intrinsic value. Like Balvers et al. (2000), we assume that the difference in intrinsic value between the natural logarithmhm of the stock index in real-dllsrs ($p^{*i}{}_{t}$) andthe naturalogarithm of a benchmark index in readolls ($p^{*i}{}_{t}$) is a stationary process. The benchmark index is the global. The stationarity assumption is not amenable to empirical evaluation due to the unobservable nature of intrinsic value processes. Nevertheless, in line with the conclusions of Balvers et al. (2000), we support this presumption with an economic justification predicated on the convergence of per capita GDP. Absolute convergence is observed in the real per capita GDP of 20 OECD countries, suggesting that real per capita GDPs approach the same equilibrium (Barro & Salami Martin, 1995), as emphasized by Spierdijk, L., Bikker, J. A., & Hoek, P. V. D. (2012). It is expected that developed countries will reduce the disparity in capital, given that a lower per capita GDP indicates greater marginal efficacy of investment (Barro, 1991). Since adopting an extant technology is more economical than developing a new one, technological catch-up occurs. The index of national stocks reflects the condition of the stock market as a whole. Additionally, the intrinsic value of the stock market and the companies that contribute to a nation's gross domestic product are directly related. As national gross domestic product converges, fundamental stock price indices should also converge. Consequently, over time, the fluctuations in fundamental stock prices among nations exhibiting absolute convergence should remain constant.

7. Half-Life model

The half-life approach will be used in the ensuing procedure to determine the mean reversion speed. The duration needed for returns to diverge by half the distance that the long-term average values of all indices have covered can be found using the half-life approach. The three stock indexes discussed earlier have mean reversion rates represented by the numerical figures. This enables a comparative analysis of the markets to ascertain which stock exchange index demonstrates a more rapid mean reversion (2018). The model of half-life is expressed as follows:

$$HL = 1 - \frac{\log(2)}{\log(\lambda)}$$

8. Hurst Exponent

The Hurst exponent measures the persistence and self-similarity of a time series over a lengthy period. It ranges between 0 and 1.

Depending on the value of H, a time series can be categorized into three categories:

- H = 0.5: Indicates a random series.
- 0 < H < 0.5: Represents an anti-persistent series (characterized by “mean-reverting” behavior).
- 0.5 < H < 1: Corresponds to a persistent series (trend-reinforcing behavior) (Bo et al., 2004).

9. Empirical Results

Table 2

Summary Statistics of Stock Market Returns

This table presents the summary statistics of stock index returns for 46 markets. The data spans the years 2002 to 2023 and includes 5,480 daily observations.

	Mean	Standard Error	Median	Min	Max	Skew	Kurtosis
WORLD	1640.20	599.58	1529.14	688.64	3248.12	0.79	-0.10
JORDAN	121.95	69.44	95.49	37.55	362.18	1.32	0.85
PAKISTAN	23168.00	15376.91	16424.03	1647.69	52876.46	0.24	-1.54
PERU	1091.74	469.69	1203.83	144.10	1917.27	-0.55	-0.75
PHILIPPINES	865.58	378.52	902.64	202.19	1519.12	-0.19	-1.40
SRI LANKA	481.45	180.23	530.39	105.74	812.76	-0.37	-1.06
TUNISIA	4539.72	2155.79	4702.84	1017.20	8825.91	-0.13	-1.13
BRAZIL	61337.57	29295.79	57717.88	8370.88	130776.30	0.34	-0.54
BULGARIA	588.63	301.36	523.99	127.93	1952.40	1.88	4.21
COLOMBIA	2038.96	826.65	2257.80	191.13	3369.76	-0.78	-0.40
CHINA	2725.25	1073.13	2913.11	764.26	5458.90	-0.15	-0.73
EGYPT	7927.39	4229.97	7263.48	465.04	18363.29	0.21	-0.59
INDIA	3433.56	1194.91	3449.44	1004.70	6161.46	-0.08	-0.98
INDONESIA	4478.05	2231.47	4993.65	372.07	7827.74	-0.40	-1.18
JAMAICA	175026.65	133803.10	98382.50	37799.20	532325.40	1.05	-0.43
MALAYSIA	491.34	118.57	517.21	232.67	669.45	-0.56	-0.88
MEXICO	32608.22	12643.96	35805.71	5941.55	52773.12	-0.68	-0.71
MOROCCO	312.28	89.35	306.90	127.13	576.94	0.25	0.20
POLAND	1551.15	367.29	1582.73	746.14	2690.31	0.34	0.45
SOUTH KOREA	236.80	80.50	249.25	65.64	440.40	-0.07	-0.11
SOUTH AFRICA	953.73	419.60	954.78	216.05	1654.01	-0.21	-1.35
THAILAND	410.28	138.63	454.48	113.39	661.35	-0.36	-1.03
TURKEY	1102057.79	866421.35	977102.87	144094.03	5551809.16	2.81	9.88
AUSTRALIA	1047.38	230.46	1061.74	539.87	1498.47	-0.19	-0.68
AUSTRIA	608.63	254.78	531.56	273.92	1437.19	1.54	1.48
BELGIUM	934.48	253.91	940.55	351.33	1481.43	-0.07	-0.90
CANADA	1706.33	452.82	1707.84	705.75	2778.06	0.04	-0.28
DENMARK	6131.96	3983.30	4479.81	1245.81	18333.27	0.99	0.17
FINLAND	627.43	148.48	621.28	323.63	1108.20	0.31	-0.24
FRANCE	1597.79	407.51	1558.32	793.03	2686.89	0.47	-0.49
GREECE	1681.32	1236.43	1044.96	440.88	5334.50	1.27	0.54
GERMANY	768.13	207.54	789.50	282.72	1160.87	-0.17	-1.06
HUNGARY	1332.55	471.81	1311.60	451.28	2659.41	0.21	-0.62
IRELAND	247.54	114.59	226.58	85.84	592.67	0.91	0.35
ITALY	841.97	251.35	767.40	464.29	1583.36	1.22	0.61
JAPAN	821.91	232.59	821.83	426.67	1363.60	0.04	-1.17
NETHERLANDS	1286.85	556.77	1117.81	507.28	3087.51	1.09	0.49
NEW ZEALAND	122.02	30.10	120.01	69.48	205.98	0.58	-0.24
NORWAY	2438.73	669.58	2489.42	762.24	3827.21	-0.53	-0.19
PORTUGAL	125.20	42.45	111.33	70.37	266.64	1.34	1.30
SPAIN	892.86	180.24	882.39	498.20	1471.39	0.71	0.73
CZECH REPUBLIC	282.42	89.86	276.24	93.40	552.31	0.48	0.24
SWEDEN	9911.92	3869.76	9353.26	2914.85	20138.90	0.47	-0.38
SLOVENIA	370.42	166.02	326.67	164.07	1057.15	2.17	4.84
SWITZERLAND	1050.46	269.02	1061.39	481.43	1731.54	0.26	-0.70
USA	4647.81	4010.30	2746.35	804.65	16573.34	1.31	0.59
UK	1779.04	295.93	1808.82	986.38	2302.42	-0.49	-0.67

10. Empirical Findings

10.1 Stationary in the stock markets indices.

A unit root test was performed to determine whether the returns of the stock indices were stationary. Ten countries, Brazil, France, Germany, Indonesia, Philippines, South Africa, Sweden, Switzerland, Thailand, and the UK, have stationarity, as shown in the plots in Table 1.

10.2 Mean reversion

Only the following 10 stock indices of the 47 countries of sample return to their average value:

1. **Brazil:** Half-life = 6.338242 years to mean reversion, therefore 2,313 working days as the data is daily; this means that in the absence of any other market shocks, we would expect that the spot price had been halfway back towards the LRM by October 2nd, 2008,

2. **France:** Half-life = 4.881576 years to mean reversion, therefore 1,782 working days as the data is daily; this means that in the absence of any other market shocks, we would expect that the spot price had been halfway back towards the LRM by April 19th, 2007,

3. **Germany:** Half-life = 3.635833 years to mean reversion, therefore 1,327 working days as the data is daily; this means that in the absence of any other market shocks, we would expect that the spot price had been halfway back towards the LRM by January 20th, 2006,

4. **Indonesia:** Half-life = 7.467894 years to mean reversion, therefore 2,726 working days as the data is daily; this means that in the absence of any other market shocks, we would expect that the spot price had been halfway back towards the LRM by November 18th, 2009,

5. **Philippines:** Half-life = 6.218291 years to mean reversion, therefore2,270 working days as the data is daily; this means that in the absence of any other

market shocks, we would expect that the spot price had been halfway back towards the LRM by August 19th, 2008,

6. **South Africa:** Half-life = 8.040427 years to mean reversion; therefore, 2,935 working days as the data is daily. It means that in the absence of any other market shocks, we would expect that the spot price would be halfway back toward the LRM by June 15th, 2010,

7. **Sweden:** Half-life = 10.519488 years to mean reversion, therefore 3,840 working days as the data is daily; this means that in the absence of any other market shocks, we would expect that the spot price had been halfway back towards the LRM by December 6th, 2012,

8. **Switzerland:** Half-life = 6.004324 years to mean reversion; therefore, 2,192 working days as the data is daily; this means that in the absence of any other market shocks, we would expect that the spot price would be halfway back toward the LRM by June 2nd, 2008,

9. **Thailand:** Half-life = 4.179764 years to mean reversion, therefore 1,526 working days as the data is daily; this means that in the absence of any other market shocks, we would expect that the spot price had been halfway back towards the LRM by August 6th, 2006 and

10. **UK:** Half-life = 2.044548 years to mean reversion, therefore 746 working days, as the data is daily. Without any other market shocks, we expect the spot price to return halfway towards the LRM by June 18th, 2004.

All results are detailed in Table 2.

10.3. Hurst Exponent

Financial time series frequently demonstrate persistence ($H > 0.5$), suggesting the presence of trends. The findings in Table 4 indicated that series characterized by higher H values were notably more predictable than those with H values closer to 0.5.

11. Conclusions

11.1. Research Contribution

Based on the assumptions presented in this study, it is concluded that stock market indices can indeed exhibit mean reversion. This can occur when prices soar excessively high or drop below their average and then return to this level in the long term. The study findings indicate that developed markets exhibit more excellent stability and lower volatility than emerging markets. Additionally, the developed stock markets show the slowest rate of returning to their average value while also presenting higher volatility when compared to emerging markets. Causes may include overvaluation or undervaluation of assets, changes in economic conditions, or the influence of human behavior and investor psychology. This phenomenon can impact investor decisions and have significant implications for the market. The current research and its findings enhance scientific understanding by filling gaps in existing knowledge regarding the subject, which needs more research. Moreover, the discrepancies between the outcomes of this study and those of prior research provide valuable insights into the subject matter. These findings can be compared with both past and future studies to derive conclusions that may prove beneficial. Ultimately, over time, the results of this study could aid in the comprehensive mapping of this field.

11.2 Policy Implications

The policy implications of mean reversion in indices could be substantial. Here are a few considerations:

- Market Regulation: Regulators may need to closely monitor market activities to ensure that trading behaviors contributing to mean reversion, such as overreactions or herding, are kept in check. Implementing regulations to mitigate excessive volatility or speculative trading could help stabilize markets.
- Investor Education: Educating investors about mean reversion and its implications could help them make more informed investment decisions. This might involve grasping the potential hazards of trading amidst drastic price fluctuations and recognizing the significance of maintaining a perspective focused on long-term investments.

- Policy Responses: Policymakers may need to develop strategies to address market inefficiencies contributing to mean reversion, such as addressing information asymmetries or market distortions. This could involve implementing measures to improve market transparency or enhancing investor protection mechanisms.
- Market Stability Measures: In response to evidence of volatility transmission between markets, policymakers may consider implementing measures to enhance market stability, such as coordinated interventions or circuit breakers to prevent excessive price fluctuations.
- Global Coordination: Given the interconnected nature of financial markets, policymakers may need to effectively coordinate their efforts to address mean reversion. This could involve sharing information and best practices among regulators and central banks to promote stability in global financial markets.

Overall, the policy implications of mean reversion in indices highlight the importance of proactive measures to maintain market stability, protect investors, and promote efficient market functioning.

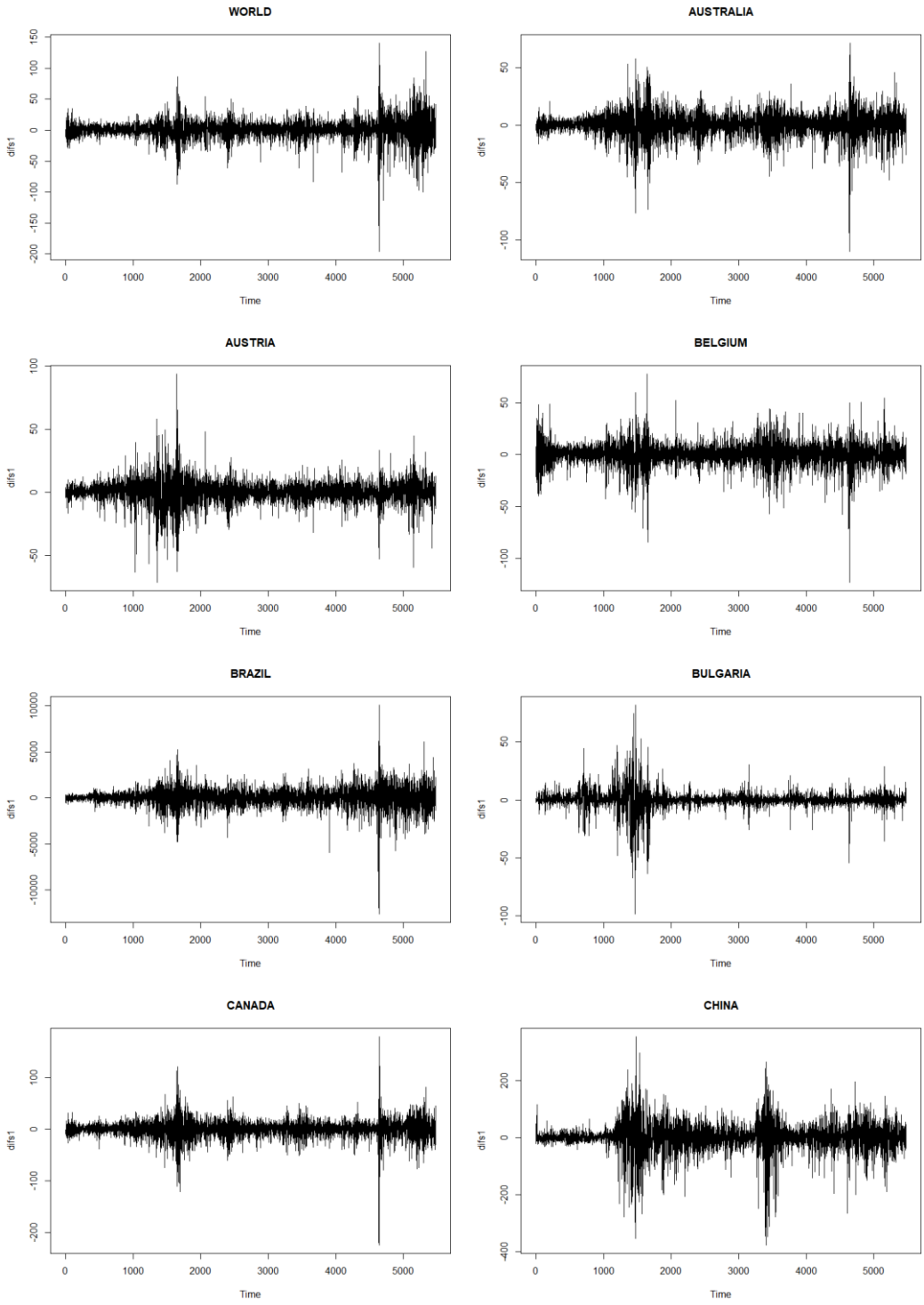
11.3. Suggestions

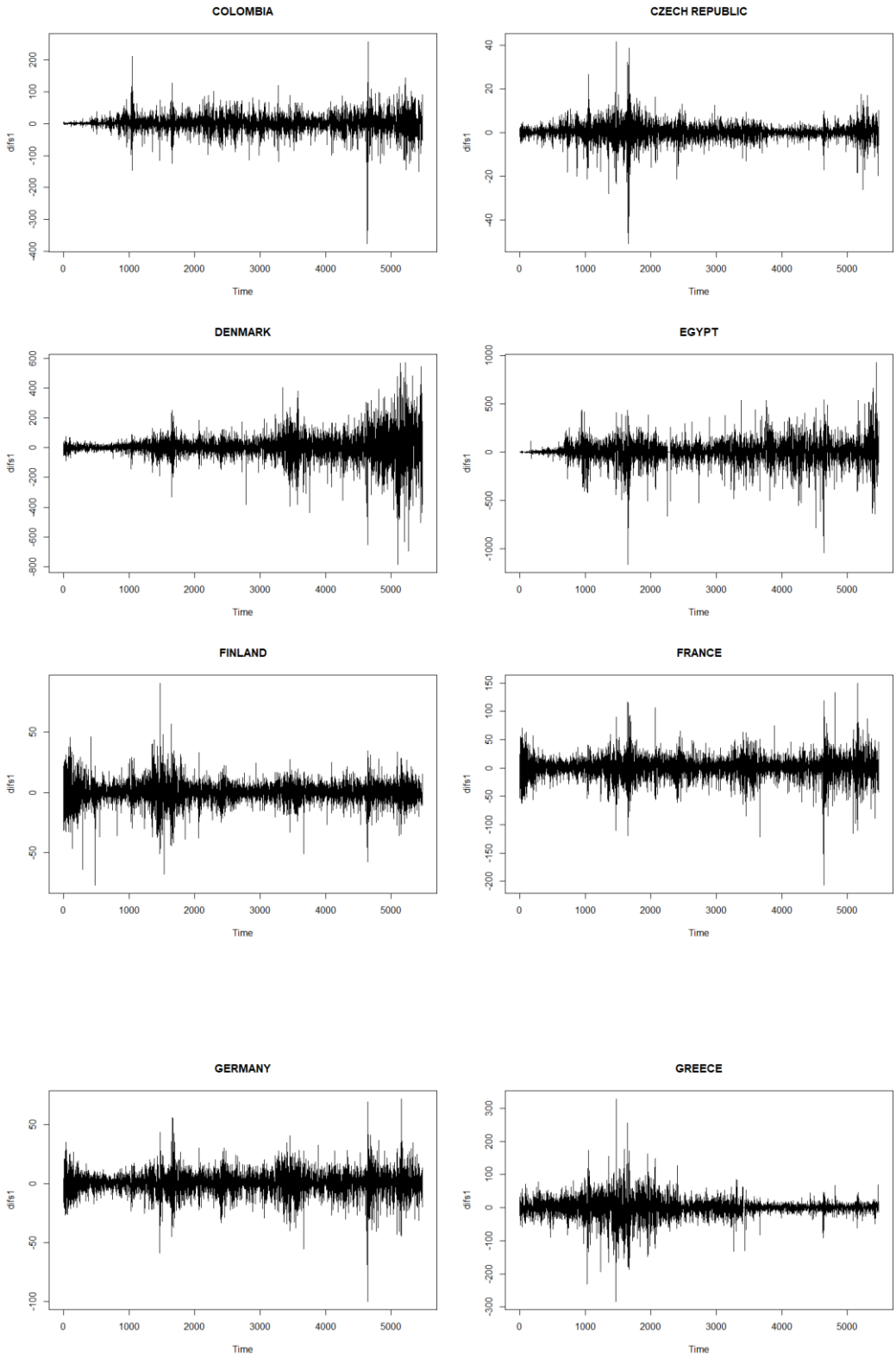
Research on a larger scale is recommended for this topic, given that the few existing studies primarily focus on the mean reversion of stock indices per country. Additionally, another research proposal examines this phenomenon's correlation with the economic crises that may affect countries over time. Investigating both aspects would be valuable for existing knowledge.

