

ANALYSES OF BORSA ISTANBUL INDEX RETURN CO-MOVEMENTS
WITH MAJOR STOCK MARKET INDICES
USING VAR-GARCH-BEKK MODELS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

CENK BUĞRA ESEN

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
THE DEPARTMENT OF ECONOMICS

FEBRUARY 2024

Approval of thesis:

**ANALYSES OF BORSA ISTANBUL INDEX RETURN CO-MOVEMENTS
WITH MAJOR STOCK MARKET INDICES
USING VAR-GARCH-BEKK MODELS**

submitted by **CENK BUĞRA ESEN** in partial fulfillment of the requirements for the degree of **Master of Science in Economics, the Graduate School of Social Sciences of Middle East Technical University** by,

Prof. Dr. Sadettin KİRAZCI
Dean
Graduate School of Social Sciences

Prof. Dr. Onur YILDIRIM
Head of Department
Department of Economics

Assoc. Prof. Dr. Esmâ GAYGISIZ
Supervisor
Department of Economics

Examining Committee Members:

Asst. Prof. Mehmet Fatih ÖZTEK (Head of the Examining Committee)
Ankara Yıldırım Beyazıt University
Department of Economics

Assoc. Prof. Dr. Esmâ GAYGISIZ (Supervisor)
Middle East Technical University
Department of Economics

Prof. Dr. Gül İpek TUNÇ
Middle East Technical University
Department of Economics

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name Last name: Cenk Buğra Esen

Signature:

ABSTRACT

ANALYSES OF BORSA ISTANBUL INDEX RETURN CO-MOVEMENTS WITH MAJOR STOCK MARKET INDICES USING VAR-GARCH-BEKK MODELS

ESEN, Cenk Buğra

M.S., Department of Economics

Supervisor: Assoc. Prof. Dr. Esma GAYGISIZ

February 2024, 60 Pages

The integration of economies via global commerce networks and the free flow of capital encourages the co-movements of global markets although the diversity of geographical locations and country-based economic differences feature distinct characteristics. There is a tendency for different stock markets to move together. Different degrees of this phenomenon appear in emerging and developed economies. Various studies are focusing on the co-movement and volatility relations of the Turkish market with other markets. Most show clear or modest correlations between these markets including Türkiye. This thesis aims to analyze the interaction of the financial market returns as well as the co-movements of the financial market volatility of Türkiye with stock markets' volatilities of the US, the UK and Germany from January 2013 to December 2023. In this regard, the analysis involves the period when the Central Bank adopted a low interest policy under high inflation environment which might affect the market dynamics of co-movements. The interactions of the chosen returns are analyzed with the Vector Autoregressive (*VAR*) Models. Furthermore, the co-movements of the selected volatilities are investigated with the Multivariate Generalized Autoregressive Heteroscedasticity (*MGARCH*) models. GARCH model

with BEKK specification is used to examine the transfer of volatility from one stock market to another.

Keywords: Market Co-movements, Market Volatility, BEKK-GARCH

ÖZ

BORSA İSTANBUL ENDEKSİNİN GETİRİ HAREKETLERİNİN BAŞLICA BORSA ENDEKSLERİ İLE VAR-GARCH-BEKK MODELLERİ KULLANARAK ANALİZİ

ESEN, Cenk Buğra

Yüksek Lisans, İktisat Bölümü

Tez Yöneticisi: Doç. Dr. Esmâ GAYGISIZ

Şubat 2024, 60 Sayfa

Ekonomilerin küresel ticaret ağları ve serbest sermaye akışı yoluyla bütünleşmesi, farklı coğrafyalarda ve farklı ekonomik koşullarda bulunan borsaların birlikte hareket etmesini teşvik etmektedir. Farklı hisse senedi piyasalarının birlikte hareket etme eğilimi vardır ve bu olgu, gelişmekte olan ve gelişmiş ekonomilerde farklı derecelerde ortaya çıkmaktadır. Türkiye piyasasının diğer piyasalarla ortak getiri ve volatilité ilişkisine odaklanan çeşitli çalışmalar bulunmaktadır. Çoğu, Türkiye de dahil olmak üzere bu piyasalar arasında açık veya makul seviyelerde korelasyonlar göstermektedir. Bu tezin amacı, Ocak 2013'ten Aralık 2023'e kadar Türkiye'deki finansal piyasa getirilerinin etkileşimini ve finansal piyasa volatilitésinin ABD, İngiltere ve Almanya hisse senedi piyasalarının volatiliteleri ile birlikte hareketini analiz etmektir. Bu bağlamda analizler, eş hareketlerin piyasa dinamiklerini etkileyebilecek yüksek enflasyon ortamında Merkez Bankası'nın düşük faiz politikası uyguladığı dönemi de kapsamaktadır. Seçilen getirilerin etkileşimleri Vektör Otoregresif (VAR) Modelleri ile analiz edilmiştir. Ayrıca, seçilen volatilitelerin birlikte hareketleri Multivariate Generalized Autoregressive Heteroscedasticity (MGARCH) modelleri ile incelenmiştir. BEKK spesifikasyonlu GARCH modeli, oynaklığın bir borsadan diğerine transferini incelemek için kullanılmıştır.

Anahtar Kelimeler: Piyasa Hareketleri, Piyasa Oynaklıđı, BEKK-GARCH

To My Mother

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to my thesis advisor, Assoc. Prof. Dr. Esmâ Gaygısız. Her great support, patience and understanding throughout the writing of my thesis has been so important for me. Without her, I would be stuck.

TABLE OF CONTENTS

PLAGIARISM	iii
ABSTRACT	iv
ÖZ	vi
DEDICATION	vii
ACKNOWLEDGMENTS.....	ix
TABLE OF CONTENTS	x
LIST OF TABLES	xii
LIST OF FIGURES.....	xiii
LIST OF ABBREVIATIONS	xiv
CHAPTERS	
1. INTRODUCTION.....	1
1.1. Stock Market Co-movements and Volatility.....	2
1.2. Turkiye’s Macroeconomic Indicators in Recent Years	5
1.3. Modelling of Volatility in Financial Time Series	9
2. DATA AND TIME SERIES PROPERTIES OF DATA	11
2.1. Data	11
2.2. Time Series Properties of Data.....	11
2.2.1. Testing Normality of Return Rates of the Selected Indices	15
2.2.2. Probability Densities of the Rates of Returns	15
2.2.3. Unit Root Tests for the Return Rates of the Selected Stock Market Indices	20
3. EMPIRICAL MODELLING OF THE INTERACTIONS OF THE RETURN RATES AND THE CO-MOVEMENTS OF THE RETURN RATES’ VOLATILITIES FOR THE SELECTED INDICIES	21
3.1. Empirical Modelling of the Interactions of the Return Rates with Vector Auto-regression Models	21
3.2. Information Criteria for Lag Selection.....	22
3.3. Impulse Responses for the Return Rates of the Selected Indices	23
3.4. Empirical Modelling of the Co-movements of the Return Rates’	

Volatilities with MGARCH Models	24
3.4.1. VAR-MGARCH-BEKK Model.....	26
3.4.2. Conditional Correlations of Indices	27
4. CONCLUSION.....	31
REFERENCES.....	34
APPENDICES	
A. VAR-BEKK-GARCH ESTIMATES	39
B. TURKISH SUMMARY/TÜRKÇE ÖZET	50
C. THESIS PERMISSION FORM/TEZ İZİN FORMU.....	60

LIST OF TABLES

Table 2.1: Descriptive Statistics (2013-2023) of Rates of Returns of the Indices ..	12
Table 2.2: Skewness and Kurtosis Tests for Rates of Returns of the Indices	14
Table 2.3: Shapiro–Wilk W Test for Normal Data	14
Table 2.4: Correlations among Indices for Period 2013-2023 with Pearson’s r Value for Each Correlation	19
Table 2.5: Correlations among Indices for Period 2013-2021 with Pearson’s r Value for Each Correlation	19
Table 2.6: Correlations among Indices for Period 2021-2023 with Pearson’s r Value for Each Correlation	20
Table 2.7: Dickey Fuller Test Unit Root Tests for the Return Rates of the Selected Indices.....	20
Table 3.1: Information Criteria for Lag Selection.....	22
Table 3.2: Multivariate Q Test	26
Table 3.3: Multivariate ARCH Test.....	26
Table A.1: BEKK-GARCH (p=5, q=5)	39
Table A.2: VAR Coefficients.....	45

LIST OF FIGURES

Figure 1.1: USD/TL FX Rate.....	6
Figure 1.2: CPI for Turkiye.....	6
Figure 1.3: CDS for Turkiye	7
Figure 1.4: The US and Turkiye 5 Year Treasury Yields.....	8
Figure 1.5: The US & Turkiye 5 Year Yield Spread and EMBI Spread	8
Figure 2.1: BIST 100 Index and Daily Log Returns.....	13
Figure 2.2: S&P 500 Index and Daily Log Returns.....	13
Figure 2.3: FTSE 100 Index and Daily Log Returns	13
Figure 2.4: DAX 40 Index and Daily Log Returns.....	13
Figure 2.5: Probability Density of the Daily Rates of Return of BIST	15
Figure 2.6: Probability Density of the Daily Rates of Return of DAX.....	16
Figure 2.7: Probability Density of the Daily Rates of Return of FTSE.....	16
Figure 2.8: Probability Density of the Daily Rates of Return of SPX	17
Figure 2.9: Q-Q Plot for BIST 100	18
Figure 2.10: Q-Q Plot for S&P500	18
Figure 2.11: Q-Q Plot for FTSE 100	18
Figure 2.12: Q-Q Plot for DAX 40	18
Figure 3.1: Roots of Comparison Matrix	22
Figure 3.2: Impulse Responses for the Return Rates of the Selected Indices.....	23
Figure 3.3: Conditional Correlation between FTSE 100 and DAX 40.....	27
Figure 3.4: Conditional Correlation between FTSE 100 and S&P 500.....	28
Figure 3.5: Conditional Correlation between FTSE 100 and S&P.....	28
Figure 3.6: Conditional Correlation between BIST 100 and DAX 40.....	29
Figure 3.7: Conditional Correlation between BIST 100 and FTSE 100.....	29
Figure 3.8: Conditional Correlation between BIST 100 and S&P 500.....	30

LIST OF ABBREVIATIONS

CBRT	Central Bank of Republic of Turkiye
FED	Federal Reserve
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
BEKK-GARCH	GARCH Baba, Engle, Kraft, and Kroner GARCH
CPI	Consumer Price Index
FX	Foreign Exchange
MCAP	Market Cap
XUTUM	BIST TUM Index
SPX	S&P 500 Index
FTSE	FTSE 100 Index
DAX	DAX 40 Index
NIKKEI	NIKKEI 225 Index
CDS	Credit Default Swap

CHAPTER 1

INTRODUCTION

The integration of economies via global commerce networks and the free flow of capital encourages the co-movements of global markets, although the diversity of geographical locations and country-based economic differences feature distinct characteristics. In Türkiye, the market movements in recent years have been turbulent. Historically, hyperinflation, high interest rates and dollarization have been the sticky problems of the Turkish economy. After the 2001 financial crisis, structural changes were made in order to tackle those troubles. Changes in the Central Bank law were made to ensure the autonomy of the CBRT. Preserving price stability was designated to the Central Bank as its primary responsibility to support the growth, employment and development of the real economy. During this time of stabilization from 2003 to around 2018, Türkiye experienced significant foreign direct investment and capital inflows, which strengthened the ties of the Turkish market to major economies and financial markets and made the study of co-movements more substantial.

After 2021, the monetary policies are directed with a claim that high interest rates cause high inflation and therefore lower interest rates should be used to reduce high inflation rates and to provide economic development. This unconventional claim fueled the discussion on the autonomy of the CBRT and brought about some deterioration of its credibility. Therefore, that indicated that price stability lost its priority for the monetary policy but its secondary role in encouraging growth and employment became the forefront. In this period of economic turbulence, studying the change in the characteristics of the market movements in Türkiye and its co-movements with major markets has been more important. In that regard, the objective of this thesis is to investigate how and to what extent the dynamics of financial markets in Türkiye evolved over a period characterized by conventional and unconventional policies.