12. Appendix

Table 3

Graphs depicting the stationarity of returns in developed and emerging stock markets.

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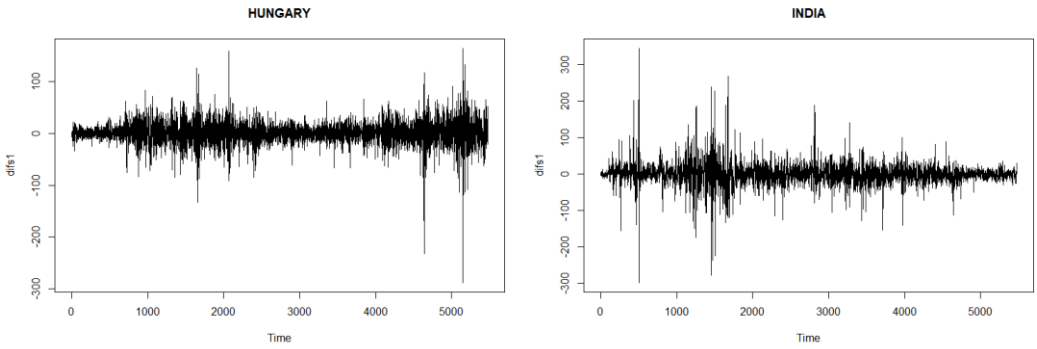
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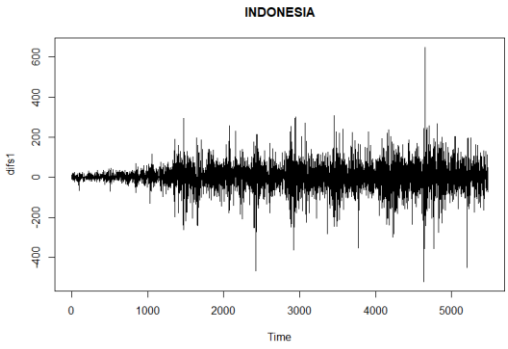
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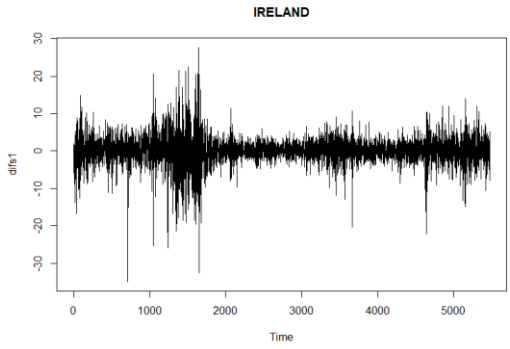
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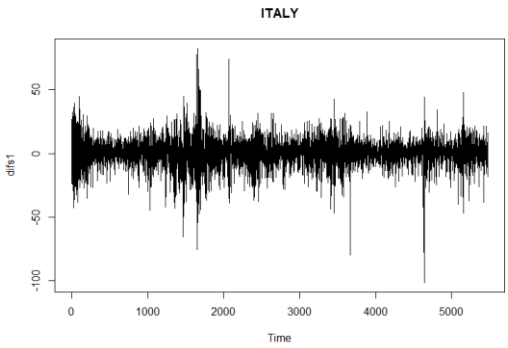
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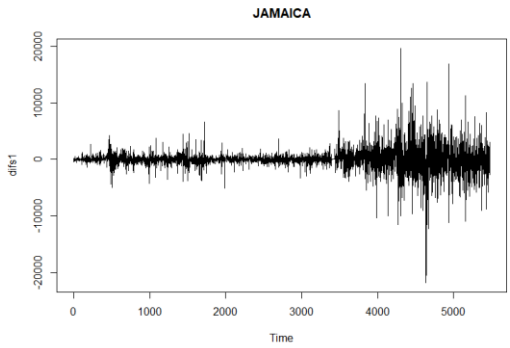
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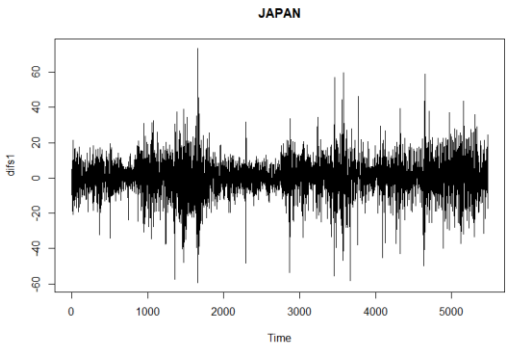
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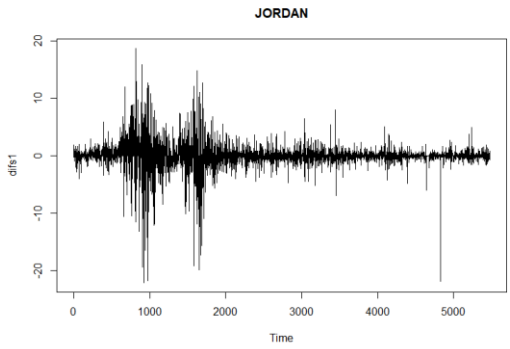
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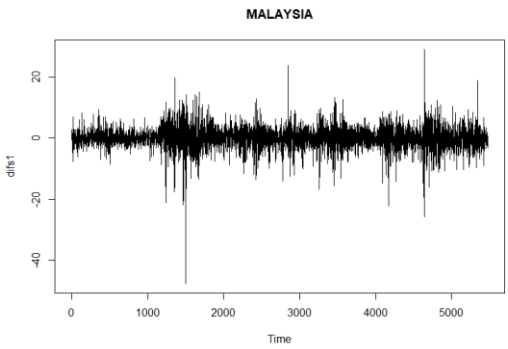
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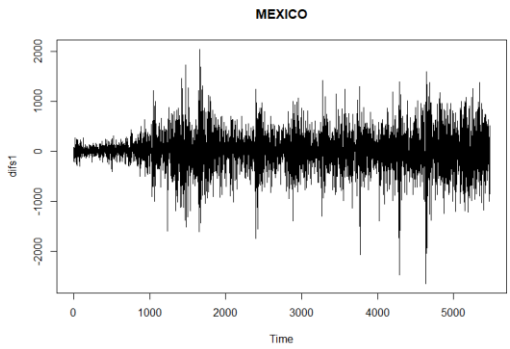
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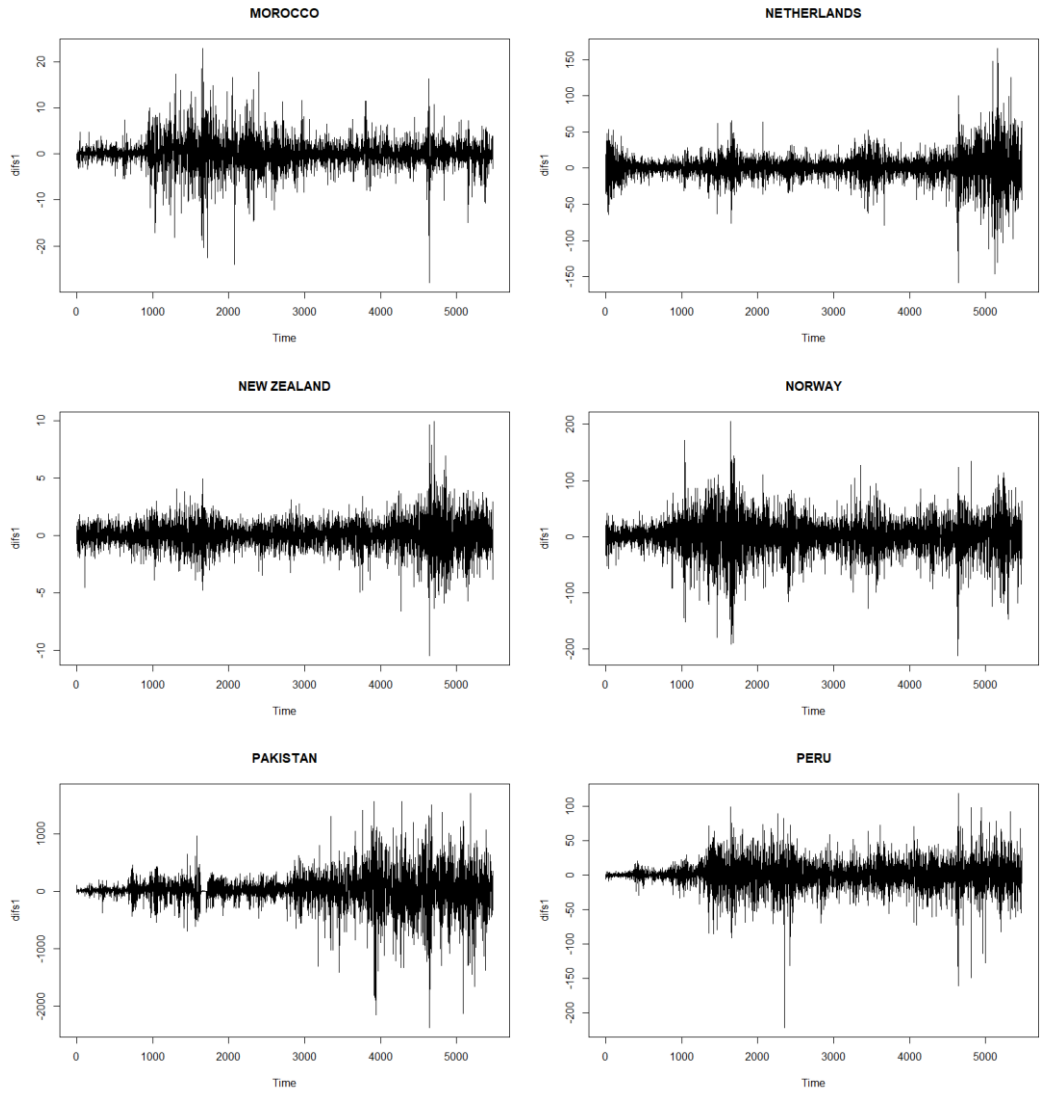
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NEW ZEALAND
NORWAY
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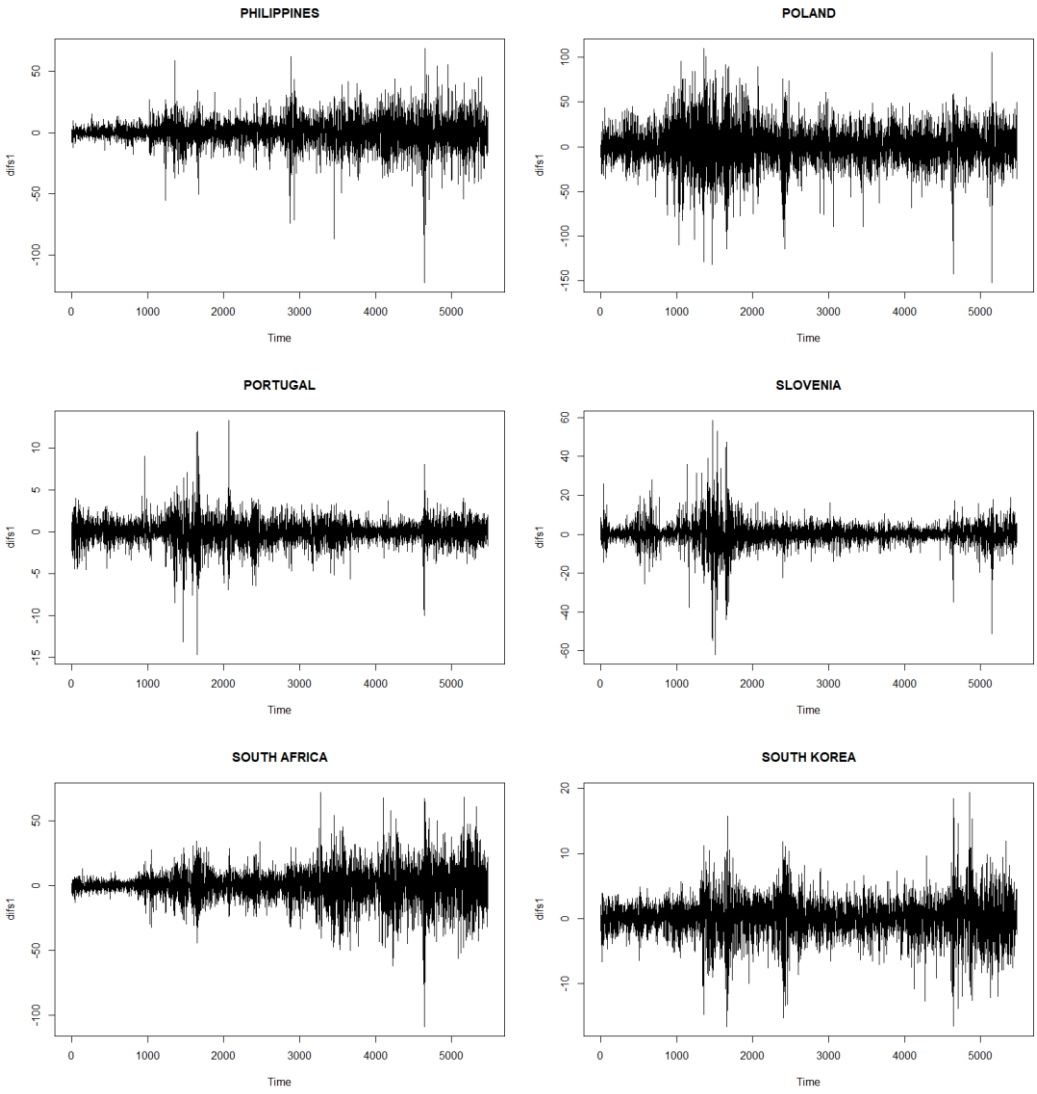
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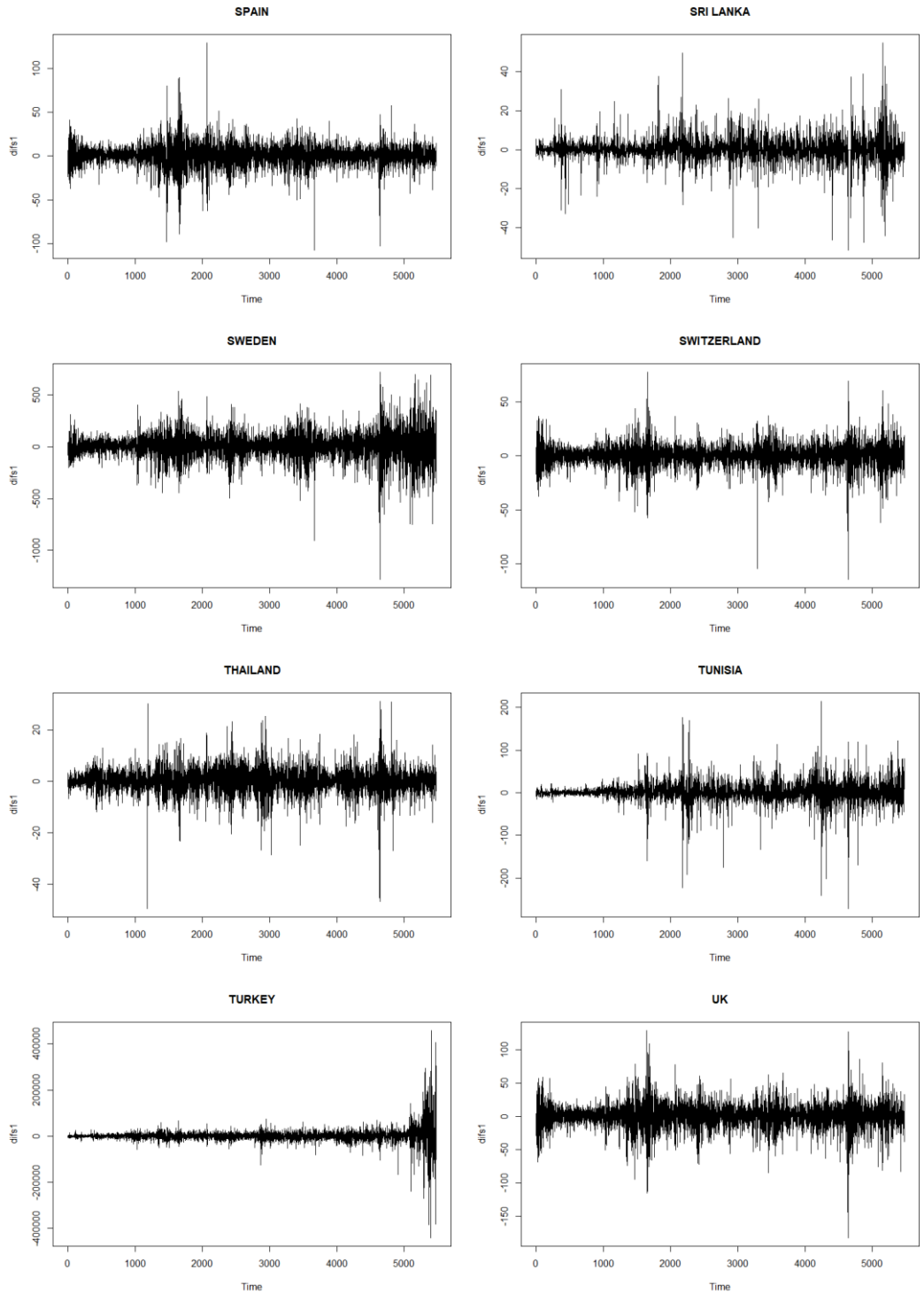
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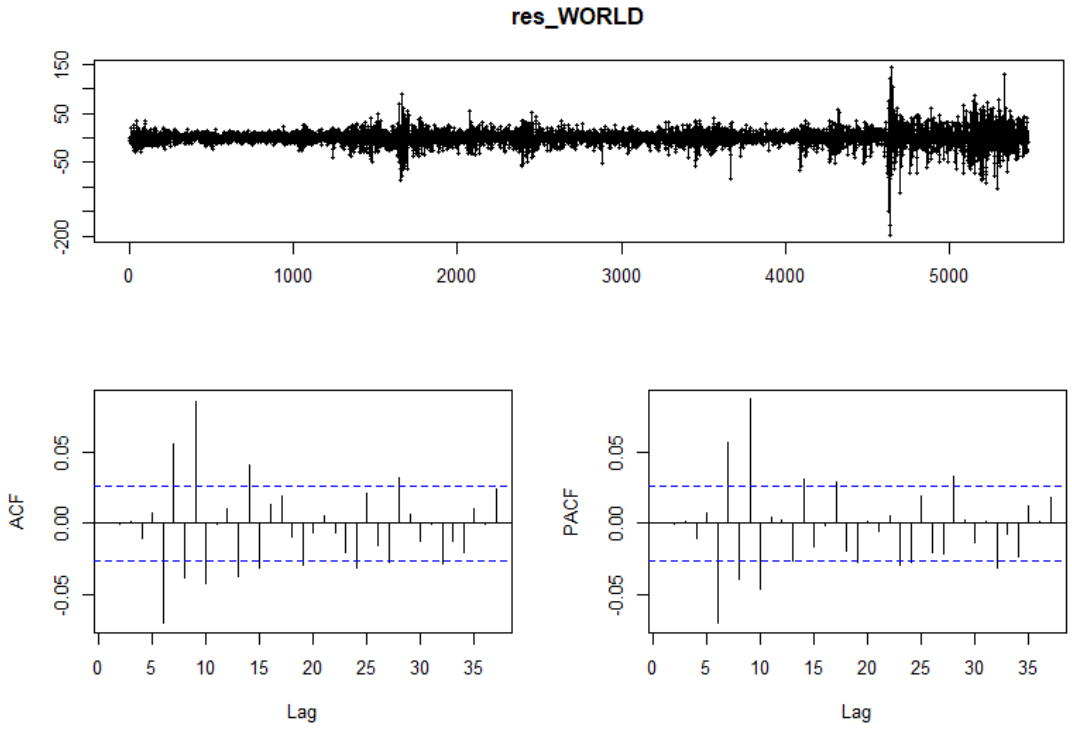
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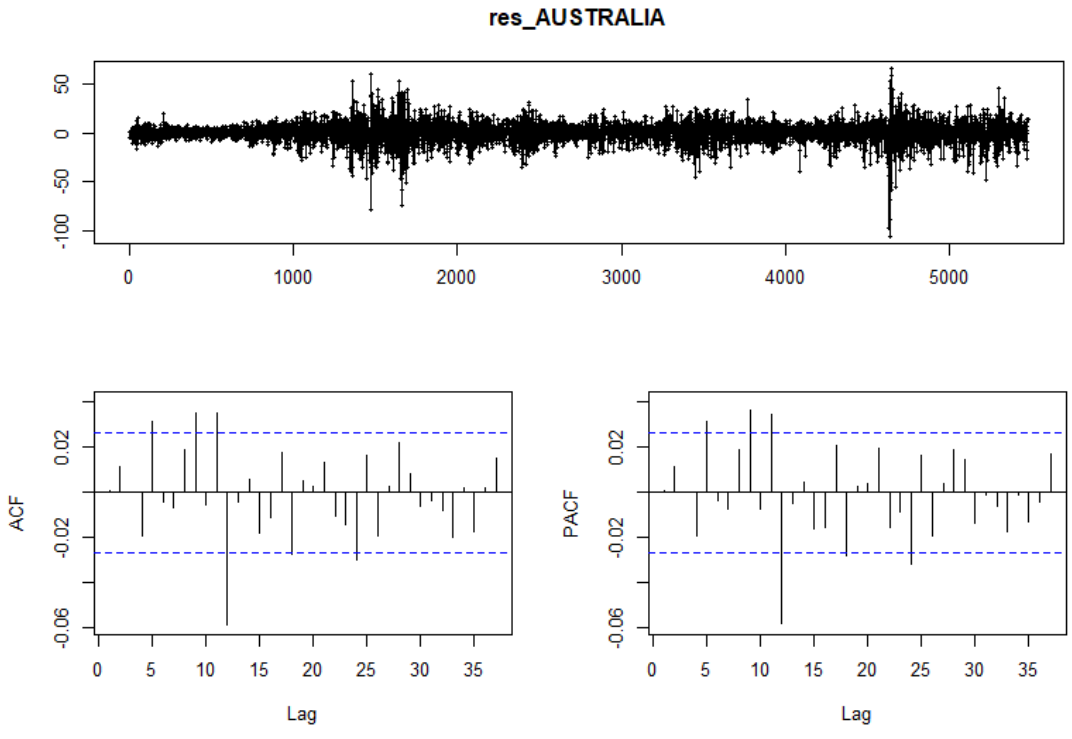
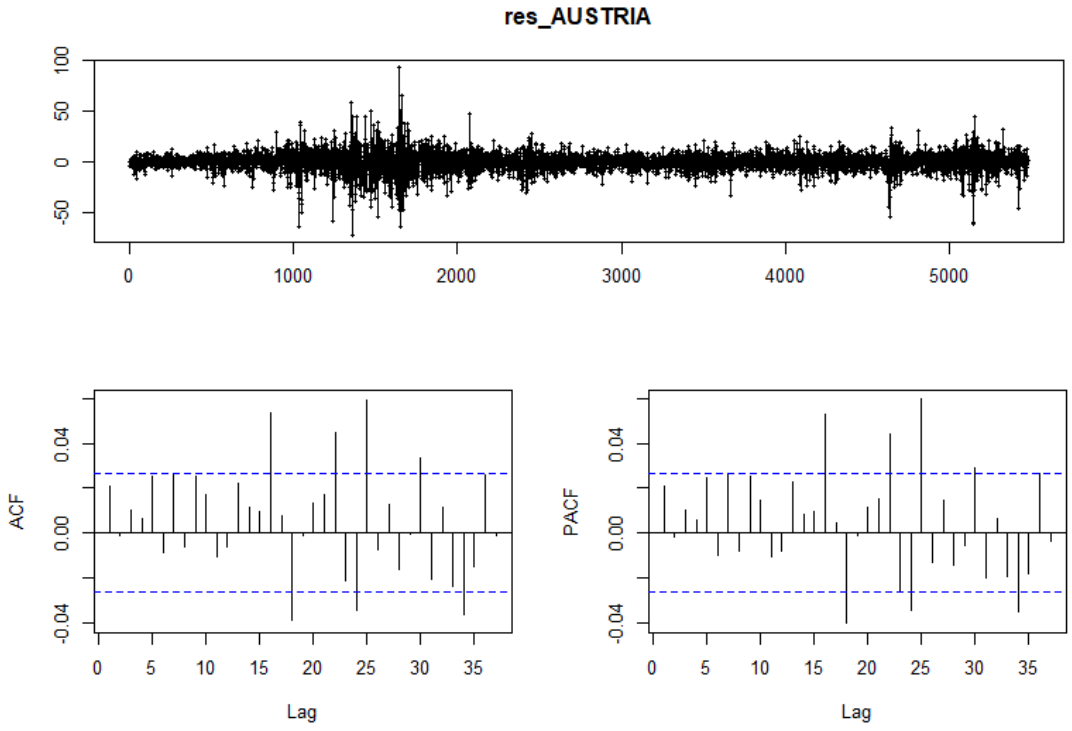
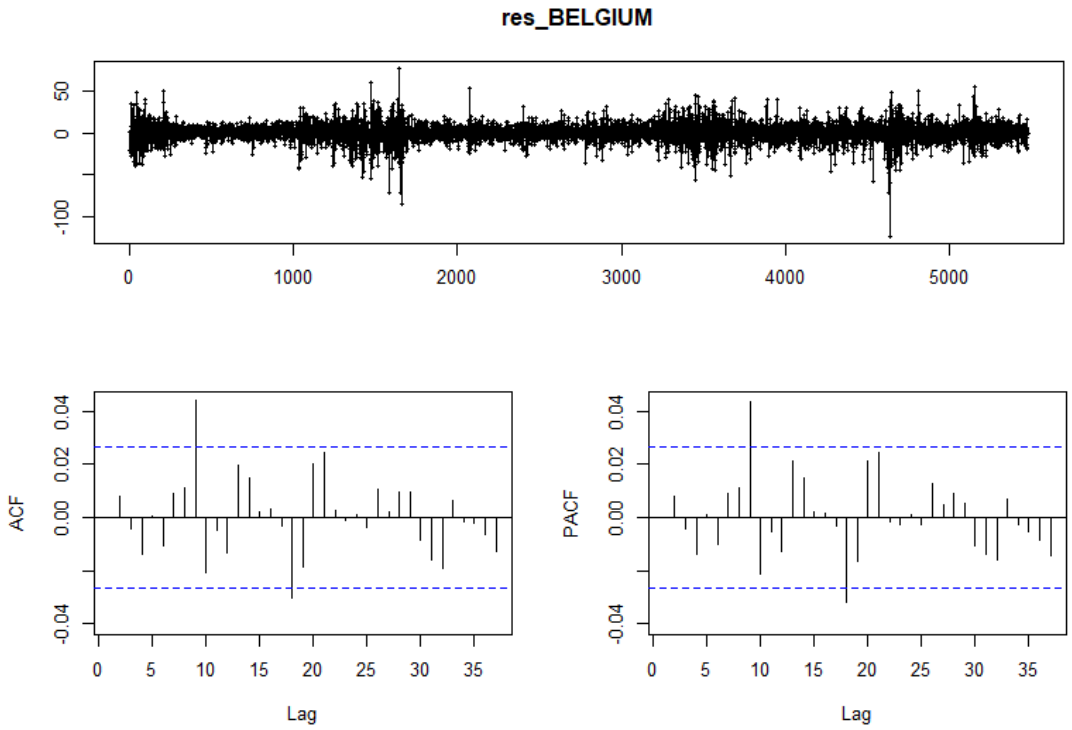
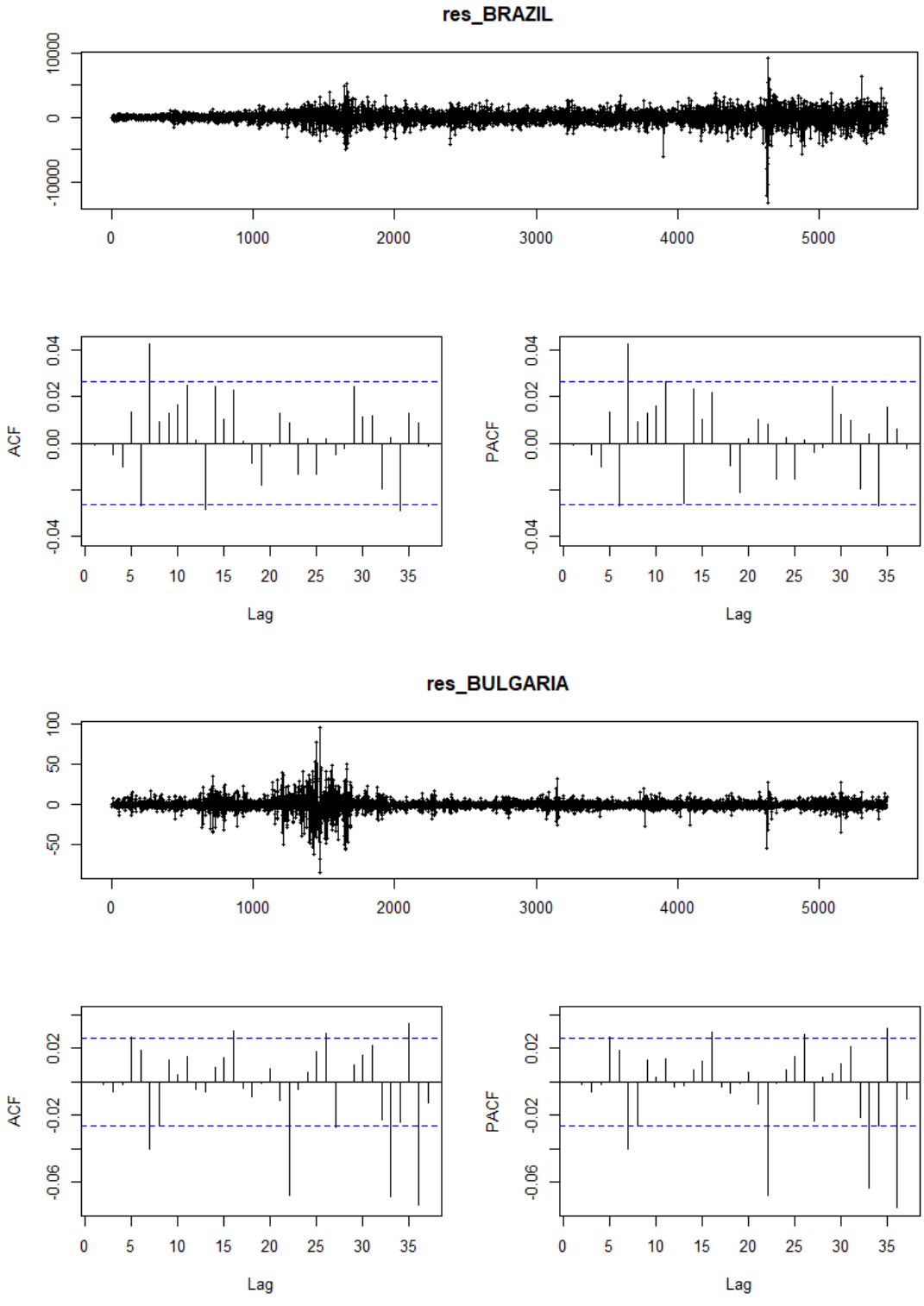
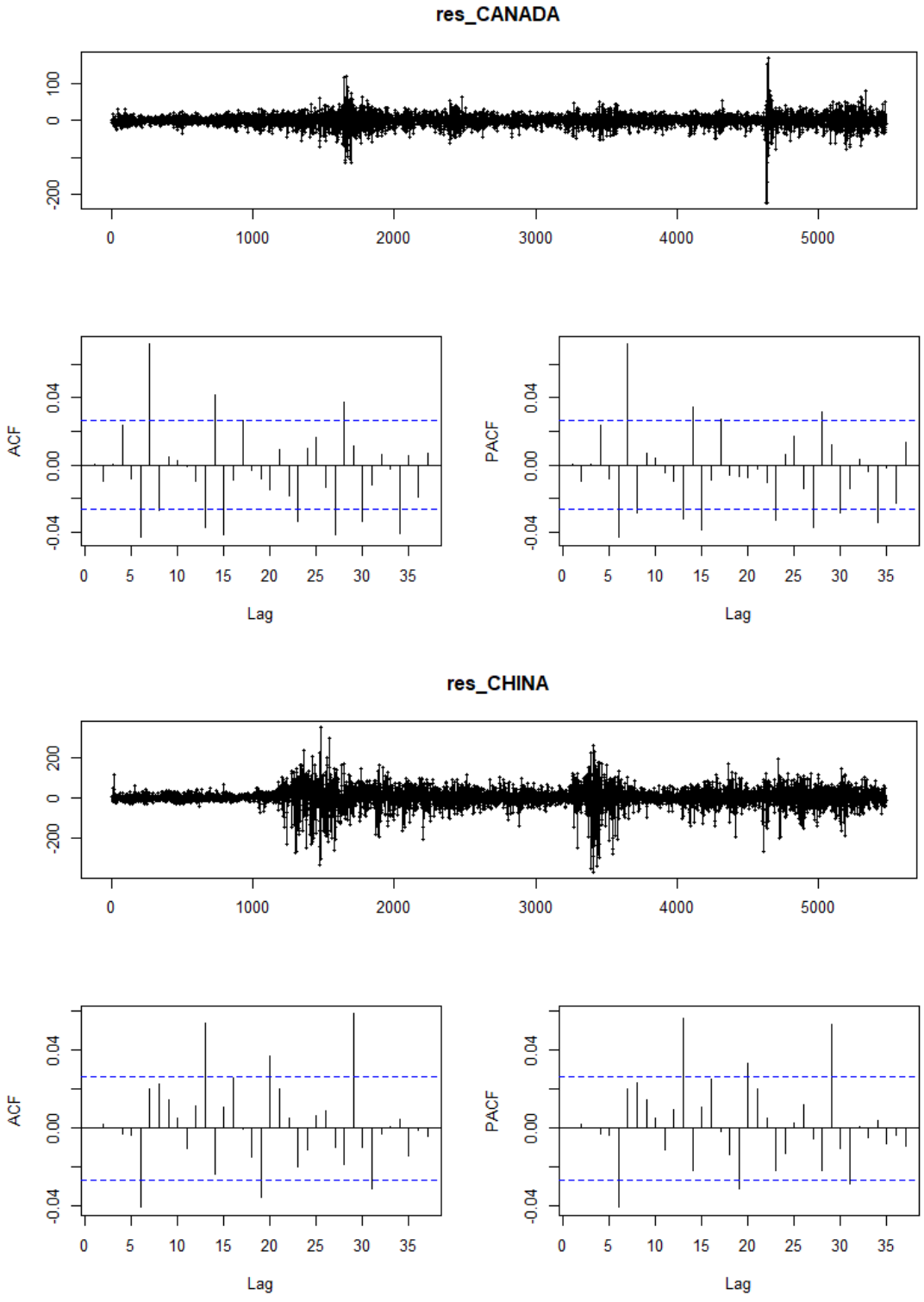
ACF
PACF
Lag
Lag

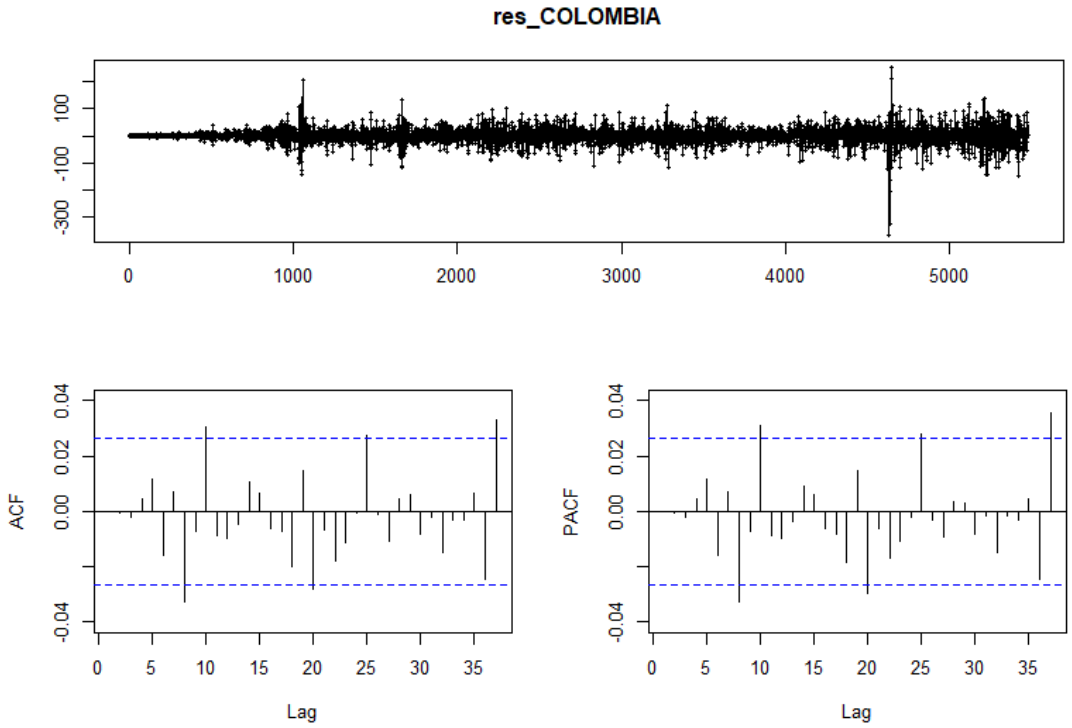

res_AUSTRALIA
ACF
PACF
Lag
Lag


res_AUSTRIA
ACF
PACF
Lag
Lag


res_BELGIUM
ACF
PACF
Lag
Lag


res_BRAZIL
10000
0
-10000
0
1000
2000
3000
4000
5000
ACF
0.04
0.02
0.00
-0.04
0
5
10
15
20
25
30
35
Lag
PACF
0.04
0.02
0.00
-0.04
0
5
10
15
20
25
30
35
Lag
res_BULGARIA
100
50
0
-50
0
1000
2000
3000
4000
5000
ACF
0.02
-0.02
-0.06
0
5
10
15
20
25
30
35
Lag
PACF
0.02
-0.02
-0.06
0
5
10
15
20
25
30
35
Lag