This thesis aims to analyze the interaction of the financial market returns as well as the co-movements of the financial market volatility of Turkiye with the major stock markets' volatilities. The interactions of the chosen returns are analyzed with the Vector Autoregressive (*VAR*) Models. Furthermore, the co-movements of the selected volatilities are investigated with the Multivariate Generalized Autoregressive Heteroscedasticity (*MGARCH*) models.

1.1. Stock Market Co-movements and Volatility

At first glance, stock markets are independent entities, each involves companies with a wide variety of business backgrounds operating in different geographies under different policies. However, a closer examination reveals a more complex dynamic of co-movements and interlinked volatilities. In the stock market, the term "co-movement" describes the tendency for different stock markets to move together. Different degrees of this phenomenon appear in emerging and developed economies. Several elements work together in the transfer of movements across markets. Globalization is the main influencing factor, enabling the unrestricted movement of capital between countries.

On top of that, information can now be shared practically instantly because of technological improvements, which have accelerated the propagation of market sentiment. Furthermore, volatility, which is a gauge of how sharply stock prices fluctuate is important to understand since it is contagious across markets. There can be a domino effect of elevated volatility in one market following a crisis in another. A famous instance of how the collapse of the US housing market caused unprecedented levels of volatility globally was the Global Financial Crisis of 2008.

The study of co-movements among equity markets begins with seminal works in financial economics. One of the first and significant studies by Grubel (1968) introduced the idea of international portfolio diversification where he suggested that the risk could be reduced by forming a portfolio across different national markets. This encouraged the examination of market interactions. International diversification of portfolios was further investigated by Solnik (1974) and Lessard (1976), who observed

that times of high market volatility tended to increase market correlations. This crucial insight suggested that there is a dynamic rather than a static link between markets. A new era in this study was marked by the rise of globalization. King, Sentana, and Wadhvani (1994) made important contributions by examining the ways in which co-movements were impacted by economic policies, particularly in major economies. Their study demonstrated that market interdependencies have increased as a result of globalization, a finding that has been repeated across different studies. Longin and Solnik (1995) examined instability in the correlation structures among markets. King (1994), Ramchand and Susmel (1998) and Morana and Beltratti (2002) and others found evidence that there is a positive relation between correlation and volatility. Forbes and Rigobon (2002) highlighted the ‘contagion’ effect, where shocks in one market spill over into others accelerated by technology.

These correlations among markets may appear differently in developed and emerging markets. Within the EU, there are studies showing the high correlations among indices in that economic framework which does not allow portfolio diversification. In European markets, Cappiello, Gerard, Kadareja, & Manganelli, (2006) examined the correlation among member states and the ones recently completed accession to the Union.

We see the role of geography in this study. Countries closer to major economies in the EU tend to correlate more after the accession such as Poland. The ones like Cyprus and Slovenia show lower correlation structures. On the other hand, a later study by Aslanidis & Savva, (2010) showed some low correlation as stated before increased. In general, results show that portfolio diversification becomes unattractive since the correlation tends to increase with the EU. The role of developing markets in the global financial system has also been the subject of recent writing. Bekaert, Hodrick, and Zhang (2009) examined how emerging markets are starting to matter when it comes to fluctuations in the global economy. This illustrates a more diverse global market environment.

There are various studies focusing on the co-movement and volatility relations of the Turkish market with other markets. Taştan, (2005) examined Türkiye in relation to Germany, the UK, France and the US by using DCC-GARCH and showed the time

varying conditional correlations among markets and Turkish market had more oscillation from 1990 to 2004. Syriopoulos & Roumpis, (2009) examined Balkan countries, Germany and the US including Turkiye from 1998 to 2007 by using bivariate asymmetric DCC-GARCH and did not present strong co-movements. Many studies point out the influence of the US stock markets' effect on other countries. In this regard, Ergun & Nor, (2010) examined the volatility spillover between Turkiye and the United States by using bivariate co-integration, ECM and CGARCH in the case of accession to the EU. They examined the period from 1999 to 2008 and particularly looked for a change in the correlations and volatility spillover from NASDAQ to Borsa Istanbul after official negotiations began with the EU in 2005. The results of their study showed a consistent significant volatility spillover with sub-periods with a lack of linkages affected by county based extreme shocks. Financial contagion was studied by Var, (2015) for Turkiye compared to the US, Brazilian, Indian, Hong Kong, UK, Japanese, Mexican, and Russian stock markets between 2009 and 2014 and found that possible shocks from the US and Germany have some degree of effect on Borsa Istanbul. Nazlıoğlu & Kök, (2021) also studied the financial contagion among developed, emerging and Turkish markets by utilizing co-integration and causality analyses. Graham, Kiviahho & Omran (2012) examined the co-movements in the MENA region including Turkiye and the US by using wavelet squared coherency. Öztekin, (2013) examined the dynamic relations of conditional correlations among Turkiye, the US, the UK, France and Germany to evaluate the potential of portfolio diversification of Turkiye via STCC-GARCH and DSTCC-GARCH from 1997 to 2010. In this study, the conditional correlation of DAX and BIST 100 was shown as high as 0.8 which is similar to the conditional correlations among developed markets. The results imply similar outcomes for FTSE and BIST 100 where conditional correlations are capable of reaching as high as 0.8, especially for periods of crises. For the conditional correlation between S&P 500 and BIST 100, average levels were relatively smaller compared to FTSE 100 and DAX 40 which around is 0.5. All these results showed that for portfolio diversification, Turkey may not be the best alternative particularly compared to European markets.

The literature goes on with different combinations of markets and different methodologies. Most show clear or modest correlations between these markets

including Turkiye. Which undermines the search for an opportunity for portfolio diversification.

1.2. Turkiye's Macroeconomic Indicators in Recent Years and Contribution of the Study

As it is presented in the previous section, there are many studies concerning the co-movements of Borsa Istanbul with other markets. However, there has been a shift in the monetary policy in recent years and it has some conclusions. Since the early 2000s, Turkiye's monetary policy has been based on the objective of inflation targeting which aims to achieve and maintain low inflation (Kara, 2012). However, the narrative over the past few years has been the conviction that high interest rates lead to high inflation and that, hence, interest rates should be lowered to combat inflation (Gürkaynak, Kısacikoğlu, & Lee, 2023). As a result, political interference has been debated frequently in the public eye and investors' understanding, and the credibility of the bank deteriorated which contributed to the failure of the unconventional policy. It seems like CBRT shifted its position on its supporting role in the growth into one of its main objectives and put the price stability background in contrary to the reforms made during the 2001 Financial Crises and its Central Bank Law. As a critical determinant of investment decisions, interest rates serve a crucial role. The negative effect of interest rates on stock prices was studied by Asprem (1989), Geske & Roll (1983), Jaffe & Mandelker (1976), and Wei (2009). The analysis of Mouna & Anis (2016) suggests that there is a causal relationship between the exchange rate, interest rates, and the stock return in most countries. The literature is large on the effect of interest rates on stock markets. This increases the importance of the study of the periods of changes on the macroeconomic indicators such as exchange rate, inflation, risk premium and the treasury yields. Therefore, one of the significant contribution of this thesis is the analysis which involves the recent years on the relations of Borsa Istanbul to major indices. As it can be seen on Figure 1.1, Turkish Lira has been experiencing some dramatic depreciation recently. It significantly depreciated from 3.75 USD/TRY on 1st of January 2018 to almost 30 USD/TRY at the end of 2023.

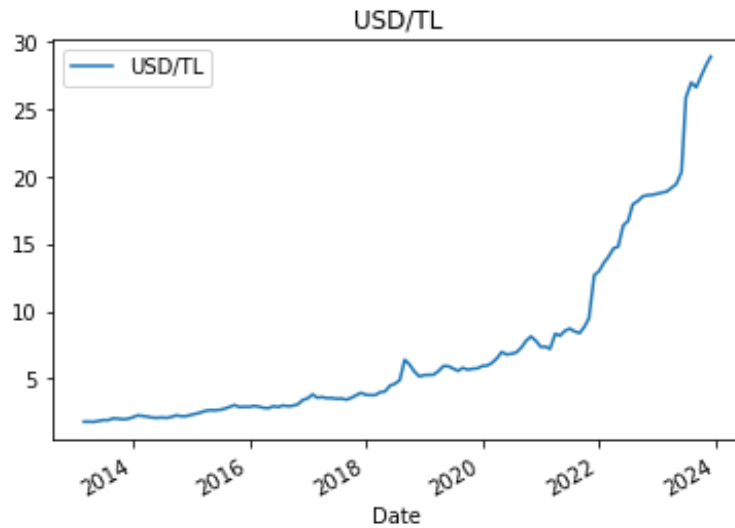


Figure 1.1: USD/TL FX Rate

Source: EVDS

In addition, we see a sharp increase in CPI, especially after the end of 2021 that coincides with the sharp depreciation of TL.

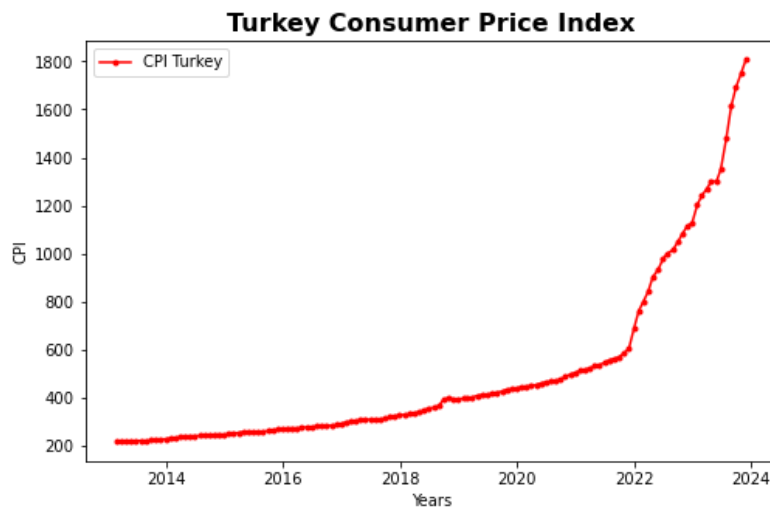


Figure 1.2: CPI for Turkiye

Source: EVDS

CDS may play a role in determining the risk associated with investing in a specific country. CDS which is a financial derivative serves as insurance for the risk of default on a country's sovereign debt and it may be interpreted as the perceived risk for investors on their view of the country's capability of repaying its debt and also the

stability of the overall economy. In addition, higher CDS so the higher risk might impact the government bond yields in a way that it can bring the yields up and increase the borrowing costs.

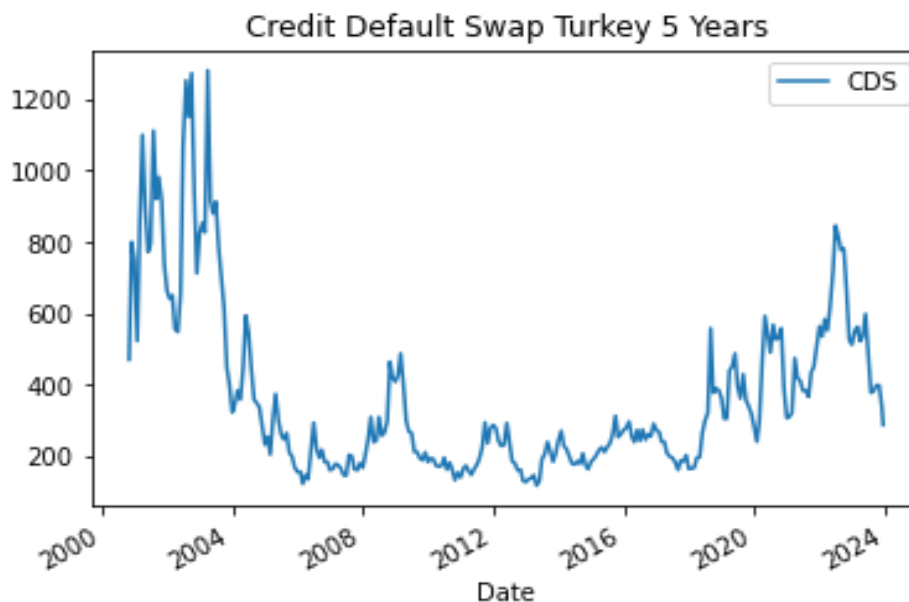


Figure 1.3: CDS for Turkiye

Source: Bloomberg

On Figure 1.3 we can see CDS for Turkiye. In early 2000s, before the effects of 2001 reforms become visible, the risk premium for Turkiye was quite high. However, after the reforms we see a sharp decrease and it usually oscillates around 200. We can observe that after 2019 and particularly after 2021 there are sharp increases which depicts the higher risk of default and increasing risk for the Turkiye.

Historically Turkiye's treasury bills have had a higher yield than the US as can be observed on Figure 1.4. However, especially after 2018 the spread between the two markets increased and the borrowing costs increased for Turkiye. One interesting change is that the EMBI Global Spread used to be larger than the US-Turkiye yield spread however this situation changed after 2018. We can interpret this as the emerging markets overall had higher borrowing costs up until 2018 than Turkiye.

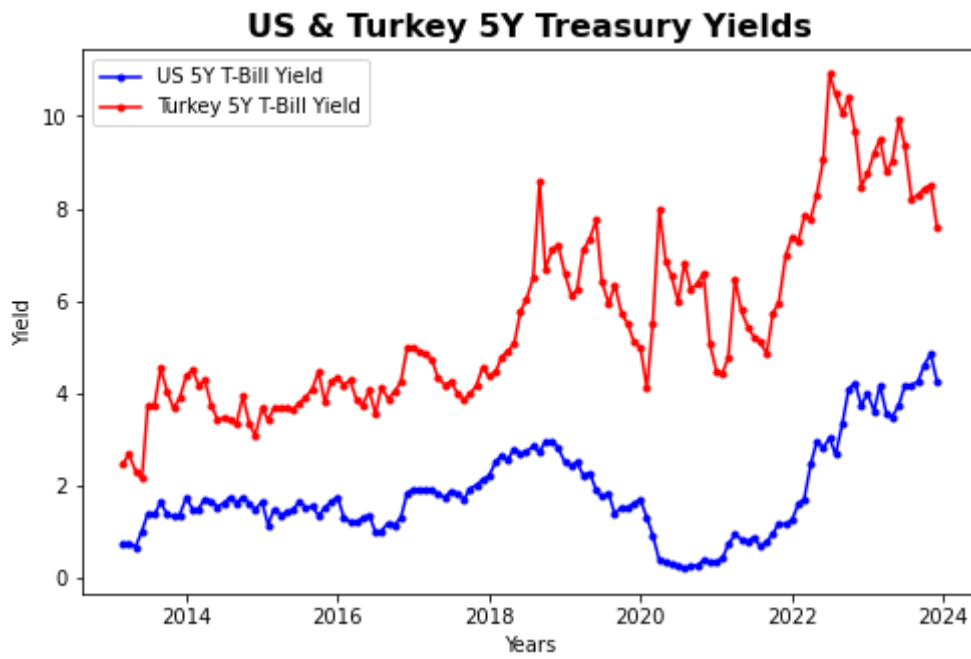


Figure 1.4: The US and Turkiye 5 Year Treasury Yields

Source: Bloomberg

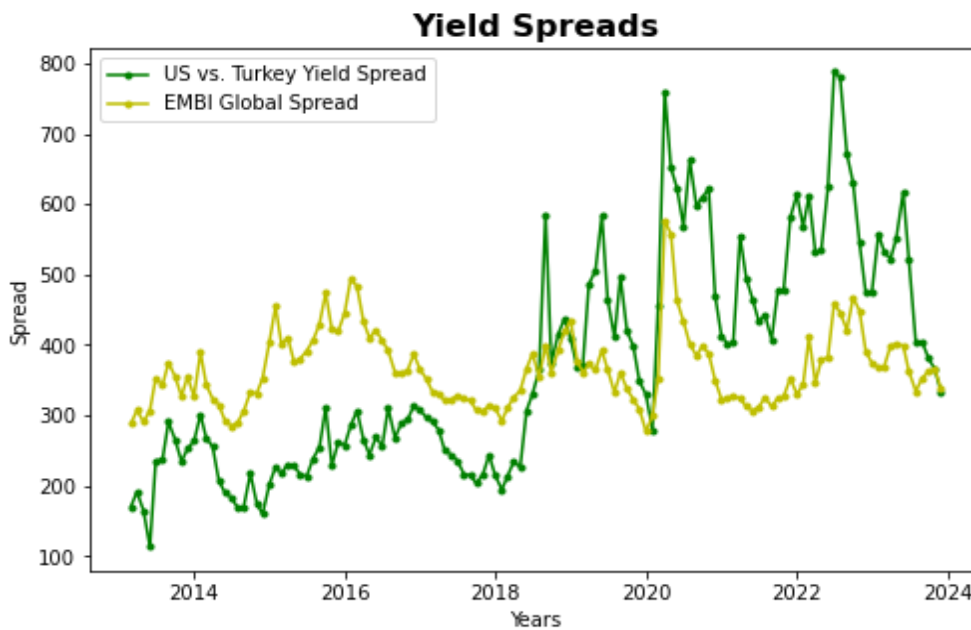


Figure 1.5: The US & Turkiye 5 Year Yield Spread and EMBI Spread

Source: Bloomberg

1.3. Modelling of Volatility in Financial Time Series

In the early 1960s, the works of Mandelbrot (1963) and Fama (1965) served an essential role in identifying the uncertainty within a financial time series as a function of variances that vary over time. The presence of prevalent clustering of volatility and leptokurtosis in these types of series were mentioned in the study of Fama (1965). Furthermore, the leverage effect which is described as the increasing risk in the future volatility caused by the decrease of an asset's value highlighted by Black (1976) Further studies by Christie (1982) and Bollerslev, Chou, & Kroner (1992) elaborated on this leverage effect. Granger & Andersen (1978) created the bilinear model. This model allowed conditional variance to depend on the series' previous observations.

The Autoregressive Conditional Heteroskedasticity (ARCH) model was proposed by Engle (1982) where he used lagged disturbances to understand the dynamics. In this ARCH model lagged errors were utilized to model the variance of the series where the oscillation of variance is allowed to occur over time. Therefore, conditional variance was characterized by a function that involves past squared errors. It came with its own limitations. Asymmetries of the volatility coming from the positive and negative shocks cannot be modeled and this is an important aspect of financial time series since stocks may respond in a different way to negative and positive shocks. To tackle the weaknesses of the model, Bollerslev (1986) proposed the extended version of ARCH, Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model. However, this version of GARCH was not capable of dealing with these asymmetric effects named as leverage effects although clustering of volatility and leptokurtosis were handled. This problem was overcome by fitting the models accordingly with the asymmetric residuals and new versions of asymmetric GARCH models proposed.

The extensions of GARCH models were examined in the financial time series analysis. King and Wadwani (1990) studied contagiousity by examining the markets in the UK, the US and Japan. The research of Karolyi & Stulz (1996) showed that relatively larger shocks in their sample markets have an impact on the persistence of correlations among markets. Similar works with various focuses were conducted in the literature that dealt with conditional correlations. VEC-GARCH, BEKK-GARCH, CCC-

GARCH, DCC-GARCH, STCC-GARCH DSTCC-GARCH, and various models were developed and utilized along the way.

Engle and Kroner (1995) proposed the GARCH model with BEKK (Baba-Engle-Kraft-Kroner) specification which ensures positive definiteness by construction in the conditional variance-covariance. As a disadvantage, BEKK-GARCH model has a large number of parameters that aggravate the inference. To ease this problem, diagonal and scalar-BEKK model restrictions can be applied Pedersen & Rahbek (2012). BEKK-GARCH model usually has been used to study the transfer of volatility among financial markets. Kearney & Patton (2000) studied the transfer of volatility exchange rates. Li (2007) used BEKK-GARCH to study the transfer of volatility from Hong Kong market to mainland China. Saleem (2007) examined the effects caused by the financial crises in Russia, on the various markets. Therefore, the BEKK-GARCH model becomes prominent to study the transfer of volatility from one stock market to another.

CHAPTER 2

DATA AND TIME SERIES PROPERTIES OF DATA

This chapter examines the data used in the analysis and its time series properties. Descriptive statistics of the rate of returns of indices and other time series properties which are skewness and kurtosis tests, normality tests, probability densities of distributions, correlations and unit root test are presented.

2.1.Data

The encompassing dataset consists of BIST index and four major stock indices S&P 500 in the US, DAX 40 in Germany, and FTSE 100 in the UK. Daily closing prices from January 2013 to December 2023 are used for the analysis. All index data are acquired from Matriks Platform. The indices are used with their currency to exclude the volatility caused by exchange rates. Daily closing prices are converted on log differences as the daily returns.

$$r_t = \log\left(\frac{p_t}{p_{t-1}}\right)$$

where r_t is the daily return at time t, p_t is the closing price at time t and p_{t-1} is the closing price at t-1.

2.2.Time Series Properties of Data

In figures 2.1, 2.2, 2.3 and 2.4; we can see the four market indices and their daily logarithmic returns. The indices show a common pattern of gains which seem to be stronger on BIST 100 and S&P 500. The presence of volatility clustering which is typical for financial time series as mentioned by Fama (1965) is also visible in returns.

It is particularly common across all markets that in March 2020 when the effects of the pandemic started to be felt in the western hemisphere.

Other than that, with similar scales we can also claim that BIST 100 has been experiencing larger fluctuations in a widespread manner compared to other indices. Therefore, a simple examination of the graph reveals more extreme gains and losses are a part of the dynamics in the Turkish market. In addition, after the pandemic era, we observe that most markets did well except in the UK. There is a reaction to the extreme loses of the pandemic era but it did put much on top of that compared to others. Moreover, BIST 100 shines out after the mid-2022 with a significant increase from 5000 levels to 8000 levels. This circumstance coincides with a more prevalent extreme returns on Figure 2.1.

Table 2.1: Descriptive Statistics (2013-2023) of Rates of Returns of the Indices

	BIST 100	S&P 500	FTSE 100	DAX 40
Number of Observations	2589	2589	2589	2589
Mean	8.92e-4	4.42e-4	8.59e-5	2.88e-4
Std. error mean	3.22e-4	2.19e-4	1.98e-4	2.45e-4
Median	0.00141	7.02e-4	6.00e-4	8.23e-4
Standard deviation	0.0164	0.0111	0.0101	0.0125
Variance	2.69e-4	1.24e-4	1.02e-4	1.56e-4
Range	0.205	0.217	0.202	0.235
Minimum	-0.111	-0.128	-0.115	-0.131
Maximum	0.0942	0.0897	0.0867	0.104
Skewness	-0.618	-0.813	-0.818	-0.530
Std. error skewness	0.0481	0.0481	0.0481	0.0481
Kurtosis	5.05	16.2	12.1	9.35
Std. error kurtosis	0.0962	0.0962	0.0962	0.0962

Note: $e+x=10^x$ and $e-x=10^{-x}$.