res_CANADA
ACF
PACF
Lag
res_CHINA
ACF
PACF
Lag


res_COLOMBIA
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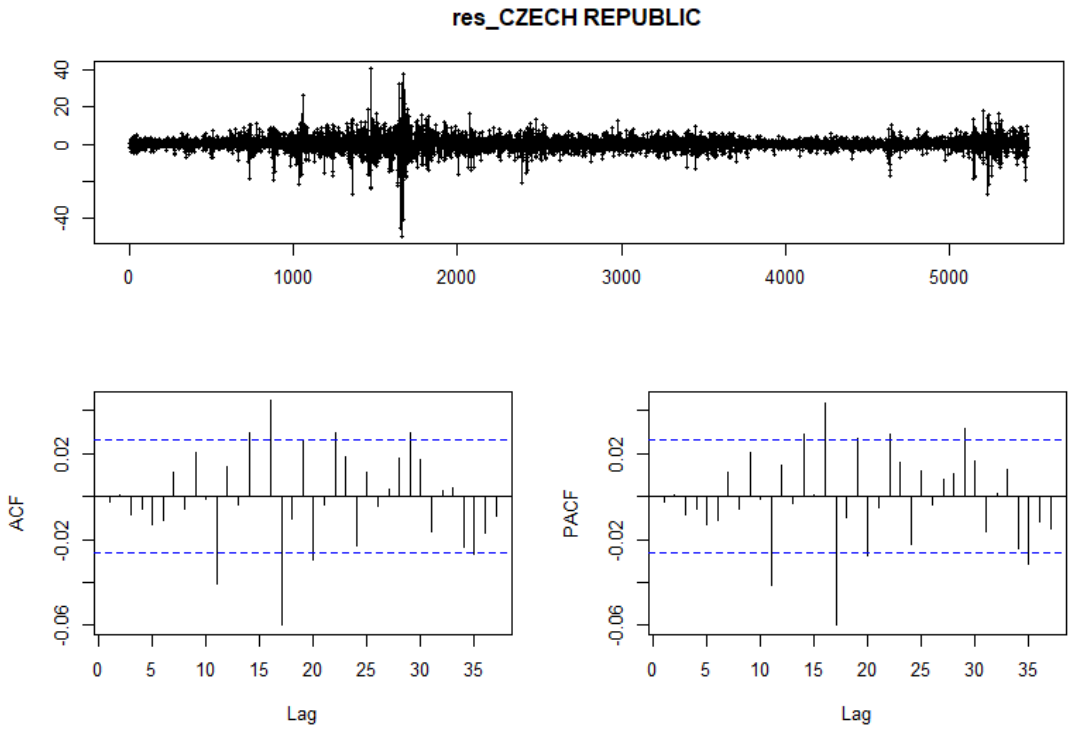
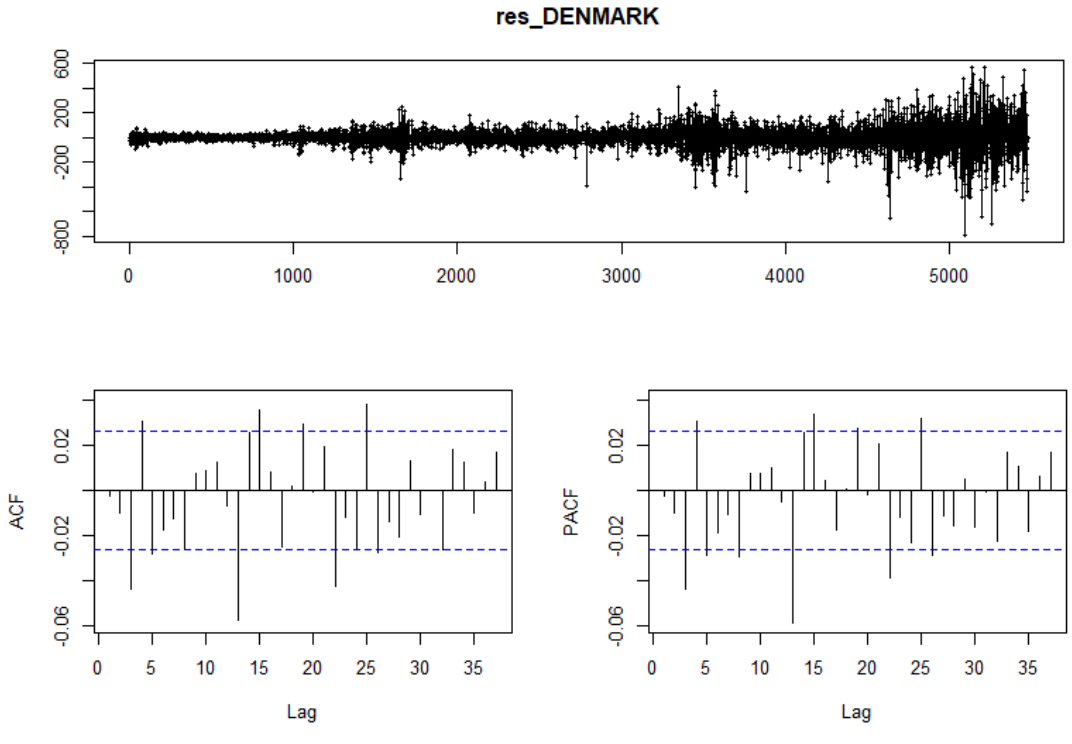
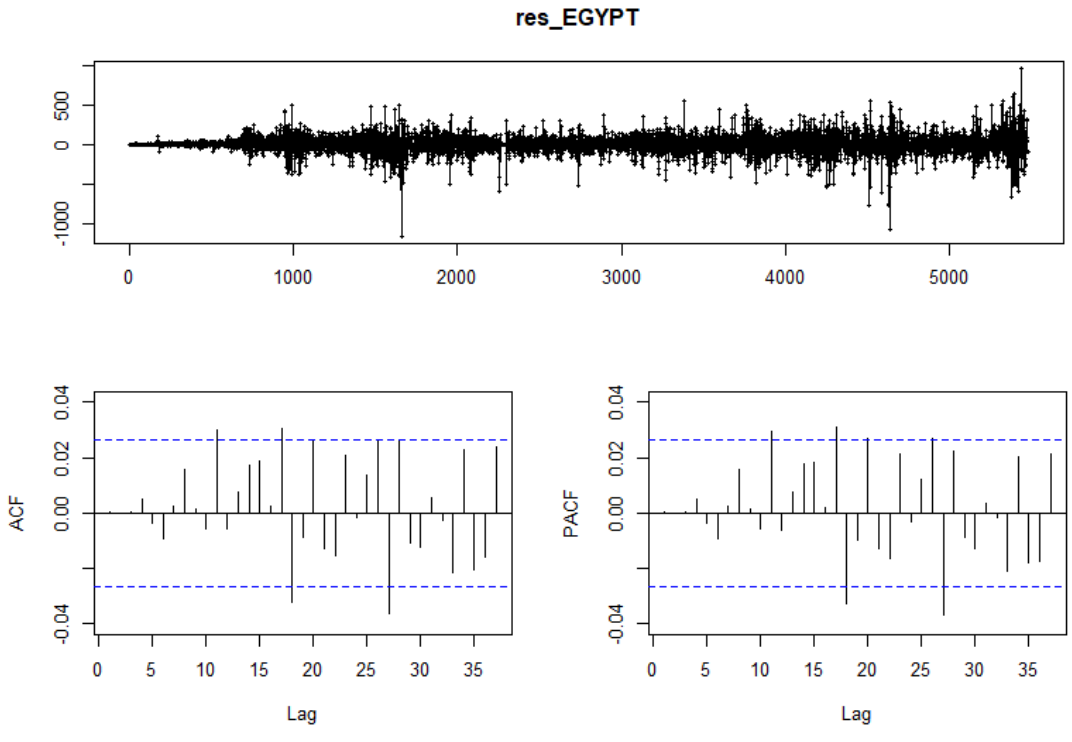
PACF
Lag
Lag


res_CZECH REPUBLIC
ACF
PACF
Lag
Lag


res_DENMARK
600
200
-200
-800
0
1000
2000
3000
4000
5000
ACF
0.02
-0.02
-0.06
0
5
10
15
20
25
30
35
Lag
PACF
0.02
-0.02
-0.06
0
5
10
15
20
25
30
35
Lag


res_EGYPT
500
0
-1000
0
1000
2000
3000
4000
5000
ACF
0.04
0.02
0.00
-0.04
0
5
10
15
20
25
30
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Lag
PACF
0.04
0.02
0.00
-0.04
0
5
10
15
20
25
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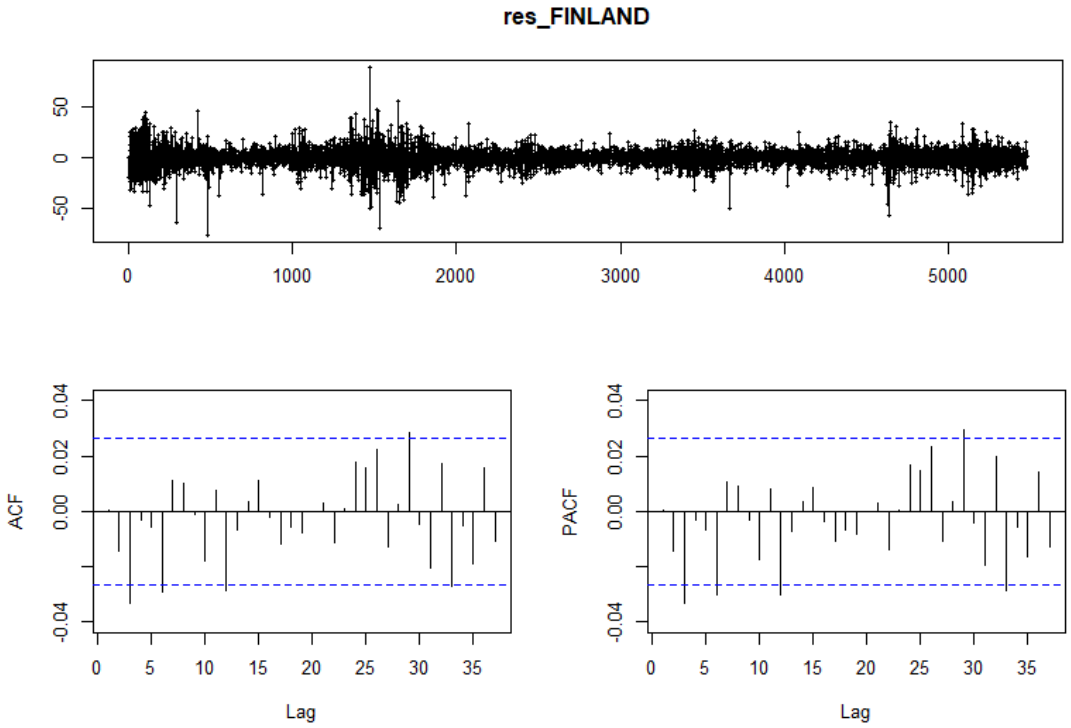
35
Lag


res_FINLAND
50
0
-50
0
1000
2000
3000
4000
5000
ACF
0.04
0.02
0.00
-0.04
0
5
10
15
20
25
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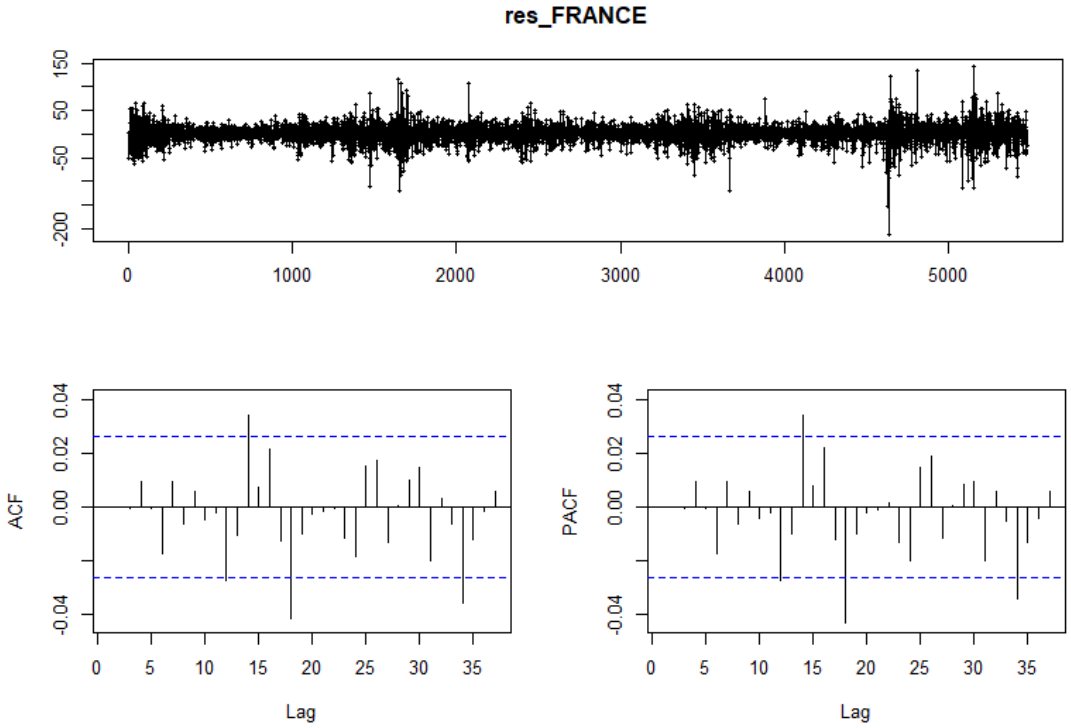
Lag
PACF
0.04
0.02
0.00
-0.04
0
5
10
15
20
25
30
35
Lag


res_FRANCE
150
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-50
-200
0
1000
2000
3000
4000
5000
ACF
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0.02
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-0.04
0
5
10
15
20
25
30
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Lag
PACF
0.04
0.02
0.00
-0.04
0
5
10
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30
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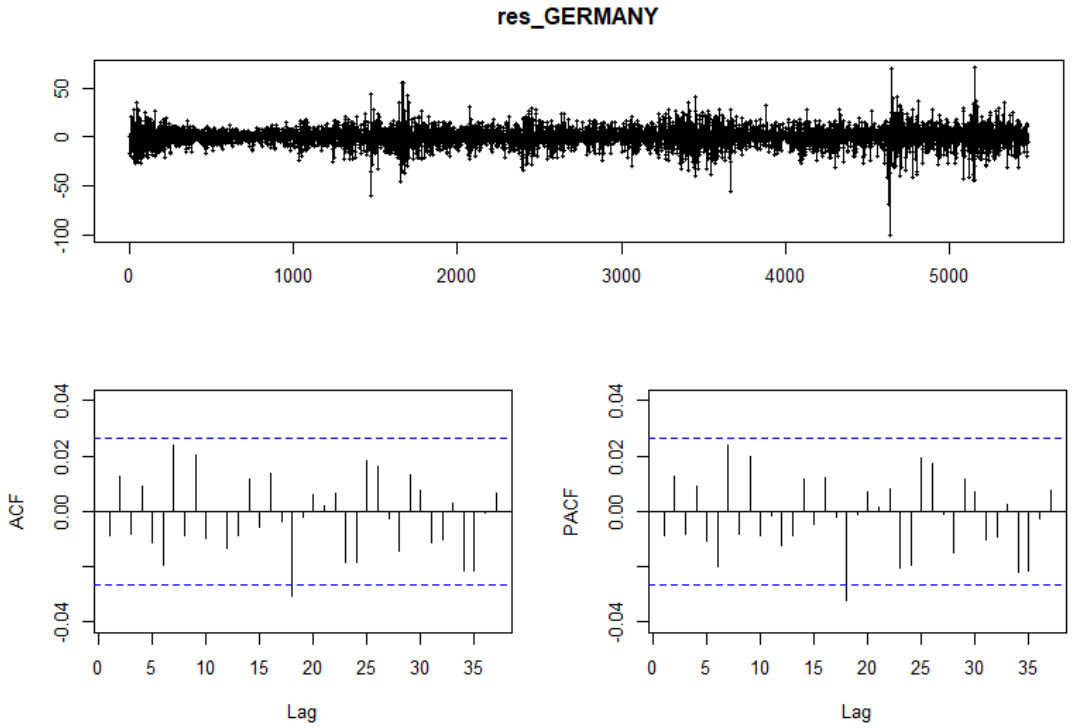
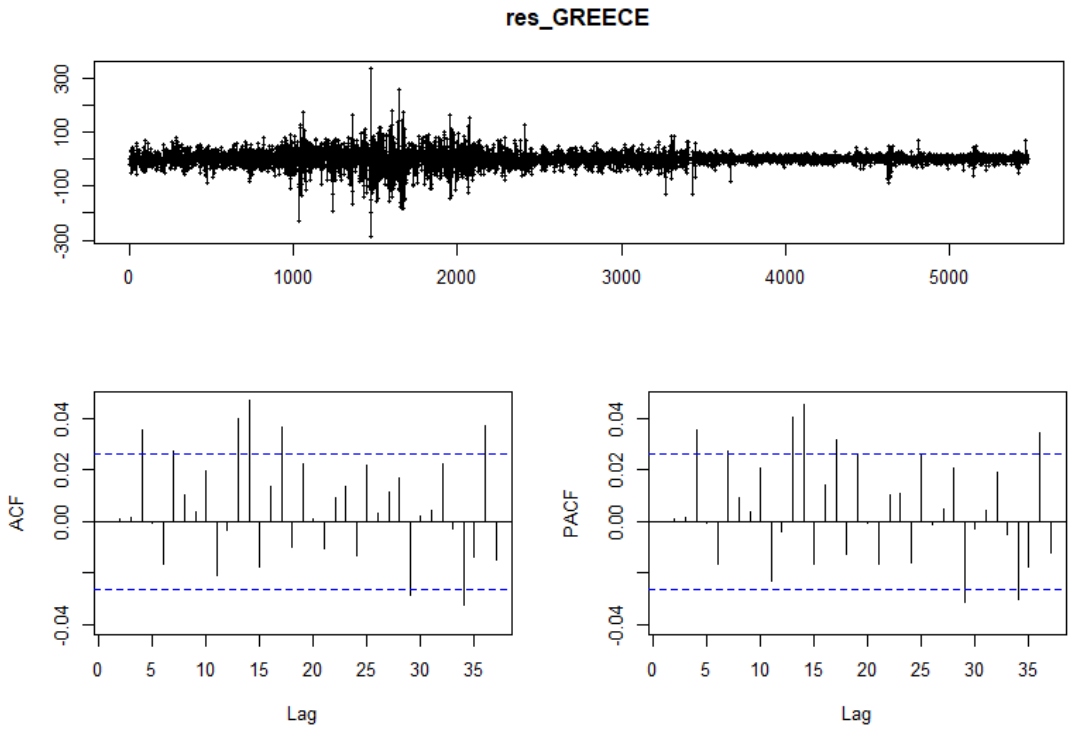
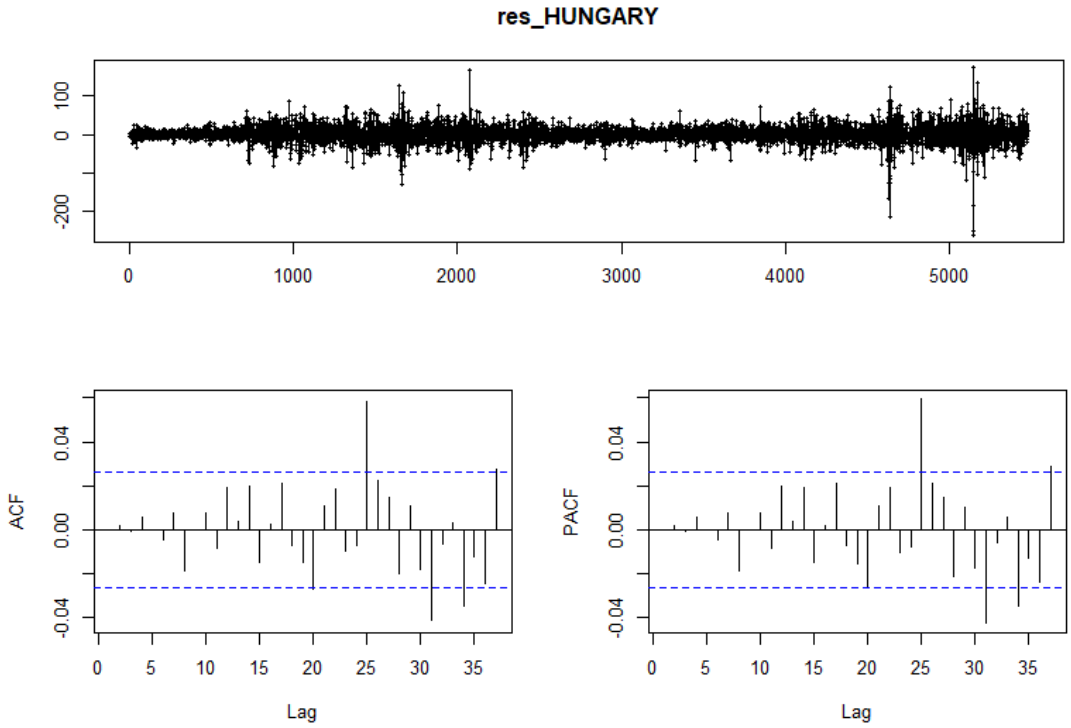
Lag