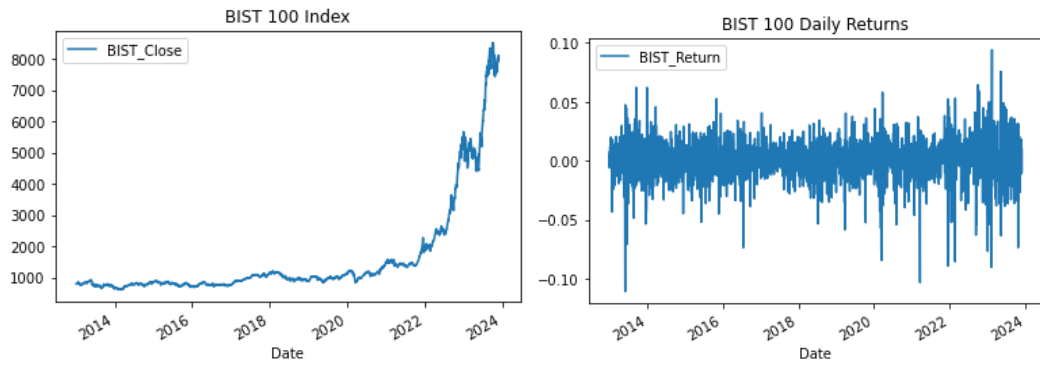


Figure 2.1: BIST 100 Index and Daily Log Returns

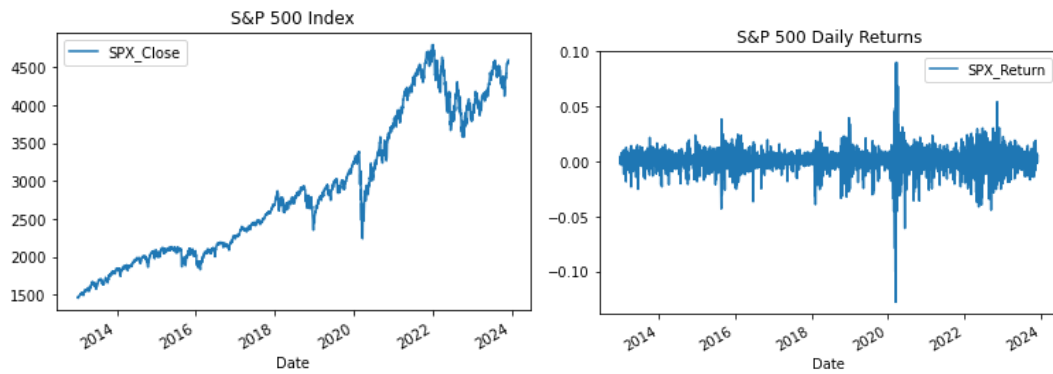


Figure 2.2: S&P 500 Index and Daily Log Returns

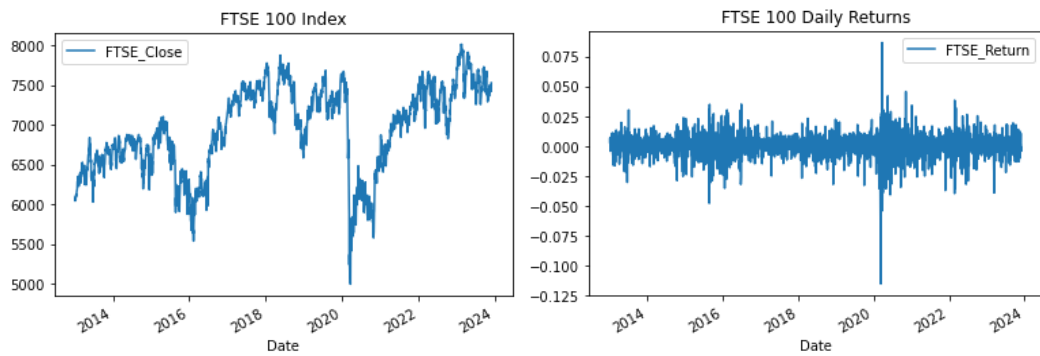


Figure 2.3: FTSE 100 Index and Daily Log Returns

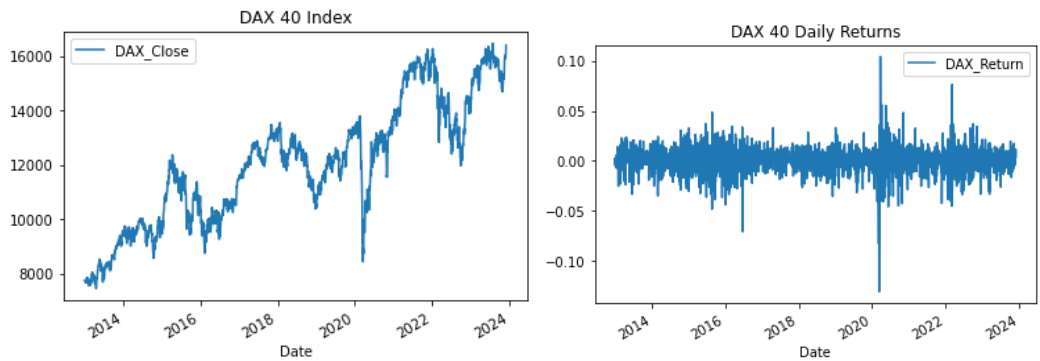


Figure 2.4: DAX 40 Index and Daily Log Returns

Similar to the observations on Figure 2.1, 2.2, 2.3 and 2.4, descriptive statistics on Table 2.1 proves the highest average gain is on BIST 100, and S&P 500, DAX 40 and FTSE 100 follow in order. We observe the largest standard deviation on BIST 100. DAX 40 has also a relatively high standard deviation compared to S&P 500 and FTSE 100. A higher variance is also observable on BIST 100.

Table 2.2: Skewness and Kurtosis Tests for Rates of Returns of the Indices

Index	Number of Observations	Pr (Skewness)	Pr (Kurtosis)	χ^2 Adj	χ^2 p-value of
S&P 500	2589	-0.813	16.2	531.62	0.000
FTSE 100	2589	-0.818	12.1	496.60	0.000
DAX 40	2589	-0.530	9.35	372.64	0.000
BIST 100	2589	-0.618	5.05	285.16	0.000

Note: Pr is probability and χ^2 is the chi-square test

Each series for the return rates display high skewness and kurtosis levels. Therefore the normality of each series is rejected at the 1% significance level.

2.2.1. Testing Normality of Return Rates of the Selected Indices

Table 2.3: Shapiro–Wilk W Test for Normal Data

Index	Number of Observations	W	V	Z	p-value of z
S&P 500	2589	0.87799	182.794	13.372	0.000
FTSE 100	2589	0.91796	122.913	12.353	0.000
DAX 40	2589	0.93183	102.129	11.877	0.000
BIST 100	2589	0.94675	79.779	11.243	0.000

Shapiro–Wilk W test results can be observed in Table 2.3. Z values are quite high and W values are less than 0.95 which indicates significant deviation from normality. As a result, normality of each return rates' series of the selected indices is rejected.

2.2.2. Probability Densities of the Rates of Returns

The figures below show the probability densities of the rates of returns of the indices.

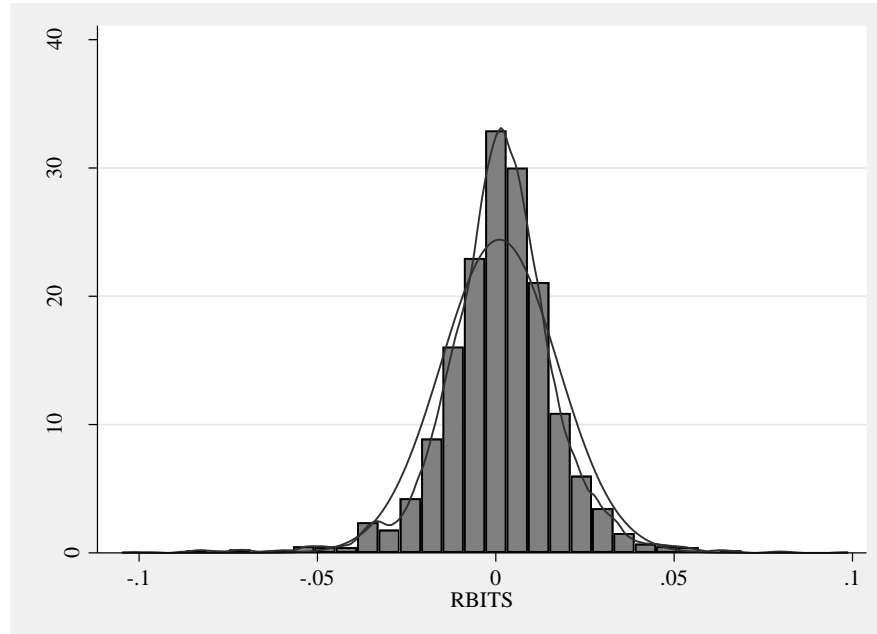


Figure 2.5: Probability Density of the Daily Rates of Return of BIST

On the probability density distribution of the rates of returns of BIST 100 index over the decade from 2013 to 2023 has a peak density above 30 which indicates a period where the index values frequently congregated. This central peak is indicative of returns with consistent performance that clusters at the central. Additionally, the histogram shows a noticeable tilt to the right side of the graph. This change indicates a slow rise in the index values over time. On the other hand, we can see that the distribution is quite wide indicates higher variance around the center and has thick tails and kurtosis is low.

On Figure 2.6, the probability density distribution of the rates of returns of DAX 40 index over the decade from 2013 to 2023 can be observed. It has a peak density above 40 which indicates higher clustering around the center compared to BIST 100. The histogram shows a noticeable tilt to the left side of the graph. However, different than BIST 100, we can see that the distribution is quite centered indicates lower variance and kurtosis is high.

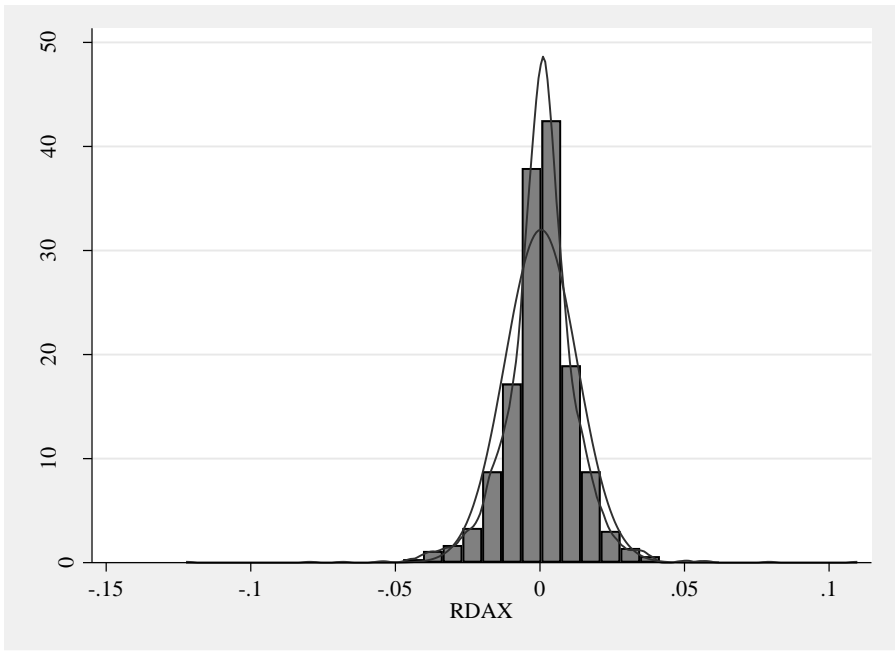


Figure 2.6: Probability Density of the Daily Rates of Return of DAX

On Figure 2.7, the probability density distribution of the rates of returns of FTSE 100 index over the decade from 2013 to 2023 can be observed. It has a peak density above 50 which indicates higher clustering around the center compared to BIST 100.

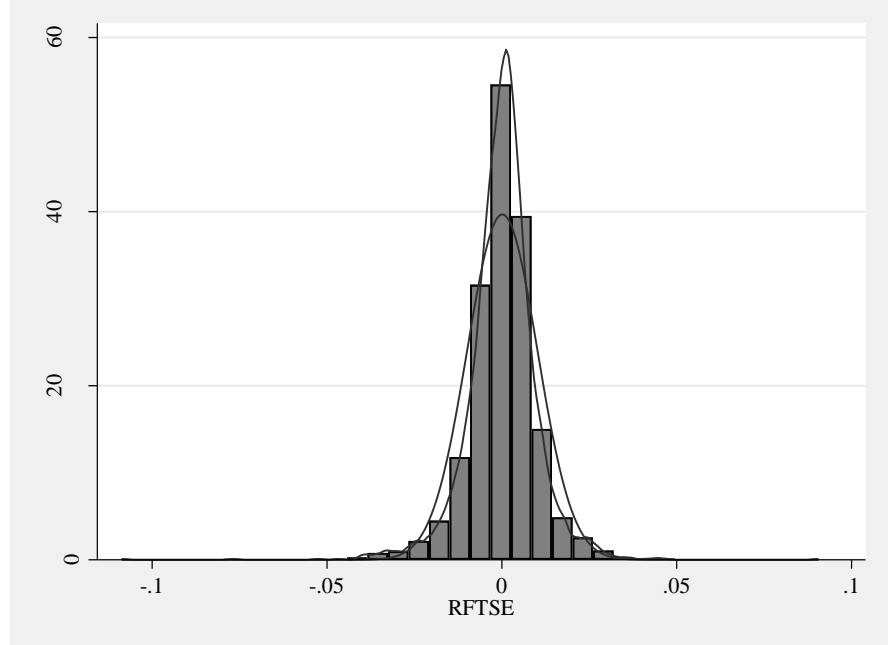


Figure 2.7: Probability Density of the Daily Rates of Return of FTSE

The histogram shows a noticeable tilt to the right side of the graph. However, different than BIST 100 and similar to DAX 40, we can see that the distribution is quite centered indicates lower variance and kurtosis is very high.

On Figure 2.8, the probability density distribution of the rates of returns of S&P 500 index over the decade from 2013 to 2023 can be observed. It has peak density above 50 which indicates very high clustering around the center compared to BIST 100. The histogram shows a noticeable tilt to the left side of the graph. However, different than BIST 100 and similar to DAX 40 and FTSE 100, we can see that the distribution is quite centered indicates lower variance and kurtosis is high.

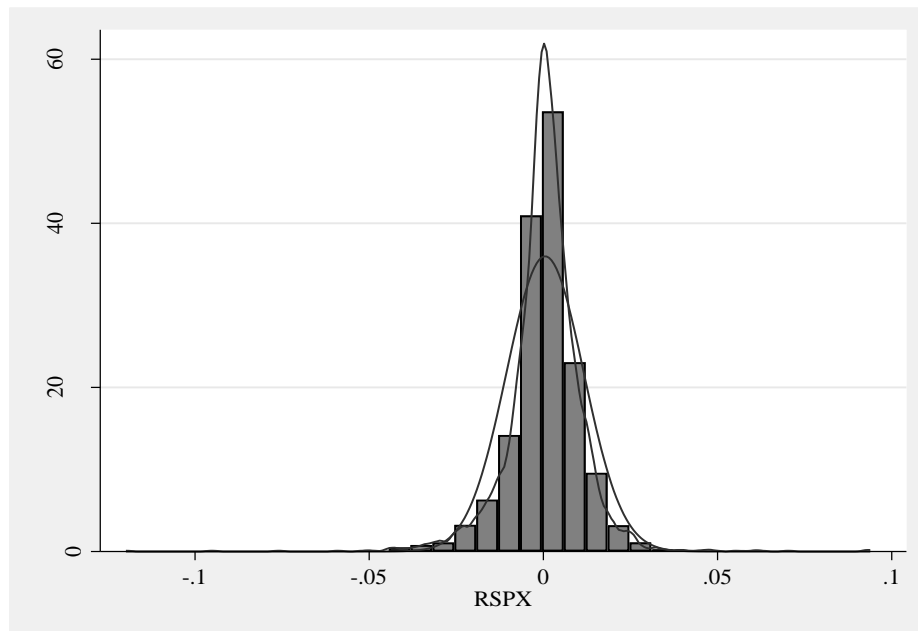


Figure 2.8: Probability Density of the Daily Rates of Return of SPX

Figures 2.5-2.8 probability distributions indicate that skewness is not heavy for the rates of returns. Descriptive statistics in Table 2.1 show that the skewness is negative in all four indices and they all have longer tails on the left side. All distributions are leptokurtic since all have larger than 3.0 kurtosis. Interestingly, Turkiye's BIST's return rates display the lowest kurtosis. This can be interpreted in a way that in the major stock markets, especially in the USA, return rates have more outliers. The Q-Q plots on Figures 2.9-2.12 verify this outcome.

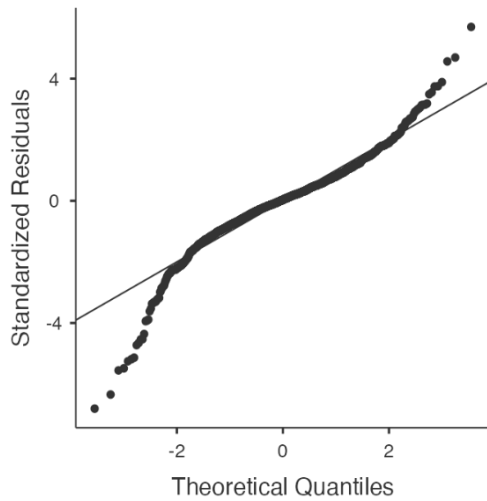


Figure 2.9 : Q-Q Plot for BIST 100

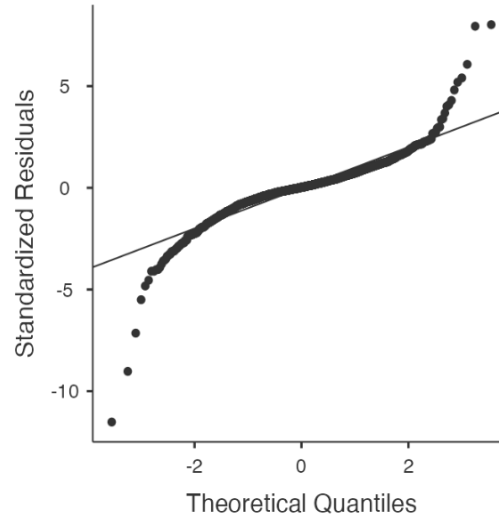


Figure 2.10 : Q-Q Plot for S&P500

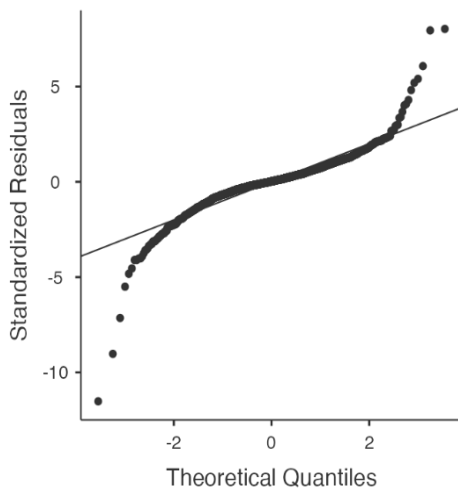


Figure 2.11 : Q-Q Plot for FTSE 100

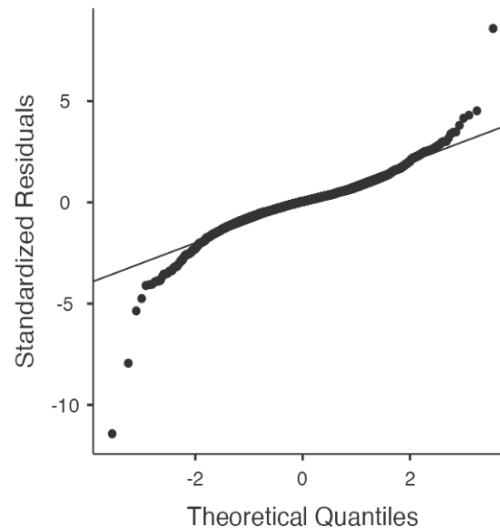


Figure 2.12 : Q-Q Plot for DAX 40

More outliers from the distribution are observable in the USA, the UK and Germany. When we specifically examine these outliers, all of them coincide with the pandemic era's extreme movements in the markets.

As a result, if we exclude this period, having extreme returns and a large amount of outliers may not be the characteristics of these markets. In addition, as we mentioned before, Shapiro-Wilk Test results with less than 0.001 p-values indicate that the data for all indices is not normally distributed.

Correlation matrices on Table 2.4, 2.5 and 2.6 show the correlations among indices with Pearson's r value for each correlation.

Table 2.4: Correlations Among the Indices Returns for Period 2013-2023 with Pearson's r Value for Each Correlation

		BIST 100	S&P 500	FTSE 100	DAX 40
BIST 100	Pearson's r	—			
	p -value	—			
S&P 500	Pearson's r	0.252 ***	—		
	p -value	<.001	—		
FTSE 100	Pearson's r	0.348 ***	0.566 ***	—	
	p -value	<.001	<.001	—	
DAX 40	Pearson's r	0.339 ***	0.590 ***	0.827 ***	—
	p -value	<.001	<.001	<.001	—

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Table 2.5: Correlations among Indices Returns for Period 2013-2021 with Pearson's r Value for Each Correlation

		BIST 100	S&P 500	FTSE 100	DAX 40
BIST 100	Pearson's r	—			
	p -value	—			
S&P 500	Pearson's r	0.314 ***	—		
	p -value	<.001	—		
FTSE 100	Pearson's r	0.401 ***	0.615 ***	—	
	p -value	<.001	<.001	—	
DAX 40	Pearson's r	0.391 ***	0.608 ***	0.836 ***	—
	p -value	<.001	<.001	<.001	—

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

When we examine the correlations from 2013 to 2023 and particularly from 2021 to 2023, the correlations among foreign indices are usually higher. The sample size is smaller for 2021-2023 but in this period all correlations among indices are smaller

compared to 2013-2021 period. In addition, BIST seems to have a higher correlation with FTSE 100 and DAX 40 compared to the S&P 500.

Table 2.6: Correlations among Indices Returns for Period 2021-2023 with Pearson’s r Value for Each Correlation

		BIST 100	S&P 500	FTSE 100	DAX 40
BIST 100	Pearson's r	—			
	p-value	—			
S&P 500	Pearson's r	0.142 ***	—		
	p-value	< .001	—		
FTSE 100	Pearson's r	0.254 ***	0.423 ***	—	
	p-value	< .001	< .001	—	
DAX 40	Pearson's r	0.248 ***	0.541 ***	0.797 ***	—
	p-value	< .001	< .001	< .001	—

Note. * p < .05, ** p < .01, *** p < .001

2.2.3 Unit Root Tests for the Return Rates of the Selected Stock Market Indices

The Dickey Fuller test’s null hypothesis is the existence of random walk without drift. Table 2.7 displays that this null hypothesis is rejected at a 1% significance level for all of the return rates of the selected indices.

Table 2.7: Dickey Fuller Test Unit Root Tests for the Return Rates of Indices

Index	Test Statistic
S&P 500	-57.888***
FTSE 100	-51.090***
DAX 40	-50.892***
BIST 100	-51.781***

Note: ***represents 1% significance level

CHAPTER 3

EMPIRICAL MODELLING OF THE INTERACTIONS OF THE RETURN RATES AND THE COMOVEMENTS OF THE RETURN RATES' VOLATILITIES FOR THE SELECTED INDICIES

In this chapter empirical modelling of the interactions of the return rates with Vector Auto-regression Models is presented first. Additionally, information criteria for the lag selection, stability of the VAR model and the impulse responses of the return rates of the indices are examined. Then, co-movements of the return rates' volatilities with MGARCH models and the VAR-MGARCH-BEKK model are presented. Finally, conditional correlations among indices are examined.

3.1 Empirical Modelling of the Interactions of the Return Rates with Vector Auto-regression Models

Vector Autoregression (VAR) models investigate the interdependencies between the chosen endogenous variables (Sims, 1980). Typically, a VAR model of n -endogenous variables with p -lags for each variable can be represented as follows:

$$x_t = A_0 + A_1x_{t-1} + \dots + A_px_{t-p} + \dots + A_px_{t-p} + u_t \quad (1)$$

where " $x_t = (x_{1,t}, x_{2,t}, \dots, x_{n,t})$ " is an n -dimensional vector of endogenous variables, while x_{t-p} is the p -order lag values. A_0 stands for the n dimensional constant terms, A_p are the p^{th} ($n \times n$) coefficient matrices of vector x_{t-p} for $p = 1, 2, \dots, P$, $u_t = (u_{1,t}, \dots, u_{n,t})$ is the n –dimensional vector of i.i.d. (identically and independently distributed) residuals with zero mean. The return rates for all of the selected indices do not have unit roots as shown above.