res_GERMANY
ACF
PACF
Lag
Lag


res_GREECE
ACF
PACF
Lag
Lag


res_HUNGARY
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0
100
0
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2000
3000
4000
5000
ACF
-0.04
0.00
0.04
0
5
10
15
20
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30
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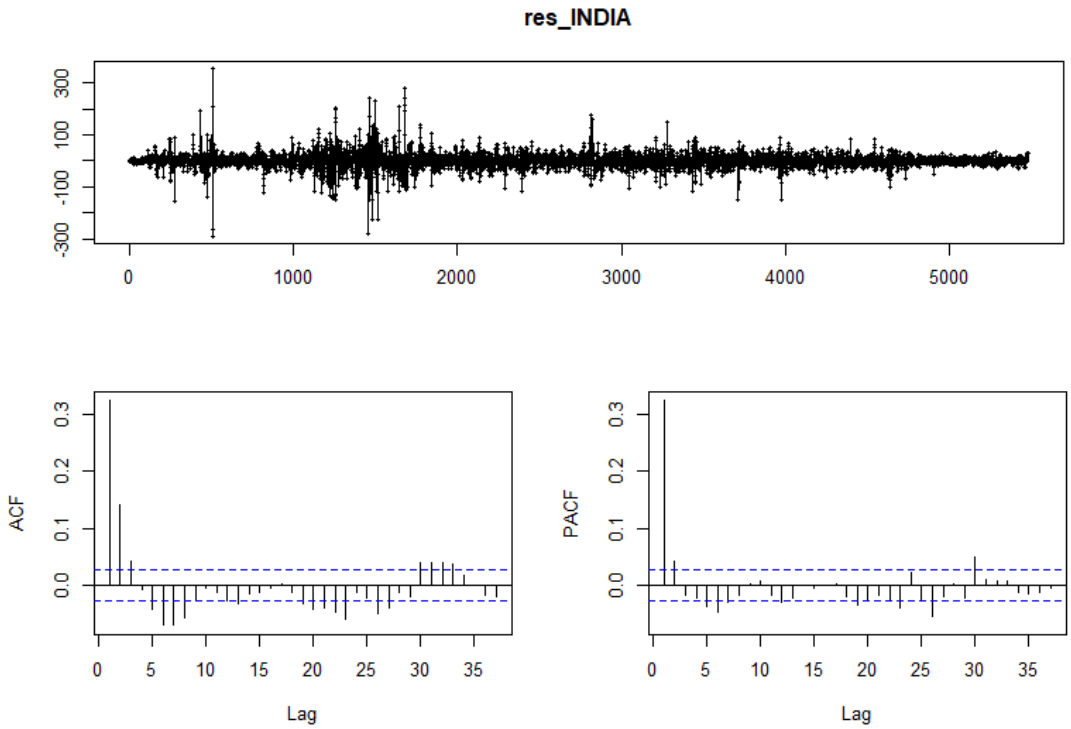
Lag
PACF
-0.04
0.00
0.04
0
5
10
15
20
25
30
35
Lag


res_INDIA
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-100
100
300
0
1000
2000
3000
4000
5000
ACF
0.0
0.1
0.2
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5
10
15
20
25
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Lag
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0.0
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0.2
0.3
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5
10
15
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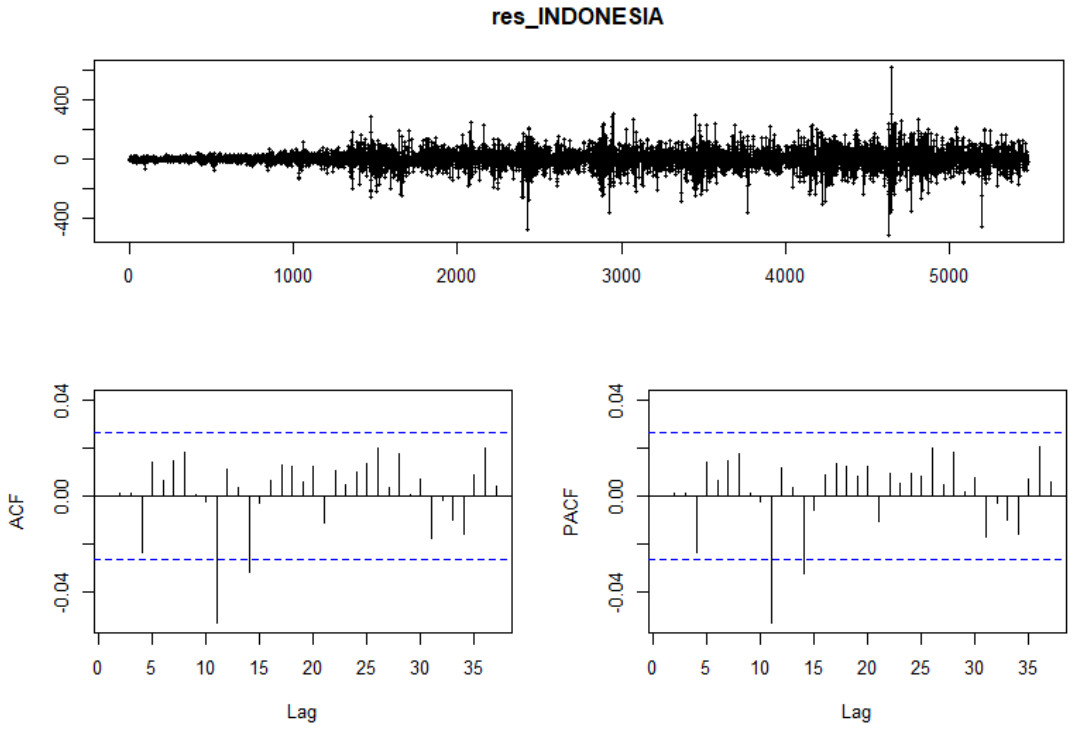
25
30
35
Lag


res_INDONESIA
400
0
-400
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2000
3000
4000
5000
ACF
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0.00
-0.04
0
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Lag
PACF
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0.00
-0.04
0
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15
20
25
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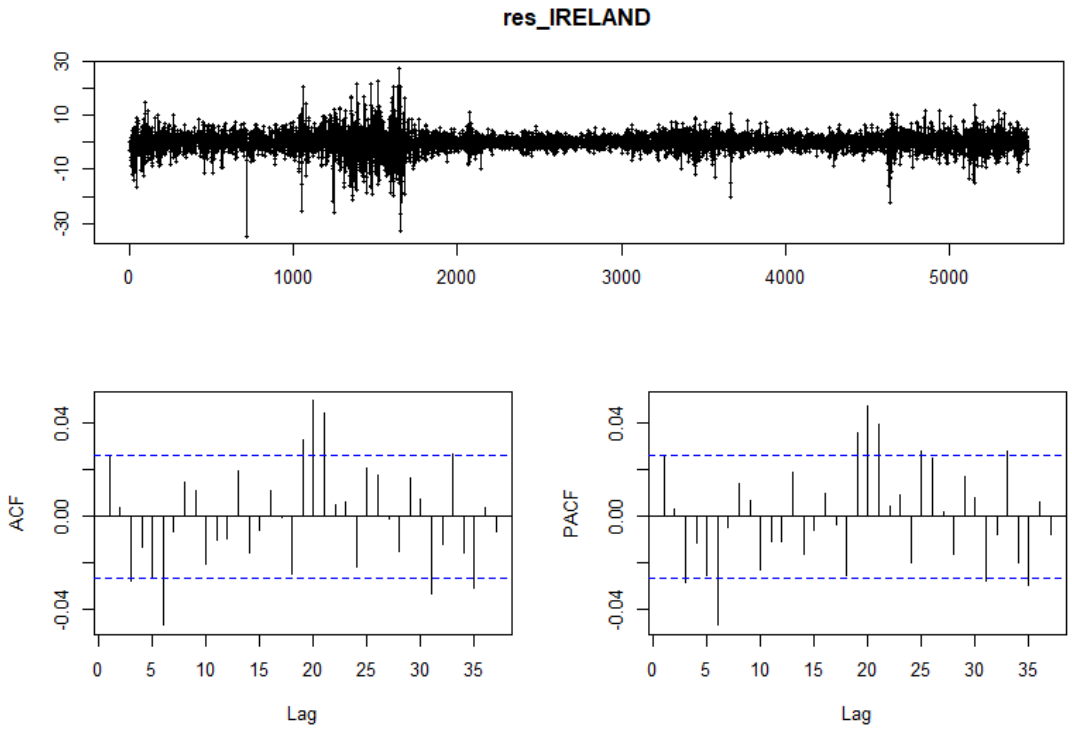
35
Lag


res_IRELAND
30
10
-10
-30
0
1000
2000
3000
4000
5000
ACF
0.04
0.00
-0.04
0
5
10
15
20
25
30
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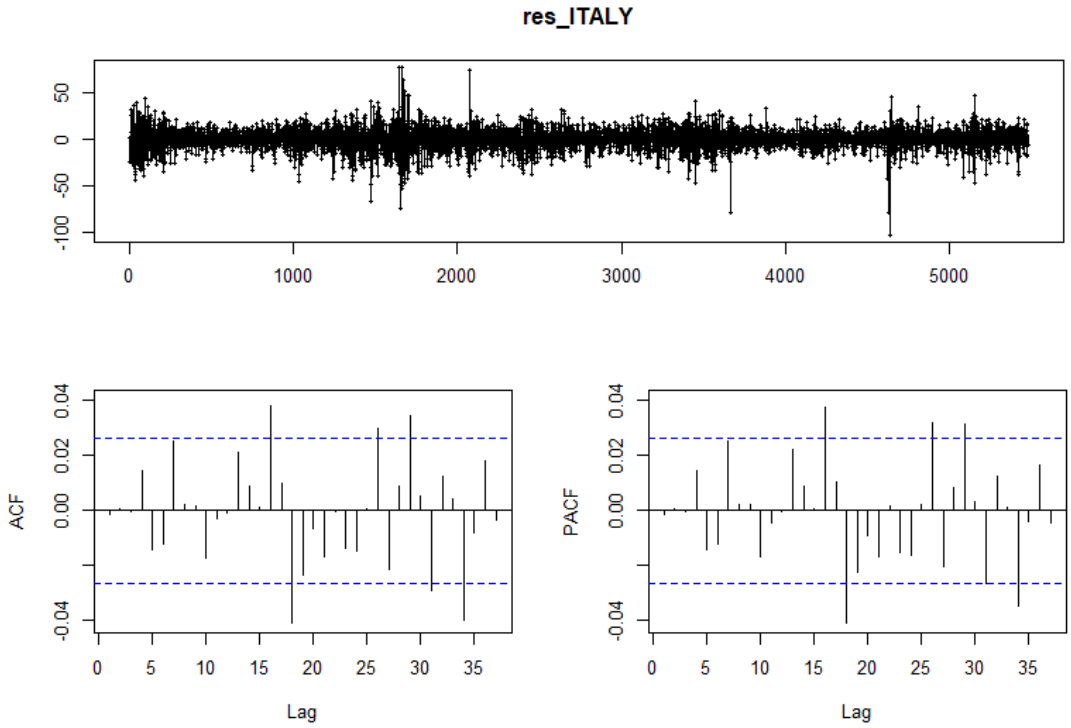
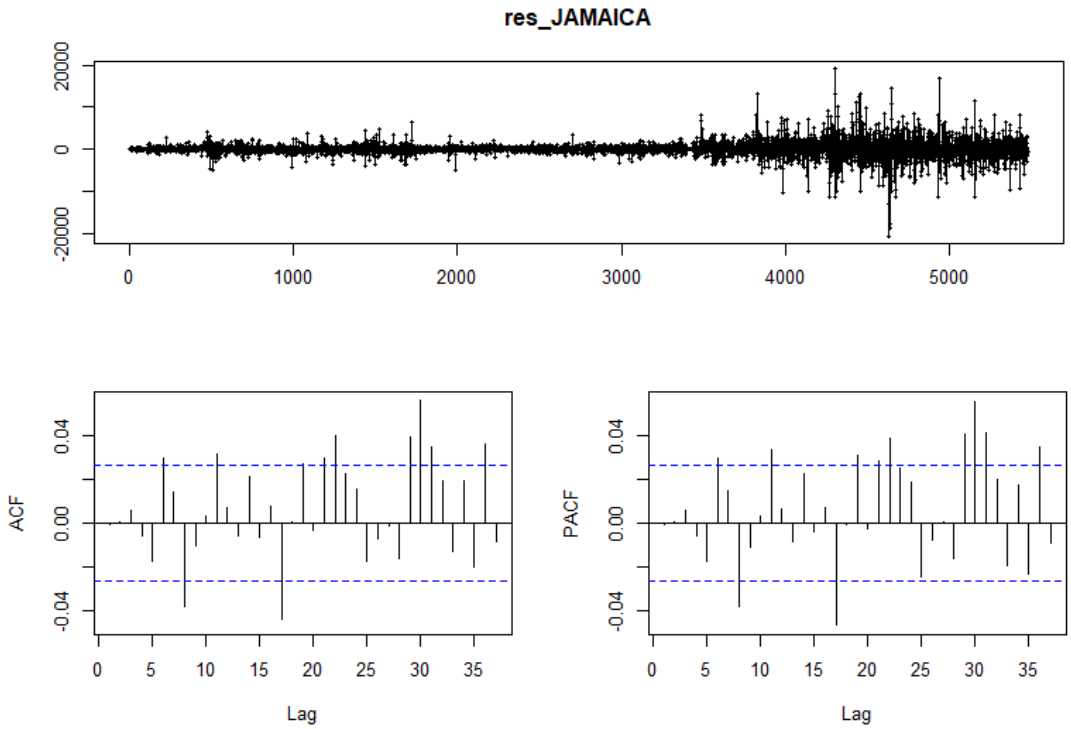
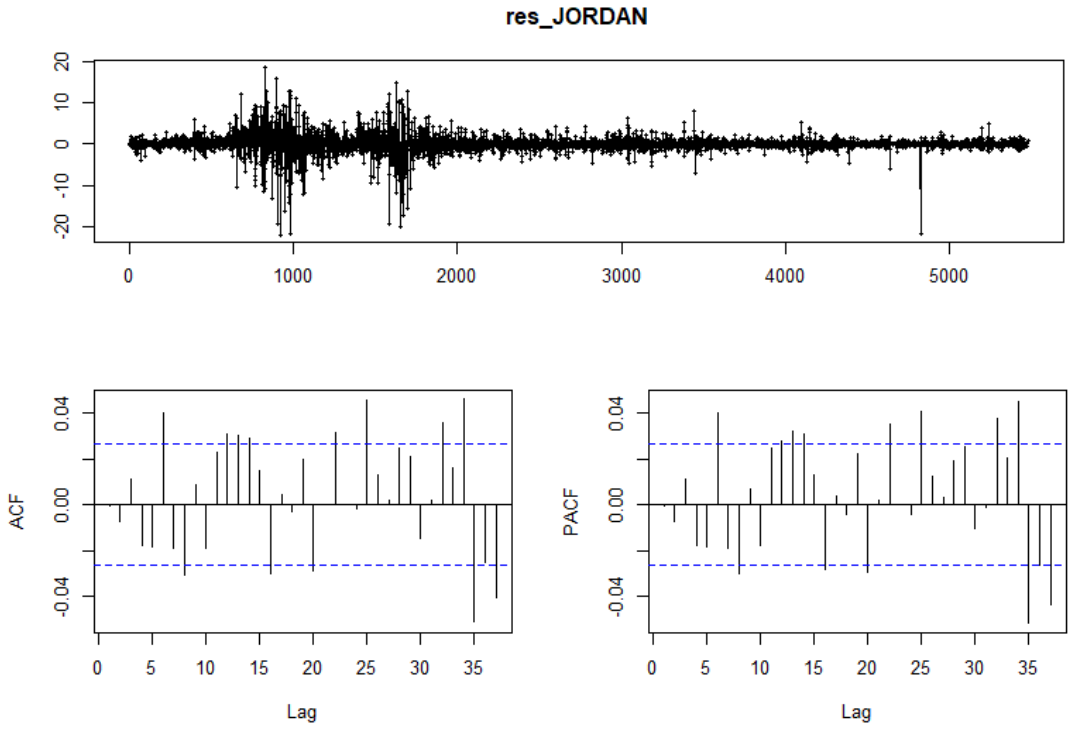
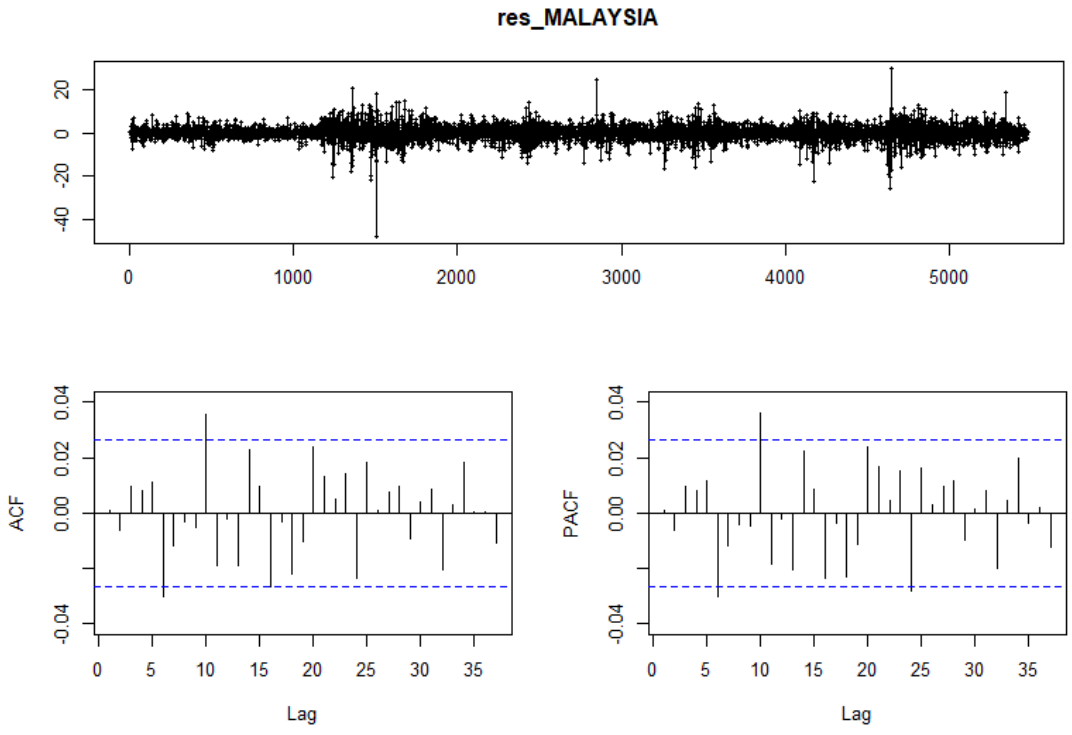
Lag
PACF
0.04
0.00
-0.04
0
5
10
15
20
25
30
35
Lag