3.3 Impulse Responses for the Return Rates of the Selected Indices

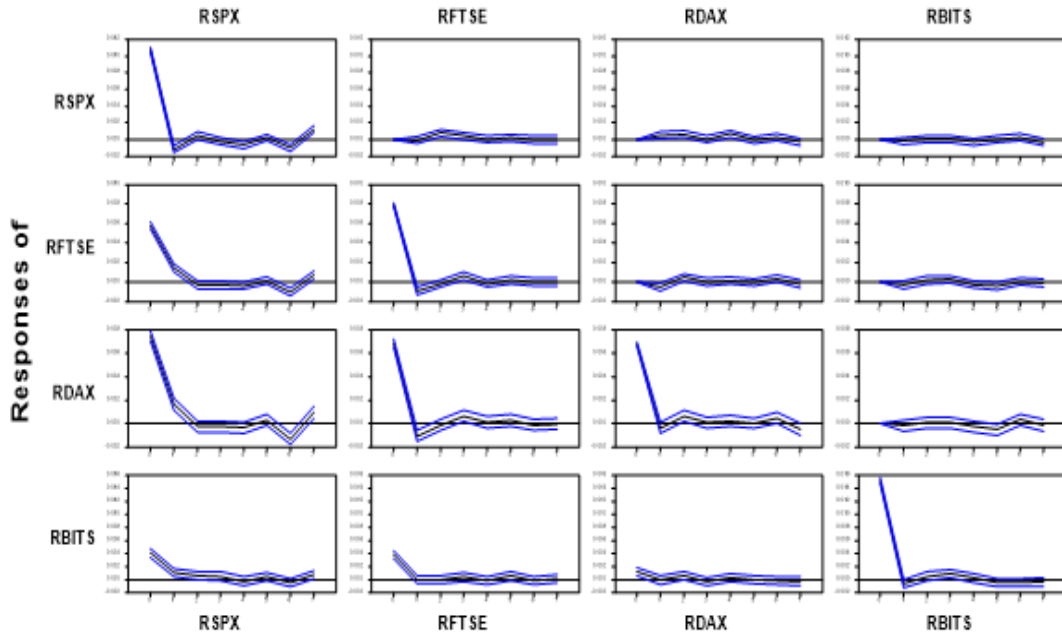


Figure 3.2: Impulse Responses for the Return Rates of the Selected Indices

When we analyze the impulse response functions we observe that all of the rates of returns are sensitive to the one-period shocks in the S&P in the US. On the other hand, S&P's rates of return do not respond to the shocks in other countries' stock markets. The return rates of DAX respond to the shocks in the US and the UK markets. When it comes to the return rates of BIST, it is sensitive to its own shocks rather than the shocks in the other countries' stock markets. The Multivariate ARCH test statistic is 7400.66 and at a 1% significance level the non-existence of ARCH effects is rejected. This indicates the existence time-varying variances of the residuals of the VAR model. This leads us to use the GARCH models for the residuals' variance equations when we use the VAR model with 8 lags as the mean model.

3.4. Empirical Modelling of the Co-movements of the Return Rates' Volatilities with MGARCH Models

We use the MGARCH model with BEKK specification in modeling the residuals' variances of the VAR model with eight lags as specified above.

Engle and Kroner (1995) proposed the GARCH model with BEKK (Baba-Engle-Kraft-Kroner) specification.

The model ensures positive definiteness by construction in the conditional variance-covariance matrix due to the quadratic form of its terms. As a result, parameters enter the model through quadratic forms that make the conditional variances positive.

The model in its general form is as follows,

$$H_t = CC' + \sum_{i=1}^q \sum_{k=1}^K A'_{ki} \varepsilon_{t-i} \varepsilon'_{t-i} A_{ki} + \sum_{j=1}^p \sum_{k=1}^K B'_{kj} H_{t-j} B_{kj} \quad (2)$$

where H_t is the conditional variance-covariance matrix where A is the coefficient matrix of the ARCH effect, B is the coefficient matrix of the GARCH effect, and C is the parameter matrix. The interaction among the conditional variance and covariance elements is allowed in this model.

In the bivariate model where $K=1$ the variance-covariance matrix and parameter matrices are defined as

$$\begin{aligned} H_{ij,t} &= \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \\ A_{ij,t} &= \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \\ B_{ij,t} &= \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \\ C_{ij,t} &= \begin{bmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{bmatrix} \end{aligned}$$

And the model takes the following form,

$$H_t = CC' + A' \varepsilon_{t-1} \varepsilon'_{t-1} A + B' H_{t-1} B \quad (3)$$

The open form of (3) is as follows,

(4)

$$H_t = \begin{bmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{bmatrix}' \begin{bmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{1,t-1}\varepsilon_{2,t-1} & \varepsilon_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \\ + \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix}' \begin{bmatrix} h_{11,t-1} & h_{12,t-1} \\ h_{21,t-1} & h_{22,t-1} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix}$$

Conditional variances as follows,

(5)

$$h_{11,t} = (c_{11}^2 + c_{12}^2) + (a_{11}^2 \varepsilon_{1,t-1}^2 + 2\alpha_{11}\alpha_{21}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{21}^2 \varepsilon_{2,t-1}^2) \\ + (\beta_{11}^2 h_{11,t-1} + 2\beta_{11}\beta_{21}h_{21,t-1} + \beta_{21}^2 h_{22,t-1})$$

(6)

$$h_{22,t} = (c_{21}^2 + c_{22}^2) + (a_{12}^2 \varepsilon_{1,t-1}^2 + 2\alpha_{12}\alpha_{22}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{22}^2 \varepsilon_{2,t-1}^2) \\ + (\beta_{12}^2 h_{11,t-1} + 2\beta_{12}\beta_{22}h_{21,t-1} + \beta_{22}^2 h_{22,t-1})$$

Conditional covariance is as follows,

(7)

$$h_{21,t} = c_{11}c_{12} + \alpha_{11}\alpha_{12}\varepsilon_{1,t-1}^2 + (\alpha_{12}\alpha_{21} + \alpha_{11}\alpha_{22})\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{21}\alpha_{22}\varepsilon_{2,t-1}^2 \\ + \beta_{11}\beta_{12} h_{11,t-1} + (\beta_{12}\beta_{21} + \beta_{11}\beta_{22})h_{21,t-1} + \beta_{21}\beta_{22}h_{22,t-1}$$

In the BEKK-GARCH model, off-diagonal elements in A and B matrices are assumed to be equal to zero so that the positiveness of conditional variances is ensured and these conditional variances are a function of their past values and their past squared residuals (Liu, 2016).

In addition, the log likelihood function of the model is as follows,

$$\ln l(\theta) = -\frac{pN}{2} \ln(2\pi) - \frac{1}{2} \sum_{i=1}^p \left(\ln |H_t| + \frac{1}{2} \varepsilon_t' H_t \varepsilon_t \right)$$

where the unknown parameter is θ and N is the number of time series, in our case indices and the number of observations are characterized with the number p.

3.4.1 VAR-MGARCH-BEKK Model

For the mean VAR model, we choose MGARCH-BEKK model with 5 lags of ARCH effects and 5 lags of GARCH effects and GED distribution.

The coefficients of the VAR (8) - MAGARCH (5, 5)-BEKK model with their standard errors and the t-tests are given in Appendix A.1 and A.2.

VAR(8)-MAGARCH(5,5)-BEKK model's residuals do not display autocorrelations as the Multivariate Q Test shows and it also does not exhibit time-varying residual variances as Multivariate ARCH Test indicates:

Table 3.2: Multivariate Q Test

Multivariate Q Test	
Test Run	Over 9 to 2587
Lags Tested	20
Degrees of Freedom	320
Q Statistic	284.0922
Significance Level	0.9264

Table 3.3: Multivariate ARCH Test

Multivariate ARCH Test		
Statistic	Degrees	Significance
2027.94	2000	0.32625

3.4.2 Conditional Correlations of Indices

In this section, we represent the conditional correlations obtained from the VAR (8)-MAGARCH (5, 5)-BEKK model, with GED distribution, individually and altogether.

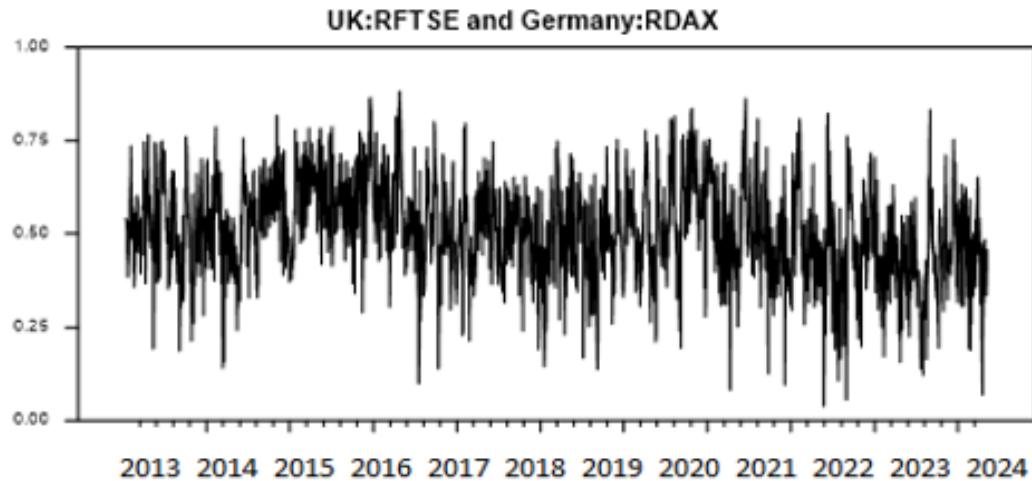


Figure 3.3: Conditional Correlation between FTSE 100 and DAX 40

The conditional correlation graph which is derived from the BEKK-GARCH model for the FTSE and DAX indices is shown on the Figure 3.3. It demonstrates the dynamic correlation between these indices over the period of 2013-2023. There is a positive relationship between indices as the correlation oscillates around a mean of 0.5. This non-zero correlation indicates that markets usually move in tandem to a certain extent which makes sense since they were in the same economic union up until 2020. However, there is some notable divergent market responses and a lower correlation period starting after 2020 which may be attributed to Brexit but we can only speculate. Additionally, there are periods, especially before 2020, where the correlation intensifies for long periods. It may potentially reflect moments of synchronized market reactions to global economic events. The absence of negative correlation throughout the period might indicate that investors do not prefer one to another as a diversification method between these European markets. As a result, with a slightly smaller conditional correlation in recent years, both markets tend to move in conjunction to a certain extent.

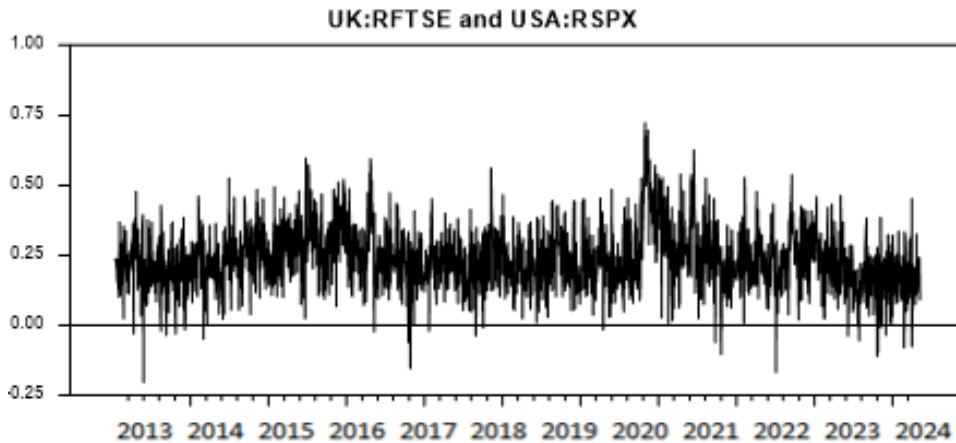


Figure 3.4: Conditional Correlation between FTSE 100 and S&P 500

On Figure 3.4 and 3.5 conditional correlation graphs of FTSE 100 and DAX 40 in relation to S&P 500 are presented. There is a positive relationship between indices as the correlation oscillates around a mean of 0.25. As compared to conditional correlations of DAX 40 and FTSE 100, the correlations are not always non-zero. Apart from that, there is great similarity in the relations of both of these indices to S&P 500. A reasonable outcome since Germany and the UK are in a more similar economic environment. There is peak in correlations when the pandemic hit financial markets but, after that, there is some degree of decrease. Without going into macroeconomic details, we might interpret this result along with the returns of the indices in a way that the US market becomes more favorable compared to Germany and the UK. One goes higher, others do not similarly follow the movement in recent period.

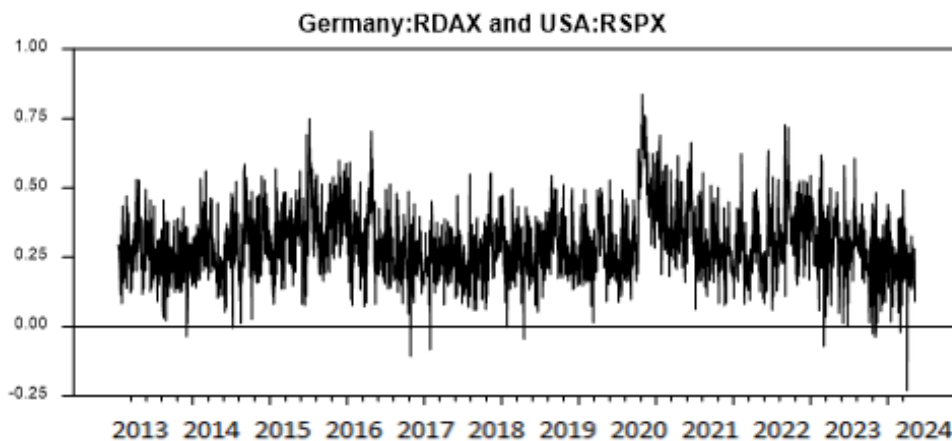


Figure 3.5: Conditional Correlation between FTSE 100 and S&P

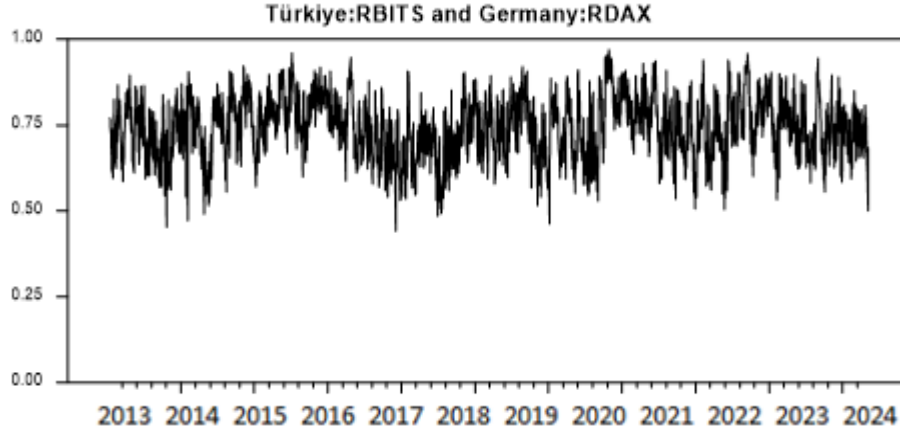


Figure 3.6: Conditional Correlation between BIST 100 and DAX 40

On Figure 3.6 and 3.7 conditional correlation graphs of FTSE 100 and DAX 40 in relation to BIST 100 are presented. There is a positive relationship between indices as the correlation oscillates around a mean of 0.75 for DAX & BIST and around 0.5 for FTSE & BIST. There is similarity in the relations of these indices but it is obvious that DAX and BIST have the strongest conditional correlation. In the scope of this thesis, we can only speculate on the reason. Strongest trade relations, Turkish diaspora, debt relations can be the reasons. After 2020 there is some degree of decrease but it is not permanent since the correlations increase again and fluctuate. For FTSE & BIST, we see a similar result with a lower conditional correlation and higher volatility. Some degree of deterioration is observable after 2020 and it does not bounce back to higher levels as we see in DAX & BIST but the correlation is mostly preserved.

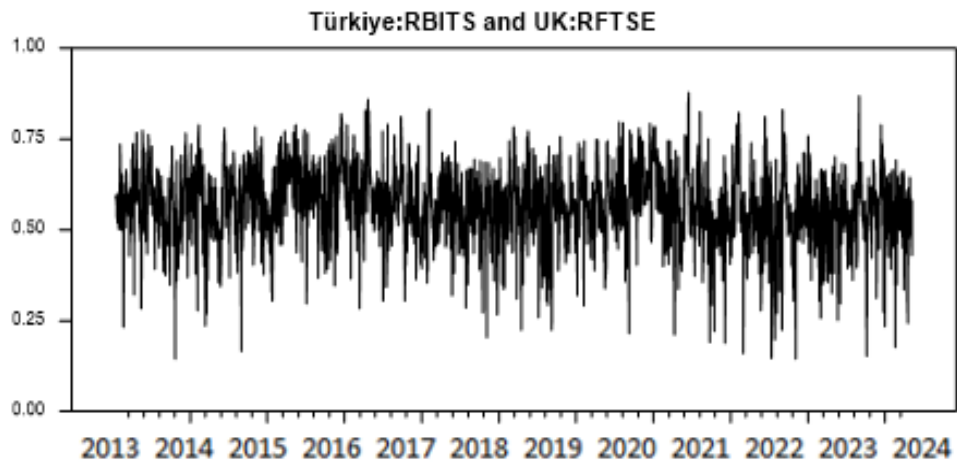


Figure 3.7: Conditional Correlation between BIST 100 and FTSE 100

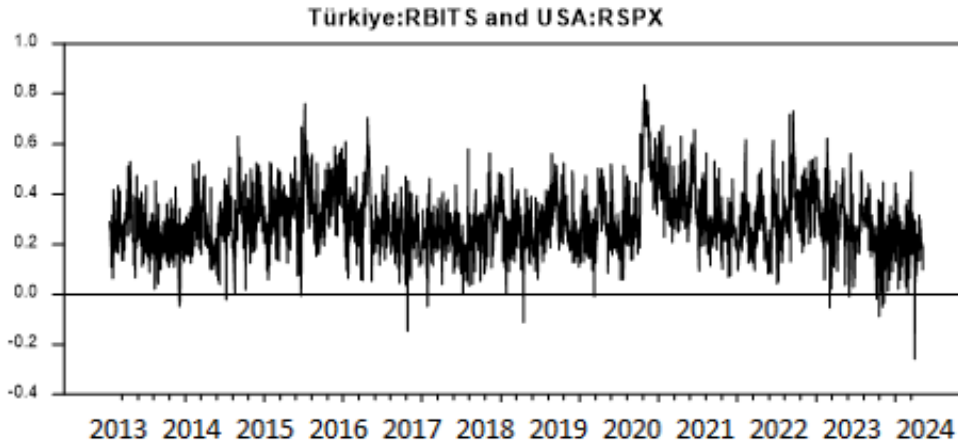


Figure 3.8: Conditional Correlation between BIST 100 and S&P 500

On Figure 3.8, conditional correlation graph of S&P 500 and BIST 100 is presented. There is usually a positive relationship between indices as the correlation oscillates around a mean of 0.20. As compared to conditional correlations of other indices, we see the weakest relation here. The correlations are not always non-zero. Apart from that, there is great similarity in the relationship of BIST 100 and S&P 500 compared to DAX 40 and FTSE 100 to S&P 500. A reasonable outcome since Türkiye is in a more similar economic environment. There is a peak in correlations when the pandemic hit financial markets but, after that, there is a continuous weakening. We might interpret this result along with the returns of the indices in a way that the US market becomes more favorable compared to Türkiye. S&P 500 goes higher, and BIST 100 does not follow the movement in a similar way since the conditional correlation is quite weak and sometimes negative in recent period.

The conditional correlation graphs derived from the BEKK-GARCH model present that co-movements of volatility in the European markets of Türkiye, Germany and the UK are highly correlated and non-zero. The strongest and continued relation of BIST 100 is with DAX 40. These markets have a similar pattern when we compare the movements to the US market.

CHAPTER 4

CONCLUSION

Stock markets are dynamic ecosystems interconnected globally. In this regard, they appear to be separate entities at first look since they each include businesses with a diverse range of business backgrounds that operate in various locations. On the other hand, a more intricate dynamic of co-movements and connected volatilities becomes apparent when we examine the dynamics of these markets. There are numerous factors which might affect these dynamics and one of which is monetary policy. In recent years, there has been a belief that high interest rates cause high inflation in Türkiye. This understanding affected some macroeconomic indicators such as the risk premium of Türkiye, the yield spreads, inflation and exchange rate. Since monetary policy is an important element of financial decision-making along with the various number of contributing factors that influence the stock market behavior, this thesis aimed to examine the index returns and volatility co-movements of Borsa Istanbul and major indices of the United States, the United Kingdom and Germany. There are a multifarious number of studies concerning the co-movements of BIST compared to other markets including emerging and developed markets. The main contribution of the study comes forward in the analysis that involves the dynamics of recent years up to December 2023.

Therefore, this thesis analyzed the interaction of the financial market returns among S&P 500, FTSE 100 and DAX 40 as well as the co-movements of the financial market volatility of Türkiye with these major stock markets' volatilities from January 2013 to December 2023. The interactions of the chosen returns are analyzed with the Vector Autoregressive (*VAR*) Models. The co-movements of the selected volatilities are investigated with the Multivariate Generalized Autoregressive Heteroscedasticity (*MGARCH*) models. For the mean *VAR* model, *MGARCH-BEKK* model with 5 lags of *ARCH* effects and 5 lags of *GARCH* effects and *GED* distribution was chosen.

The analyses of the impulse response functions showed that all of the rates of returns are sensitive to the one-period shocks in the indices. The American index, S&P's rates of return do not respond to the shocks in other countries' stock markets. The return rates of DAX respond to the shocks in the US and the UK markets both. The examination of the return rates of BIST indicates that it is sensitive to its own shocks rather than the shocks in the other countries' stock markets.

Furthermore, the MGARCH model with BEKK specification in modeling the residuals' variances of the VAR model with eight lags was used. All indices experienced an increase in the correlations during the pandemic period which is an anticipated result as the studies of Solnik (1974) and Lessard (1976) and many other studies stated that times of crises tended to increase market correlations. The conditional correlations among indices revealed that European markets, FTSE 100, DAX 40 and including BIST 100 have relatively high conditional correlation. Particularly, the correlation between DAX 40 and BIST 100 is strong. These European indices also have non-negative correlations which indicates, under the closer economic environment, more similar movements. On the other hand, all indices have negative conditional correlation periods with S&P 500. This is not specific to the recent period but we see frequent negative results, especially after 2021. In addition, after 2021, BIST 100 and the other two indices of the UK and Germany seem to have a lower positive correlation except the times of negative ones with the S&P 500. We do not see a change in correlations of DAX 40 and FTSE 100 regarding BIST 100.