res_ITALY
ACF
PACF
Lag
Lag


res_JAMAICA
ACF
PACF
Lag
Lag


res_JORDAN
ACF
PACF
Lag
Lag


res_MALAYSIA
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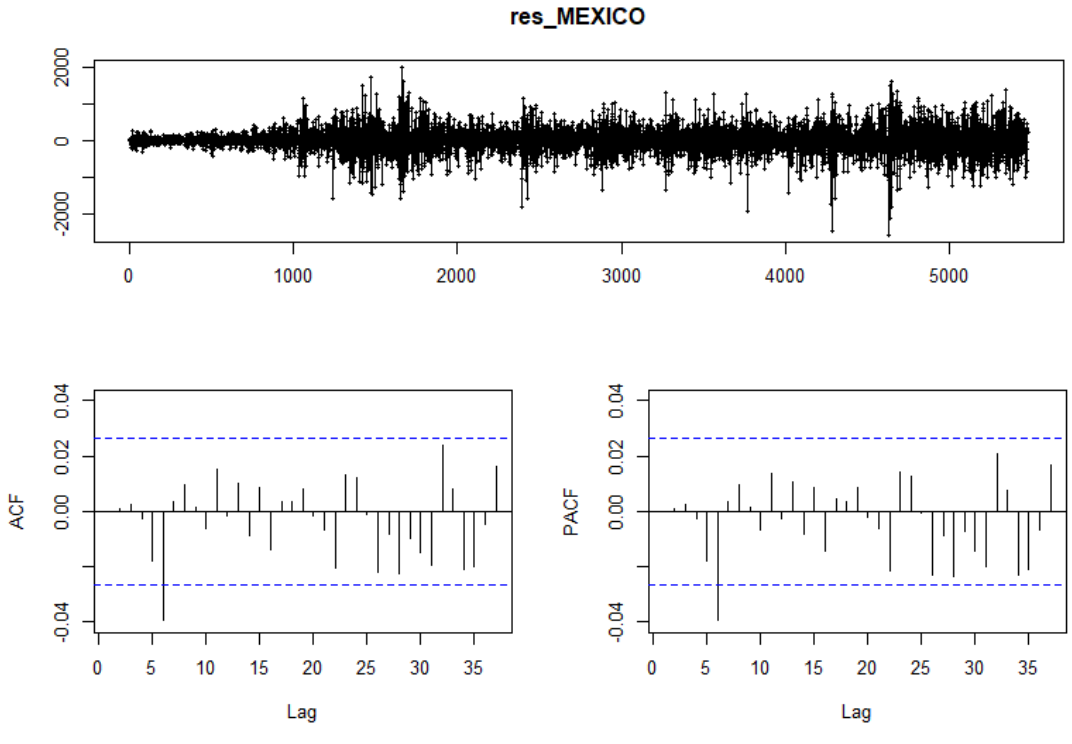
PACF
Lag
Lag


res_MEXICO
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-2000
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2000
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ACF
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0.02
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15
20
25
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Lag
PACF
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0.02
0.00
-0.04
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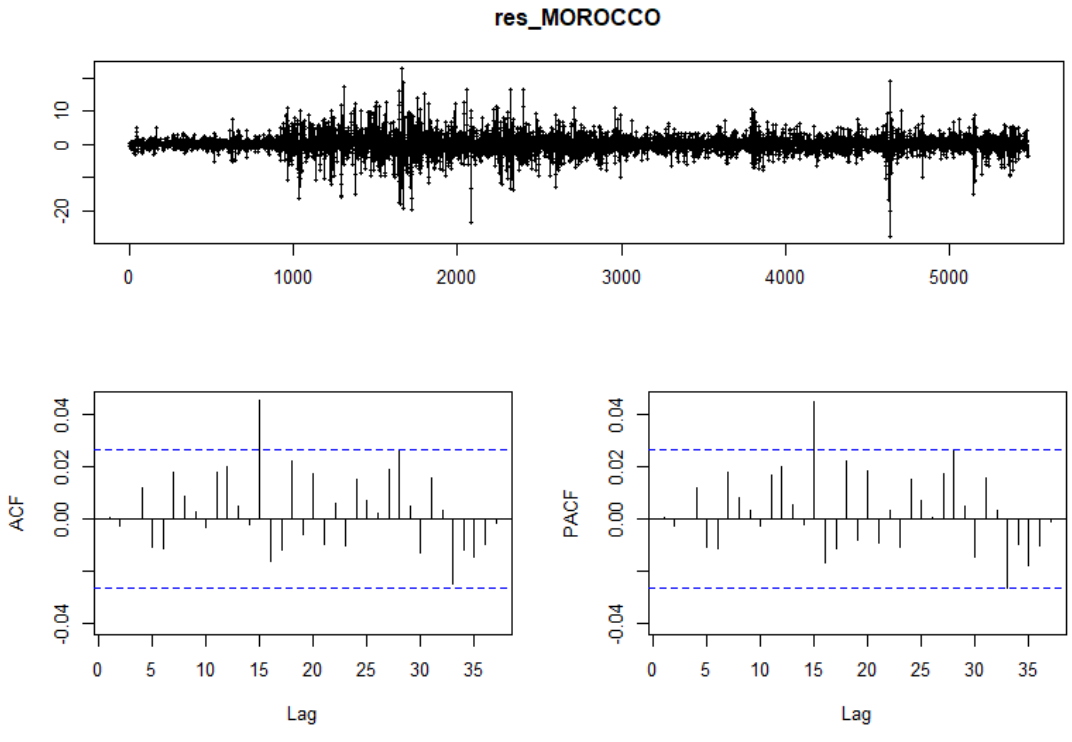
Lag


res_MOROCCO
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0
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2000
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4000
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ACF
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0.02
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-0.04
0
5
10
15
20
25
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Lag
PACF
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0.02
0.00
-0.04
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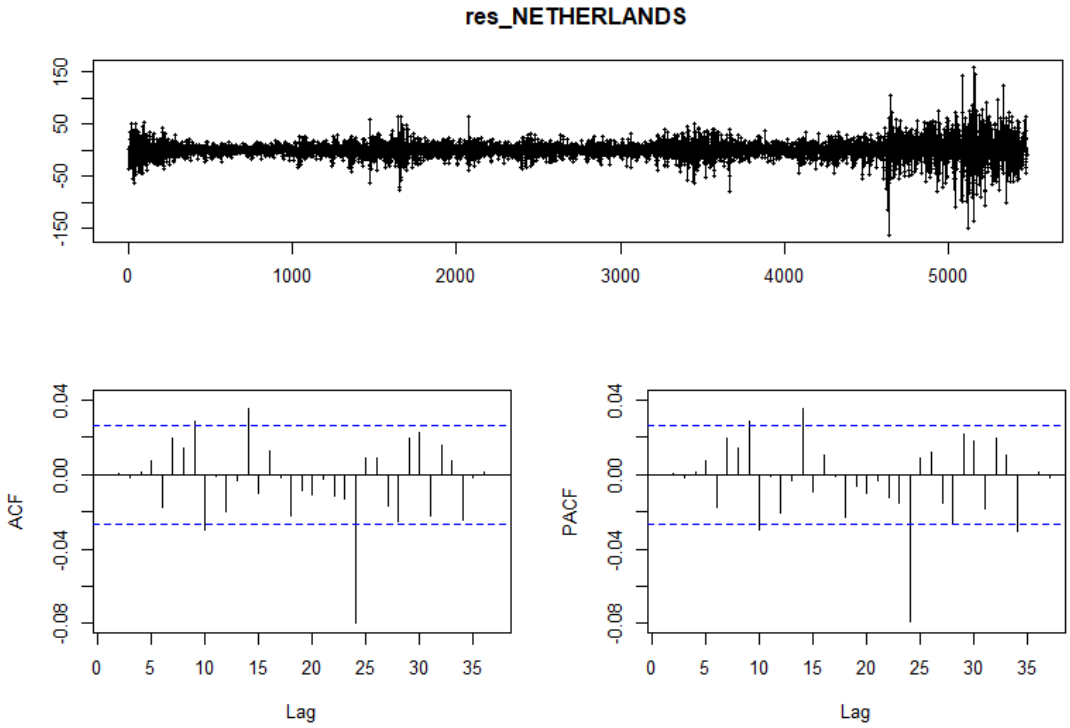
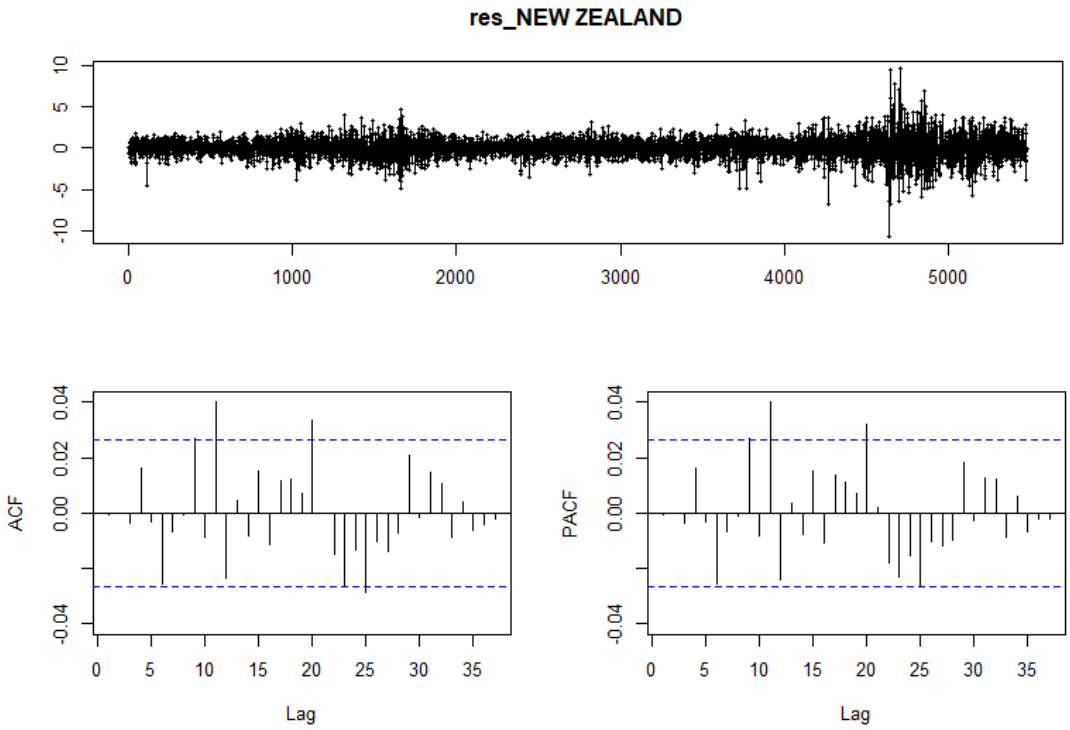
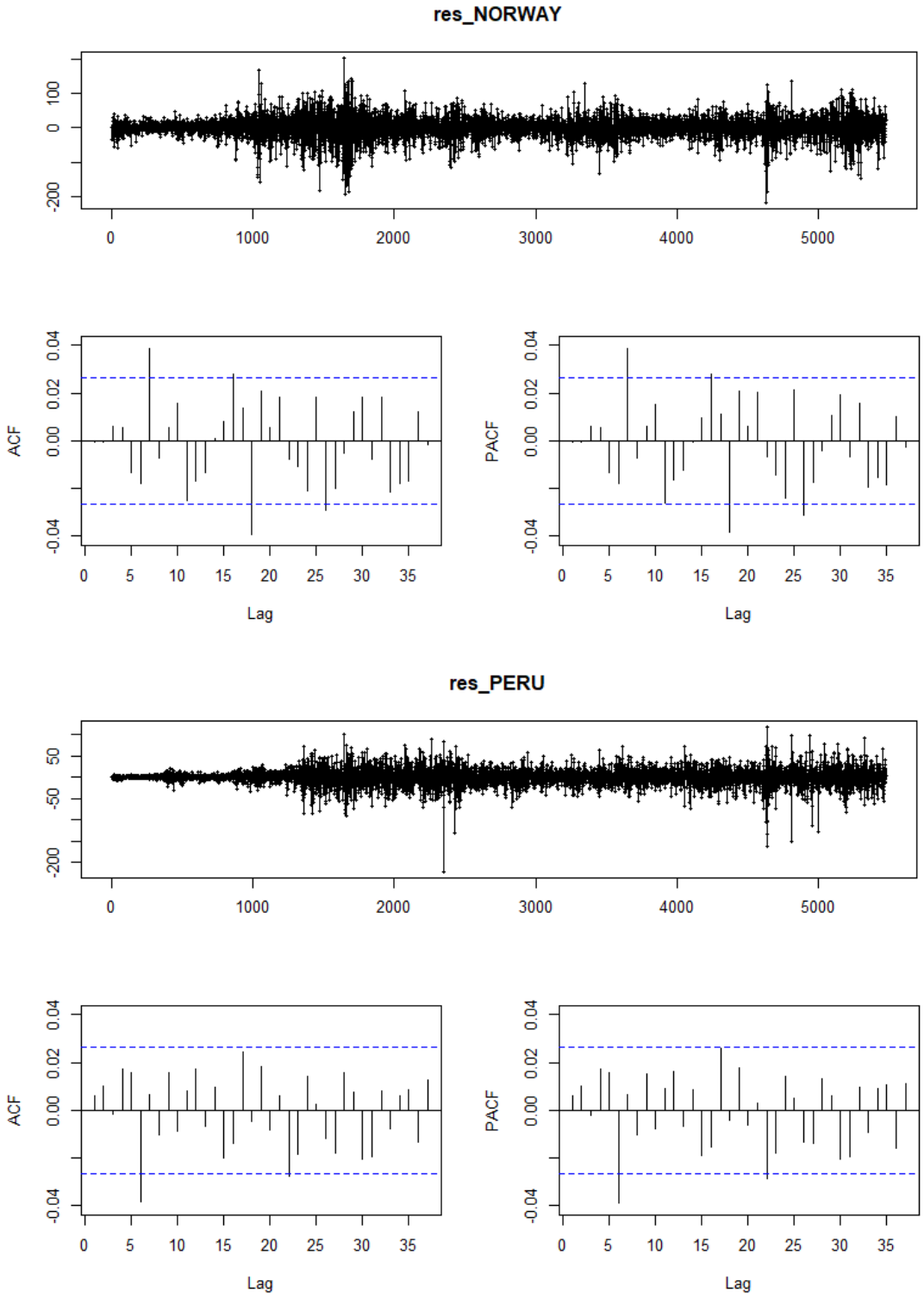
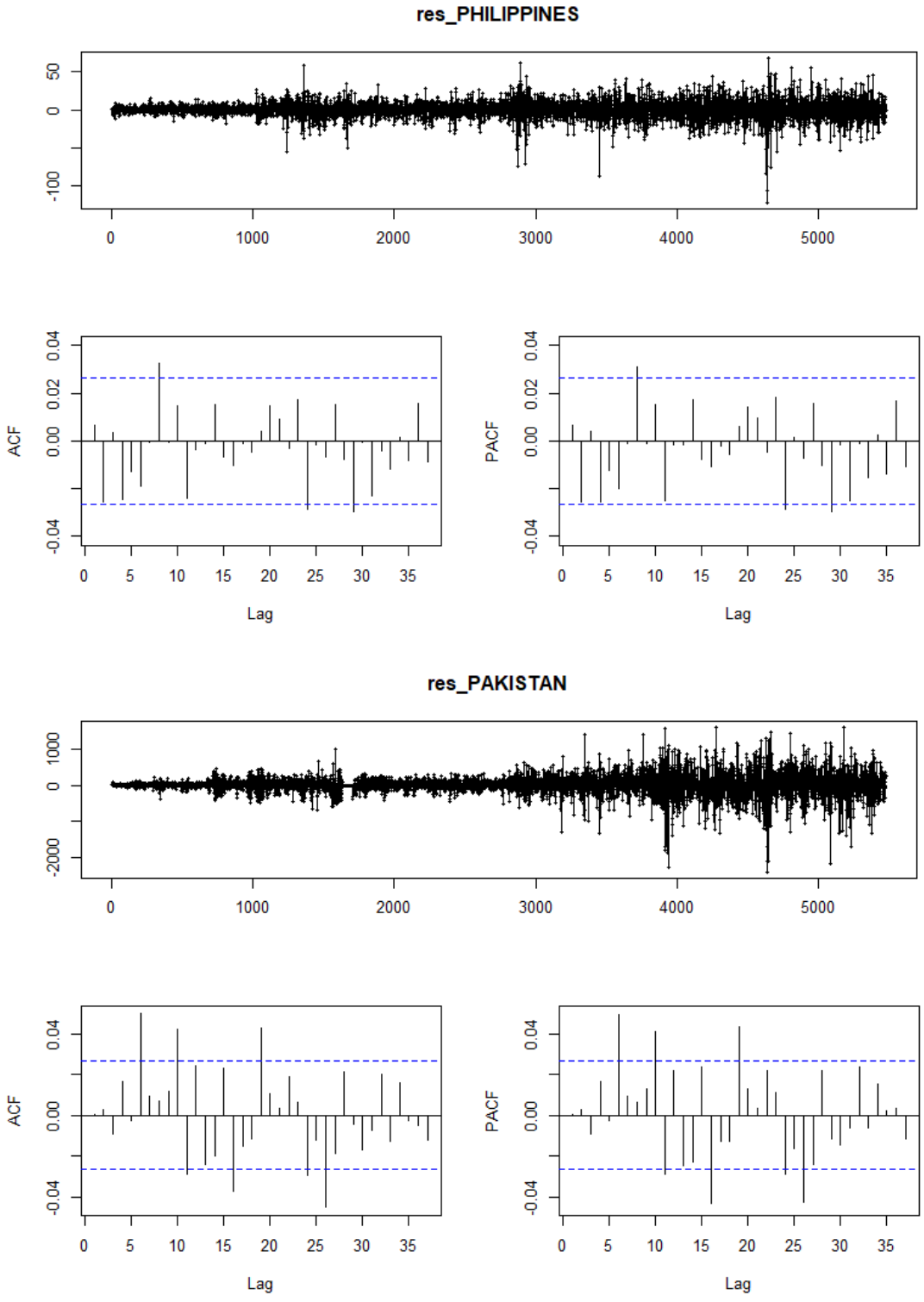
35
Lag


res_NETHERLANDS
ACF
PACF
Lag
Lag


res_NEW ZEALAND
ACF
PACF
Lag
Lag


res_NORWAY
ACF
PACF
Lag
res_PERU
ACF
PACF
Lag


res_PHILIPPINES
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0
-100
0
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2000
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4000
5000
ACF
0.04
0.02
0.00
-0.04
0
5
10
15
20
25
30
35
Lag
PACF
0.04
0.02
0.00
-0.04
0
5
10
15
20
25
30
35
Lag
res_PAKISTAN
1000
0
-2000
0
1000
2000
3000
4000
5000
ACF
0.04
0.00
-0.04
0
5
10
15
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PACF
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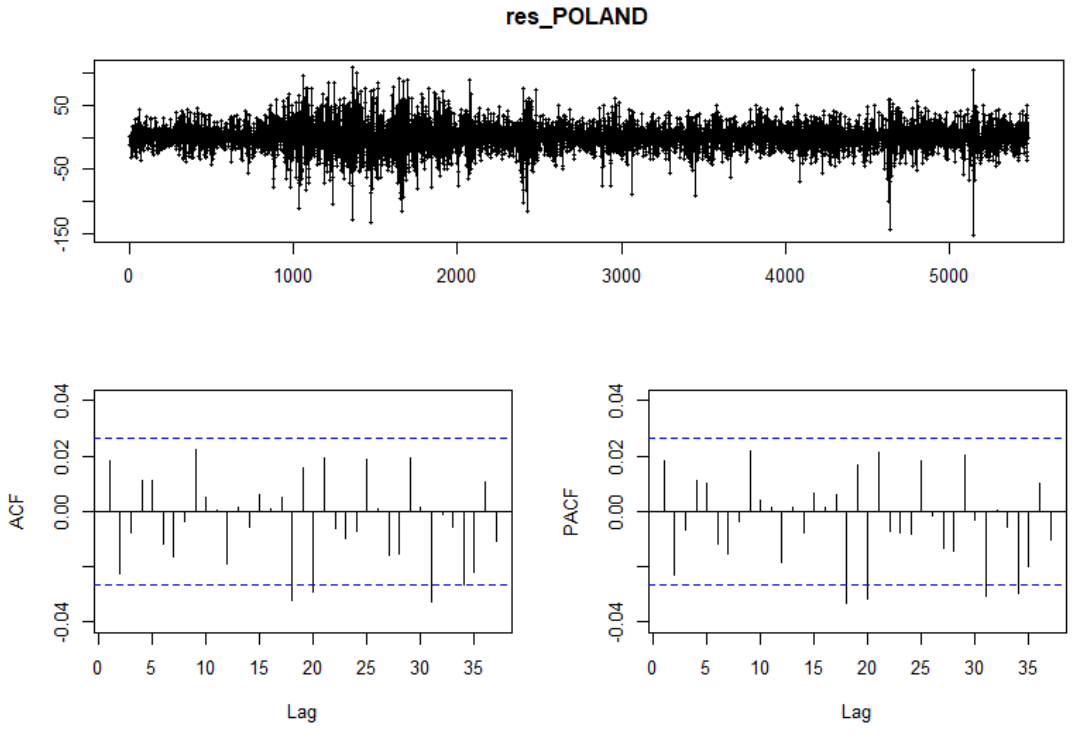
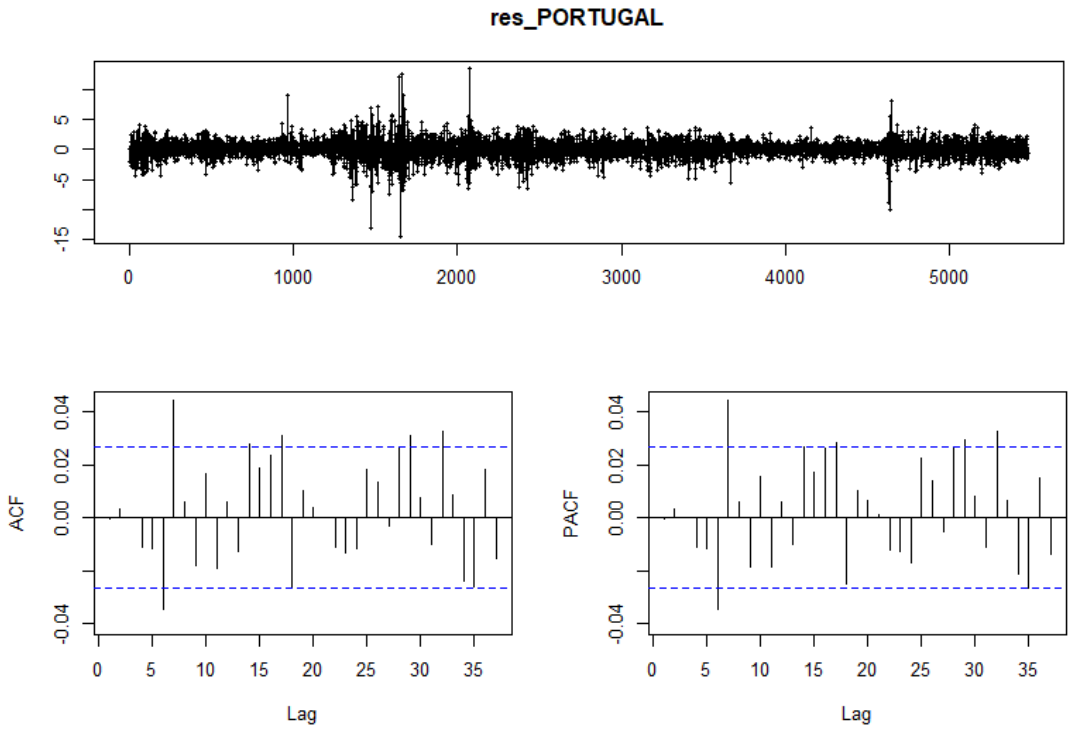
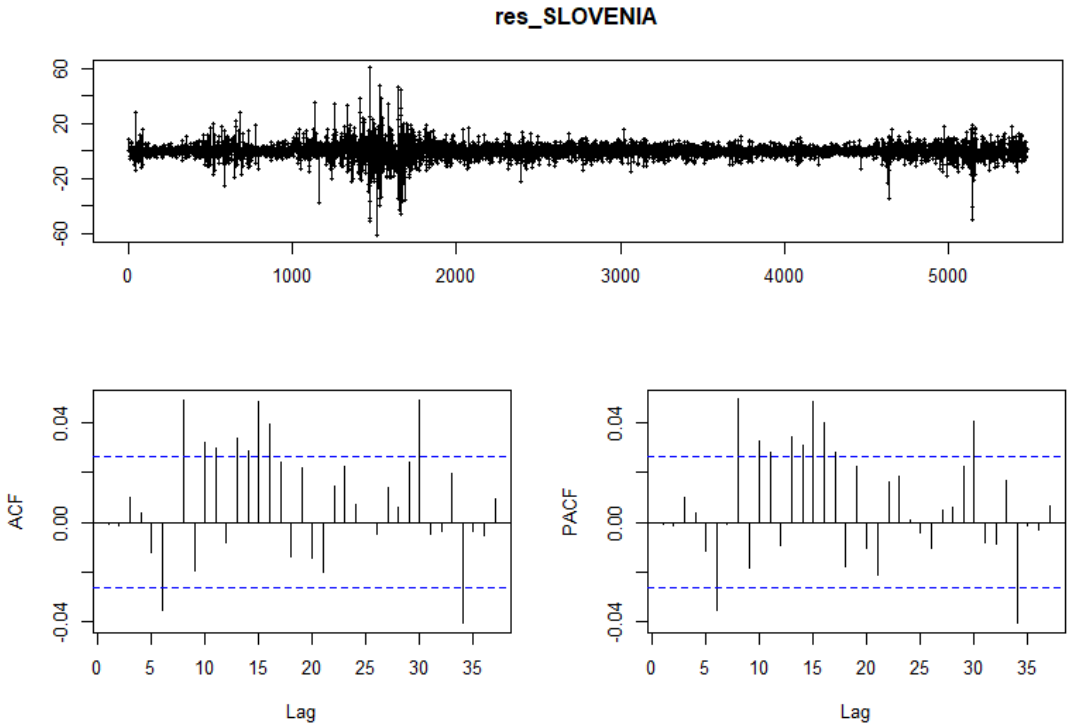
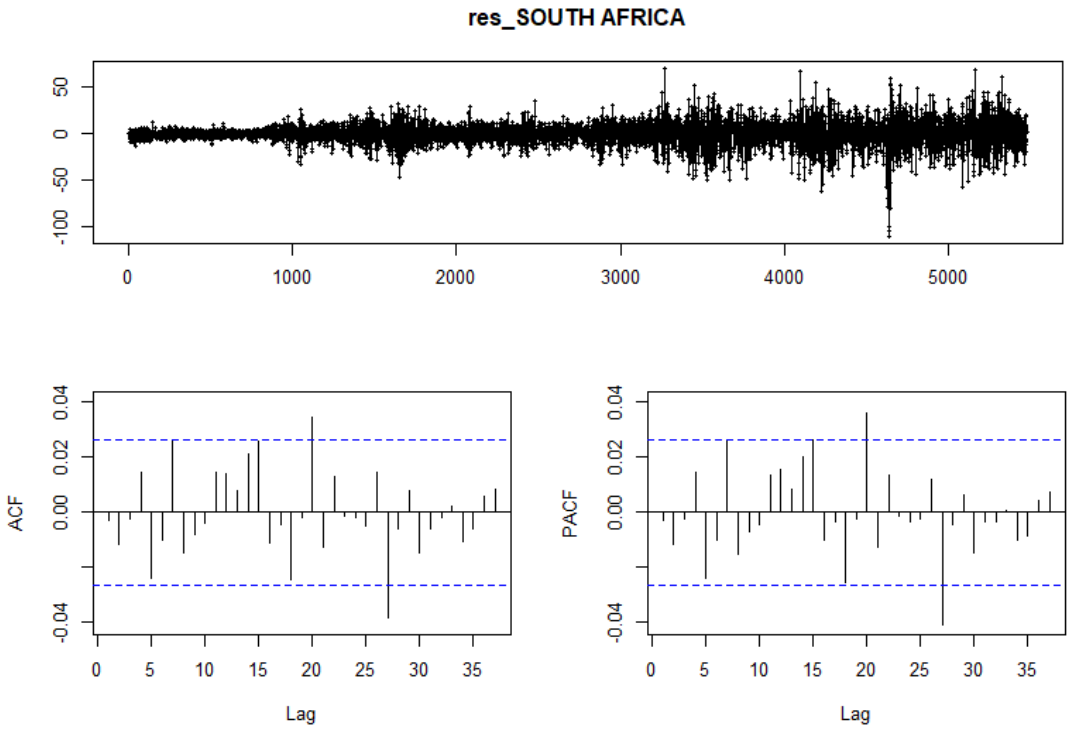
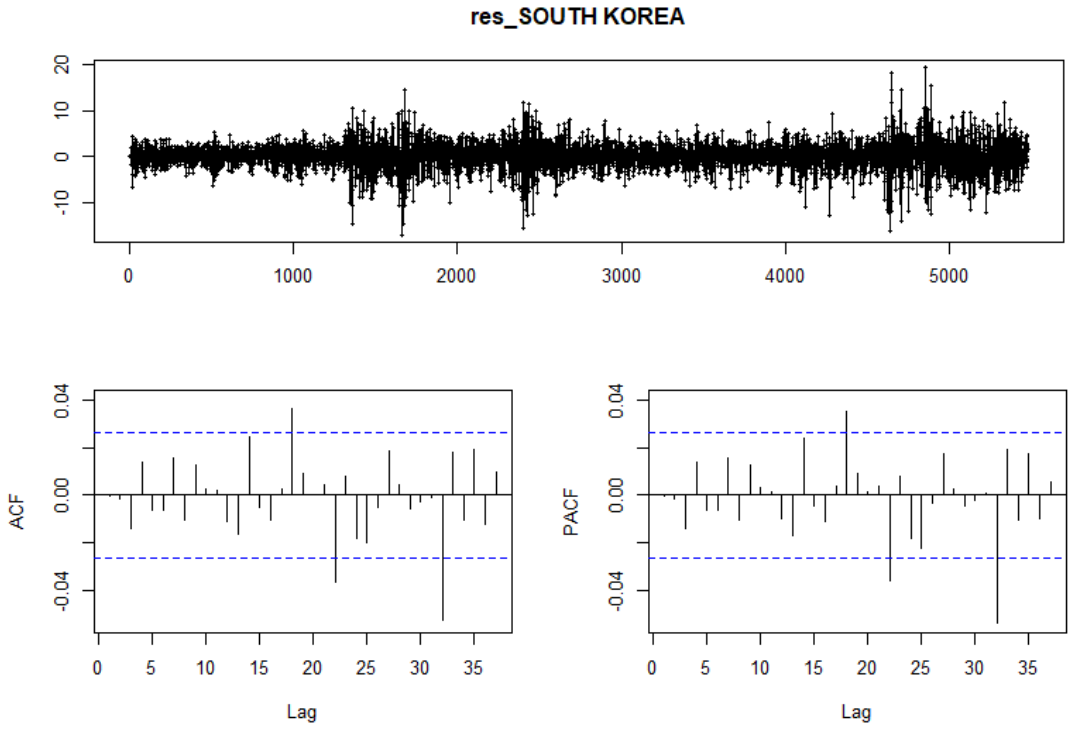
Lag

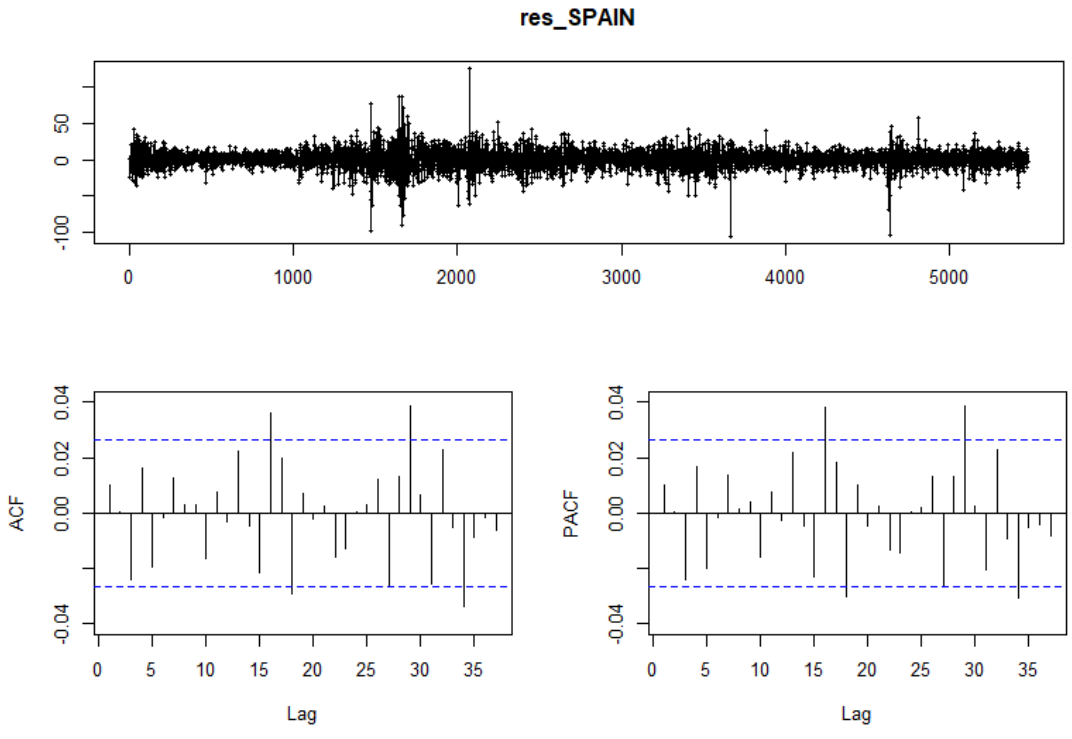

res_POLAND
ACF
PACF
Lag
Lag

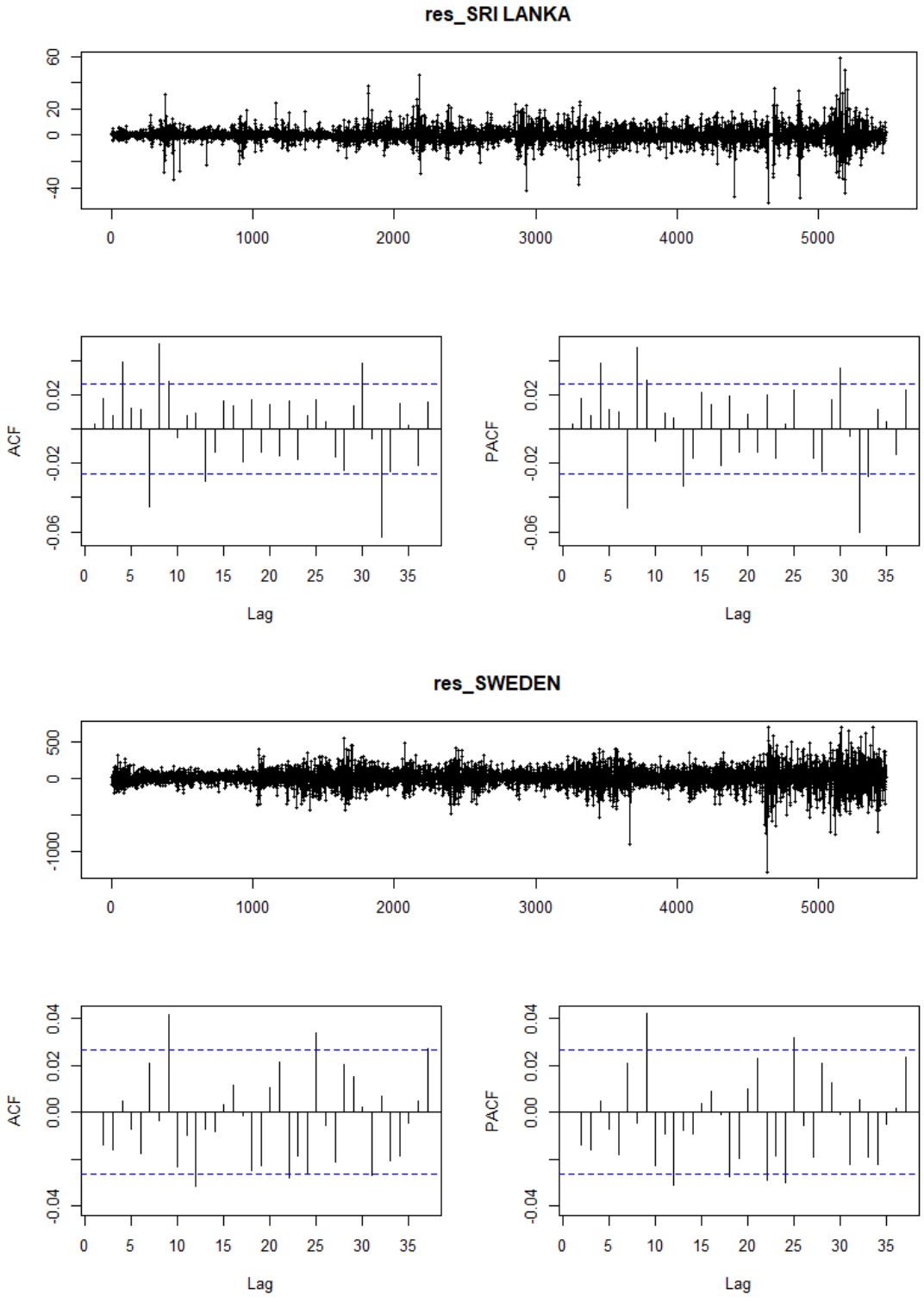

res_PORTUGAL
ACF
PACF
Lag
Lag

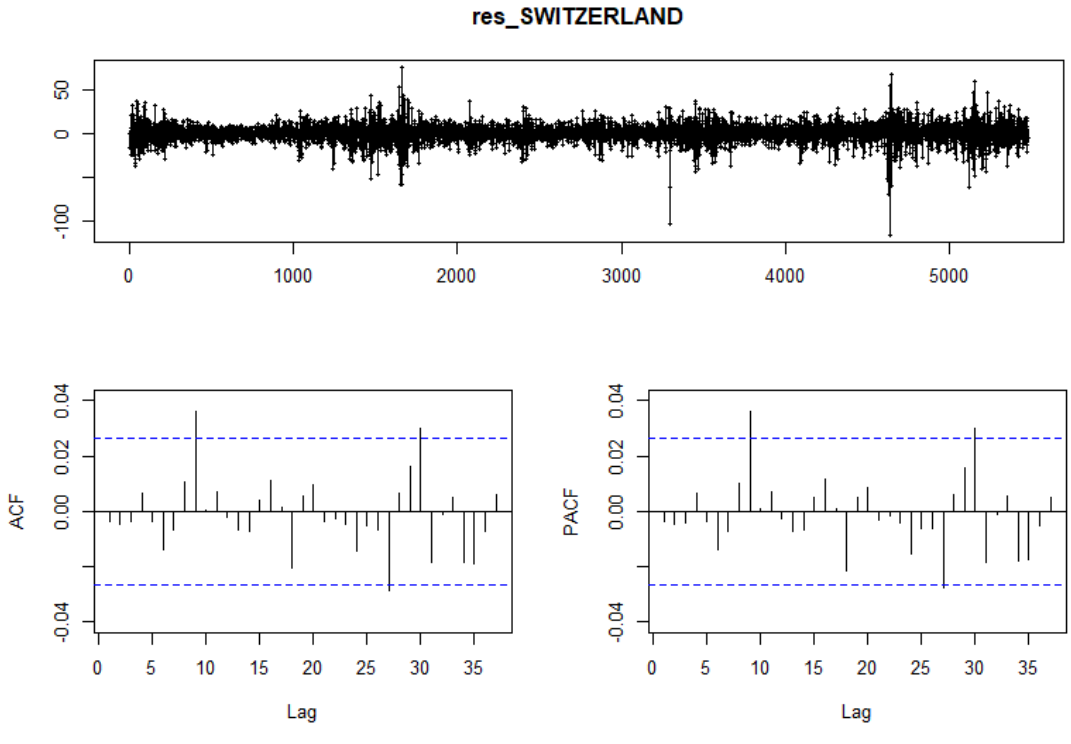

res_SLOVENIA
ACF
PACF
Lag
Lag

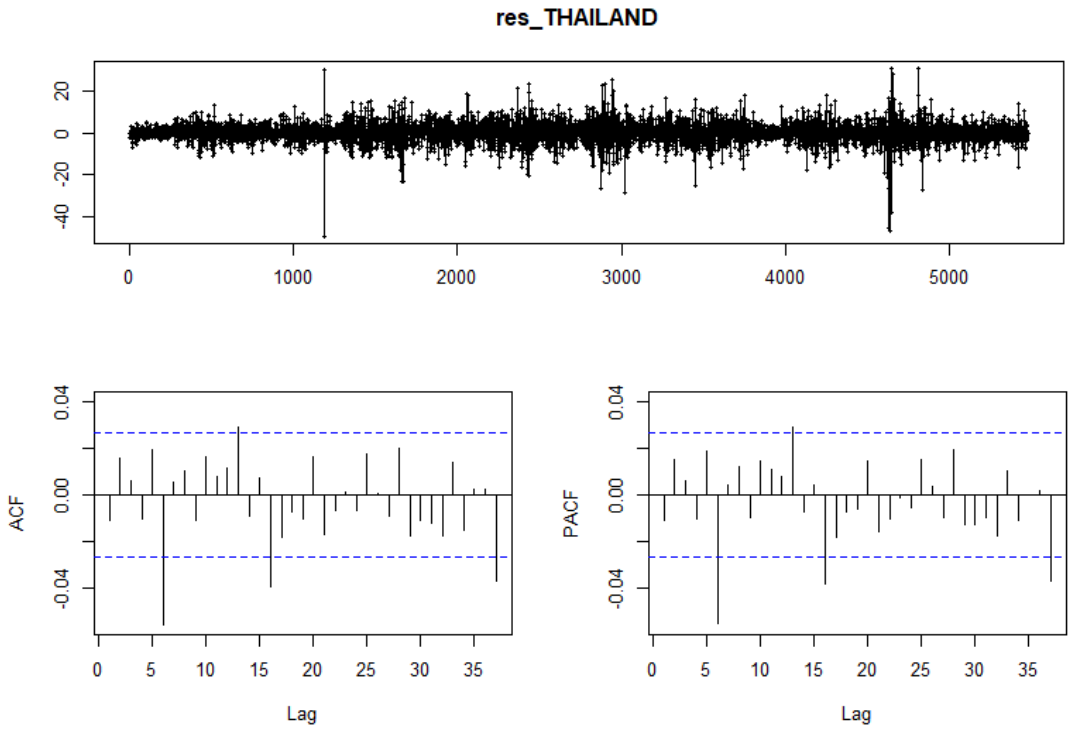

res_SOUTH AFRICA
ACF
PACF
Lag
Lag

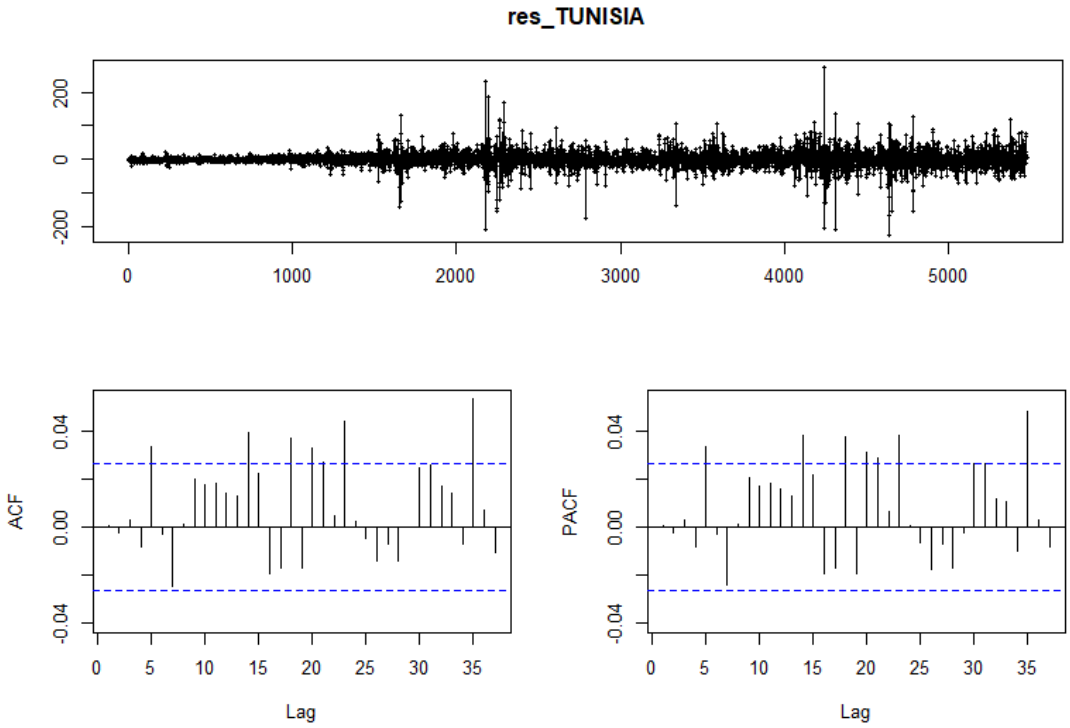

res_SOUTH KOREA
ACF
PACF
Lag
Lag


res_SPAIN
ACF
PACF
Lag
Lag


res_SRI LANKA
ACF
PACF
Lag
res_SWEDEN
ACF
PACF
Lag


res_SWITZERLAND
ACF
PACF
Lag
Lag


res_THAILAND
ACF
PACF
Lag
Lag


res_TUNISIA
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0
-200
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2000
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ACF
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0.00
-0.04
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5
10
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Lag
PACF
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0.00
-0.04
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10
15
20
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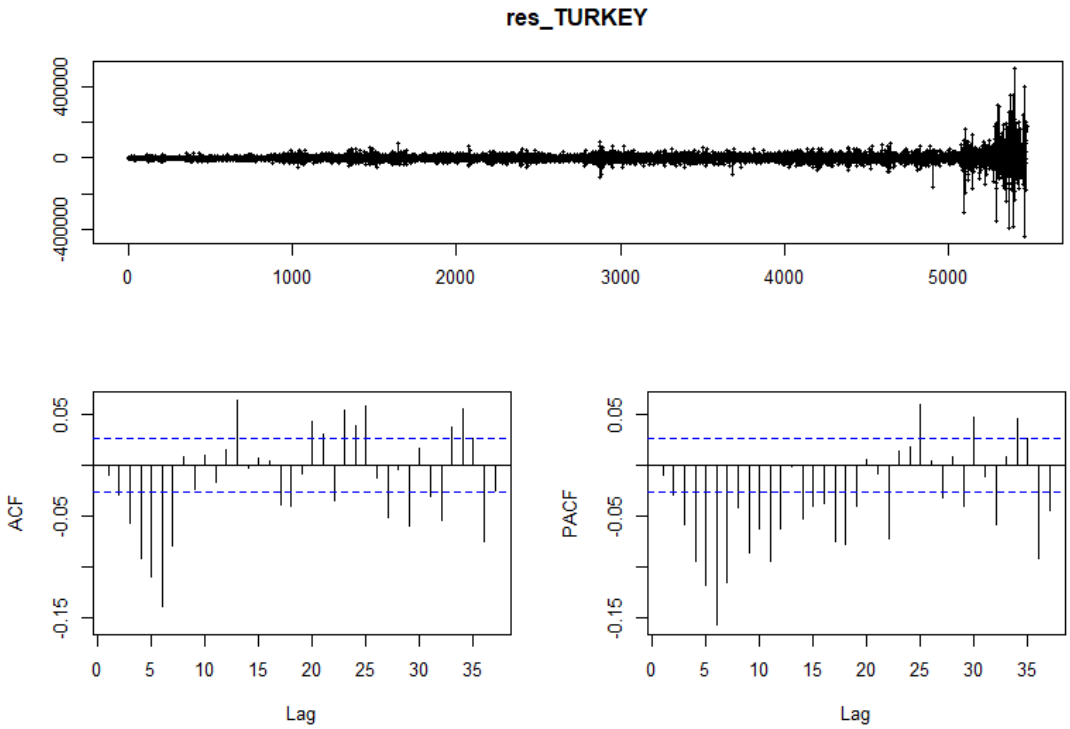
Lag


res_TURKEY
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-400000
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4000
5000
ACF
0.05
-0.05
-0.15
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20
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PACF
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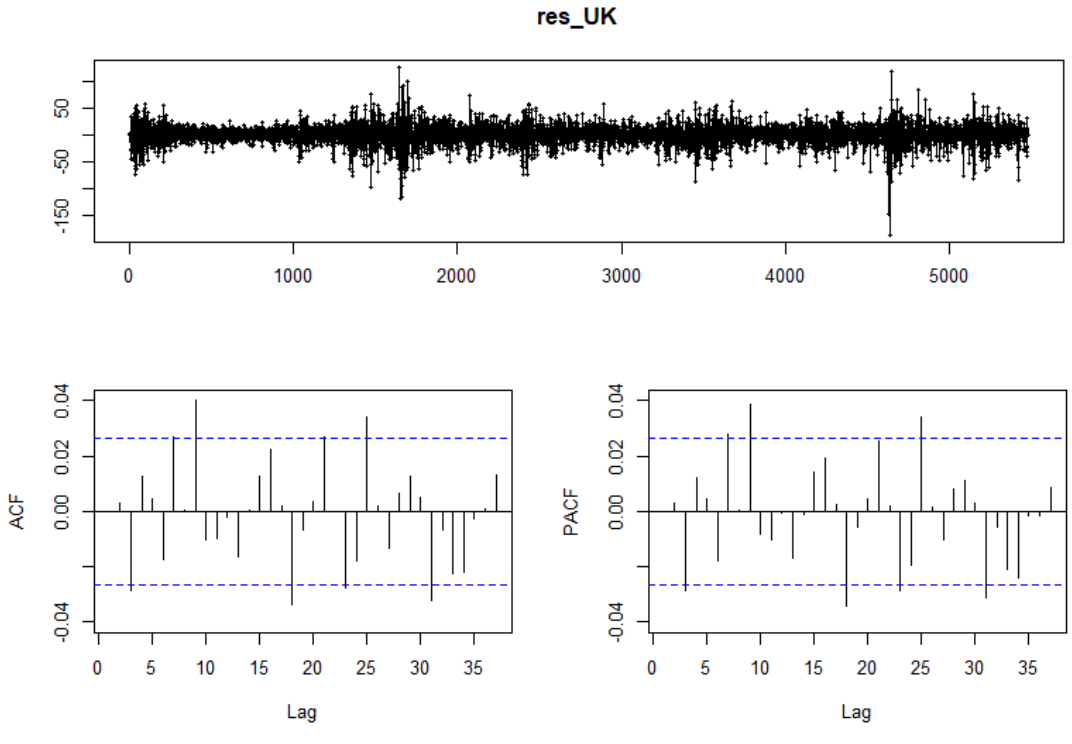
25
30
35
Lag


res_UK
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-150
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1000
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4000
5000
ACF
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0.02
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-0.04
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25
30
35
Lag
PACF
0.04
0.02
0.00
-0.04
0
5
10
15
20
25
30
35
Lag

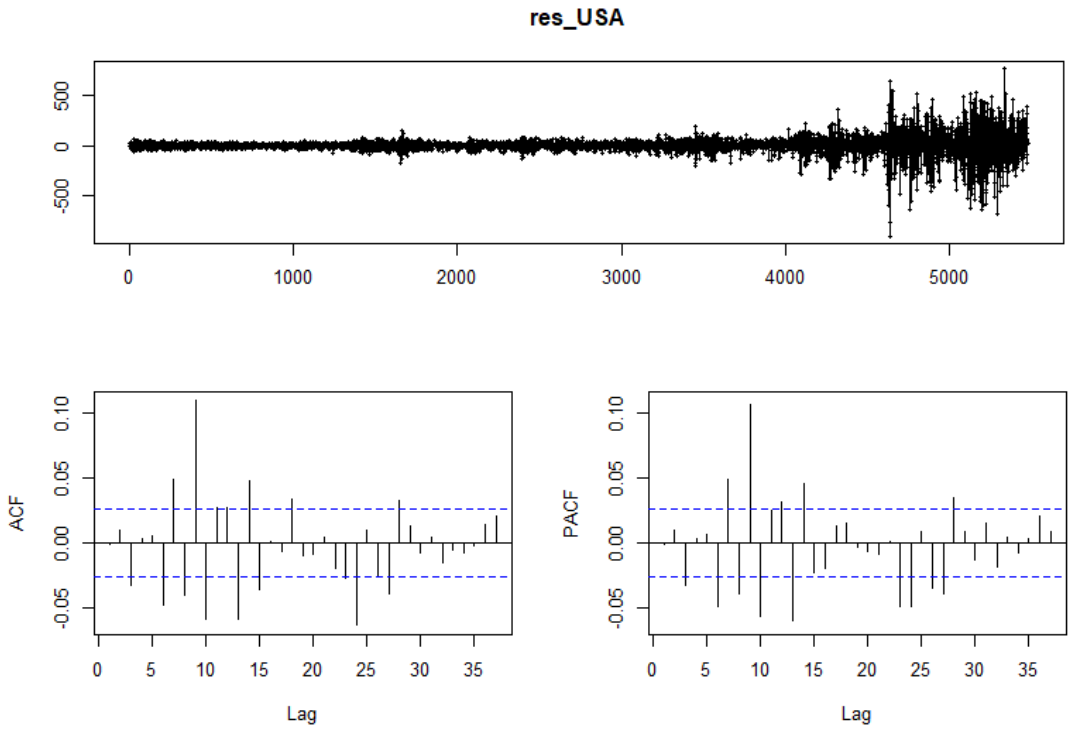
res_USA
500
0
-500
0
1000
2000
3000
4000
5000
ACF
0.10
0.05
0.00
-0.05
0
5
10
15
20
25
30
35
Lag
PACF
0.10
0.05
0.00
-0.05
0
5
10
15
20
25
30
35
Lag

Table 4

	COUNTRY	YEARS TO MEAN REVERSION	HALF-LIFE LAMBDA	RESIDUALS NORMALITY	STATIONARITY (1st_DIFFS)	HURST EXPONENT
4	BRAZIL	6.338242	-0.0005992303	FALSE	TRUE	0.4900515
13	FRANCE	4.881576	-0.0007780411	FALSE	TRUE	0.4969307
14	GERMANY	3.635833	-0.0010446208	FALSE	TRUE	0.4753230
18	INDONESIA	7.467894	-0.0005085860	FALSE	TRUE	0.4906864
32	PHILIPPINES	6.218291	-0.0006107894	FALSE	TRUE	0.4964338
36	SOUTH AFRICA	8.040427	-0.0004723713	FALSE	TRUE	0.4910015
40	SWEDEN	10.519488	-0.0003610505	FALSE	TRUE	0.4931503
41	SWITZERLAND	6.004324	-0.0006325553	FALSE	TRUE	0.4962133
42	THAILAND	4.179764	-0.0009086797	FALSE	TRUE	0.4941637
45	UK	2.044548	-0.0018576562	FALSE	TRUE	0.4676631

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