Consequently, the analysis which involves the period of monetary policy and macroeconomic changes reveals that the BIST 100 index is not as sensitive as the other indices' responses to the shocks in the other countries' stock markets. Results showed that BIST is sensitive to its own shocks. Moreover, the Turkish market preserves its high conditional correlation with Germany and the United Kingdom. Similar to the results of Öztekin, (2013), conditional correlations among BIST 100, DAX 40 and FTSE 100 is high. This conditional correlation seems to be smaller and more frequently negative when we compare BIST to S&P in recent years. However, this divergence is also valid for DAX and FTSE. Therefore, we may conclude that the Turkish market with its high correlation with European markets shows similar dynamics and did not

diverge from European markets. Since the result of the analysis does not show a Turkish specific outcome, the analysis can be elaborated and to eliminate this deficiency, further studies which involves the macroeconomic parameters as input can be conducted.

REFERENCES

- Alzoubi, M. (2022). Stock market performance: Reaction to interest rates and inflation rates. *Banks and Bank Systems*, 189-198.
- Aslanidis, N., & Savva, C. (2010). Stock market integration between new EU member states and the Euro-zone. *Empirical Economics*, 337-351.
- Asprem, M. (1989). Stock prices, asset portfolios and macroeconomic variables in then Europeam countries. *Journal of Banking and Finance*, 589-612.
- Bansal, R., & Zhou, H. (2002). Term structure of interest rates with regime shifts. *Journal of Financial*, 1997-2043.
- Berkman, N. G. (1978). On the significance of weekly changes in M1. *New England Economic Review*, 5-22.
- Berument, H., & Gunay, A. (2003). Exchange rate risk and interest rate: a case study for Turkey. *Open Economies Review*, 19-27.
- Black, F. (1976). Studies in stock price volatility change. *Proceedings of the 1976 Business Meeting of the Business and Economics Statistics Selection* (pp. 177-181). American Statistical Association.
- Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 307-327.
- Bollerslev, T., Chou, R. Y., & Kroner, K. F. (1992). ARCH modelling in finance: A review of the theory and emprical evidence. *Journal of Econometrics*, 5-59.
- Brunner, K. (1961). Some Major Problems in Monetary Policy. *American Economic Review*, 47-56.
- Cappiello, L., Gerard, B., Kadareja, A., & Manganelli, S. (2006). Financial integration of new EU member states. *European Central Bank Working Paper*.
- Celasun, O., Gelos, R. G., & Prati, A. (2004). Would “cold turkey” work in Turkey? *IMF Staff Papers*, 493-509.
- Christie, A. A. (1982). The stochastic behavior of common stock variances: Value, leverage and interest rate effects. *Journal of Financial Economics*, 407-432.
- Ekinci, C., Akyildirim, E., & Corbet, S. (2019). Analysing the dynamic influence of US macroeconomic news releases on Turkish stock markets. *Finance Research Letters*(31), 155-164.

- Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the Econometric Society*, 987-1007.
- Engle, R. F., & Kroner, K. F. (1995). Multivariate simultaneous generalized ARCH. *Econometric Theory*, 11(1), 122-150.
- Engle, R. F., & Sheppard, K. (2001). *Theoretical and empirical properties of dynamic conditional correlation multivariate GARCH*. Cambridge, MA: National Bureau of Economic Research.
- Ergun, U., & Nor, A. M. (2010). The stock market relationship between Turkey and the United States under Unionisation. *Asian Academy of Management Journal of Accounting and Finance*, 19-33.
- Fama, E. F. (1965). The behavior of stock-market prices. *Journal of business*, 34-105.
- Friedman, M. (1961). The lag in effect of monetary policy. *Journal of Political Economy*, 447-466.
- Friedman, M., & Schwartz, A. J. (1963). Money and business cycles. *Review of Economics and Statistics*, 32-64.
- Geske, R., & Roll, R. (1983). The fiscal and monetary linkage between stock returns and inflation. *The Journal of Finance*, 1-33.
- Granger, C. W., & Andersen, A. (1978). An introduction to bilinear time series models. *Vandenhoeck und Ruprecht*.
- Gürkaynak, R. S., Kisacikoğlu, B., & Lee, S. S. (2023). Exchange rate and inflation under weak monetary policy: Turkey verifies theory.
- Hashimzade, N., & Thornton, M. A. (2013). *Handbook of research methods and applications in empirical macroeconomics*. Edward Elgar Publishing Limited.
- Homa, K. E., & Jaffee, D. M. (1971). The supply of money and common stock prices. *Journal of Finance*, 1056-1066.
- Huang, Y., Su, W., & Li, X. (2010). Comparison of BEKK GARCH and DCC GARCH models: An empirical study. *Advanced Data Mining and Applications - 6th International Conference* (pp. 99-110). Springer.
- Humpe, A., & Macmillan, P. (2020). Macroeconomic variables and long-term stock market performance. A panel ARDL cointegration approach for G7 countries. *Congent Economics and Finance*, 1-7.

- Jaffe, J., & Mandelker, G. (1976). The fisher effect for risky assets: An empirical investigation. *Journal of Finance*, 447-458.
- Kara, H. (2012). *Monetary policy in Turkey after the global crises*. Ankara: Central Bank of the Republic of Turkey.
- Karolyi, G., & Stulz, R. (1996). Why do markets move together? An investigation of U.S.-Japan stock return co-movements. *Journal of Finance*, 951-986.
- Kaya, H. (2013). The yield curve and the macroeconomy: Evidence from Turkey. *Economic Modelling*, 100-107.
- Kearney, C., & Patton, A. J. (2000). Multivariate GARCH modeling of exchange rate volatility transmission in the European Monetary System. *Financial Review*, 29-48.
- Keran, M. W. (1971, January). Expectations, money and the stock market. *Federal Reserve Bank of St. Louis*, pp. 16-31.
- King, M., E. Sentana, and S. Wadhvani, 1994, Volatility and links between national stock markets, *Econometrica* 62, 901-934.
- Kontonikas, A., MacDonald, R., & Saggiu, A. (2013). Stock market reaction to fed funds rate surprises: State dependence and the financial crisis. *Journal of Banking and Finance*, 37(11), 4025-4037.
- Kumar, M. (2013). Returns and volatility spillover between stock prices and exchange rates: Empirical evidence from IBSA countries. *International Journal of Emerging Markets*, 108-128.
- Lessard, D. R. (1976). World, country, and industry relationships in equity returns: implications for risk reduction through international diversification. *Financial Analysts Journal*, 32(1), 32-38.
- Li, H. (2007). International linkages of the Chinese Stock Exchanges: A Multivariate GARCH analysis. *Applied Financial Economics*, 285-297.
- Liu, C. (2016). Spillover effects in major equity markets: A GARCH BEKK approach. *Open Access Library Journal*.
- Lynge, M. J. (1981). Money supply announcements and stock prices. *The Journal of Portfolio Management*, 40-43.
- Mandelbrot, B. (1963). The Variation of Certain Speculative Prices. *Journal of Business*, 394-419.

- Marcu, N., Gorun, A., & Acatrinei, M. (2013). A DCC-GARCH model to estimate the risk to the capital market in Romania. *Romanian Journal of Economic Forecasting*, 136-148.
- Mouna, A., & Anis, J. (2016). Market, interest rate, and exchange rate risk effects on financial stock returns during the financial crisis: AGARCH-M approach. *Cogent Economics and Finance*, 4, 1-16.
- Nas, T., & Perry, M. (2000). Inflation, inflation uncertainty, and monetary policy in Turkey: 1960-1998. *Contemporary Economic Policy*, 170-180.
- Nazloğlu, E. H., & Kök, D. (2021). Contagion in Turkish Stock Market: Evidences from developed and emerging markets. *Ege Academic Review*, 407-425.
- Öztek, M. F. (2013). Modeling co-movements among financial markets: Applications of multivariate autoregressive conditional heteroscedasticity with smooth transitions in conditional correlations.
- Pedersen, R. S., & Rahbek, A. (2012). Multivariate variance targeting in the BEKK-GARCH model. *The Econometrics Journal*, 24-55.
- Pokhrel, L., & Mishra, A. K. (2020). Thye dynamic linkage between interest rates and stock prices: An application of ARDL bound test. *Journal of Financial Planning and Management*, 27-35.
- Saleem, K. (2007). International linkage of Russian market and Russian financial crisis: A Multivariate GARCH analysis. *SSRN Electronic Journal*.
- Savva, C. S., Osborn, D. R., & Gil, I. L. (2009). Spillovers and correlations between US and major European markets: the role of the euro. *Applied Financial Economics*, 337-351.
- Sellin, P. (2001). Monetary policy and the stock market: Theory and empirical evidence. *Journal of Economic Surveys*, 15(4), 491-541.
- Sensoy, A. (2017). Firm size, ownership structure, and system-atic liquidity risk: The case of an emerging market. *Journal of Financial Stability*, 62-80.
- Smith, J. M., & Taylor, J. B. (2009). The term structure of policy rules. *Journal of Monetary Economics*, 907-917.
- Solnik, B. H. (1974). Why not diversify internationally rather than domestically?. *Financial Analysts Journal*, 30(4), 48-54.
- Soztanacı, B. K., & Ojaghlu, M. (2022). Interest rate pass-through and monetary transmission mechanism in Turkey. *Isletme ve Iktisat Calismaları Dergisi*, 46-54.

- Syriopoulos, T., & Roumpis, E. (2009). Dynamic correlations and volatility effects in the Balkan equity markets. *Journal of International Financial Markets*, 565-587.
- Taştan, H. (2005). Dynamic interdependence and volatility transmission in Turkish and European equity markets. *Turkish Economic Association Discussion*.
- Tripathi, V., & Kumar, A. (2015). Relationship between macroeconomic factors and aggregate stock returns in BRICS Stock Markets – A panel data analysis. *New Age Business Strategies in Emerging Global Markets*, 104-123.
- Var, U. (2015). Türkiye ile bazı gelişmiş ve gelişmekte olan ülkelerin hisse senedi piyasaları arasındaki getiri ve volatilité yayılma ilişkisi ile entegrasyonun analizi (2009-2014). *İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü İşletme Mühendisliği Anabilim Dalı* .
- Wei, C. (2009). Does the stock market react to unexpected inflation differently across the business cycle? *Applied Financial Economics*, 1947-1959.

APPENDICES

A. VAR-BEKK-GARCH ESTIMATES

Table A.1: BEKK-GARCH (p=5, q=5)

	Coefficient	Standard Error	t-Statistics	Significance
C(1,1)	0.00041409	0.00024798	1.66988000	0.09494213
C(2,1)	0.00106359	0.00056941	1.86789000	0.06177791
C(2,2)	0.00053333	0.00074028	0.72044000	0.47125584
C(3,1)	-0.00021873	0.00054055	-0.40464000	0.68574066
C(3,2)	0.00039778	0.00058144	0.68413000	0.49389300
C(3,3)	0.00000252	0.00099916	0.00252000	0.99798710
C(4,1)	0.00068627	0.00159371	0.43061000	0.66675147
C(4,2)	-0.00163747	0.00056329	-2.90700000	0.00364912
C(4,3)	-0.00001036	0.00213838	-0.00485000	0.99613278
C(4,4)	-0.00000097	0.00146229	-0.00066505	0.99946937
A{1}(1,1)	0.23019934	0.02664594	8.63919000	0.00000000
A{1}(1,2)	-0.03337546	0.02434239	-1.37108000	0.17034887
A{1}(1,3)	-0.07025451	0.02957560	-2.37542000	0.01752893
A{1}(1,4)	-0.05168840	0.03079521	-1.67846000	0.09325821
A{1}(2,1)	0.05410903	0.02610261	2.07294000	0.03817827
A{1}(2,2)	0.17770641	0.02685587	6.61704000	0.00000000
A{1}(2,3)	0.05672450	0.03124691	1.81536000	0.06946807
A{1}(2,4)	0.03690895	0.04310693	0.85622000	0.39187693
A{1}(3,1)	-0.05399271	0.02219854	-2.43226000	0.01500476
A{1}(3,2)	-0.02333832	0.02380676	-0.98032000	0.32692664
A{1}(3,3)	0.10468640	0.02917466	3.58826000	0.00033289

A{1}(3,4)	-0.02177021	0.03578261	-0.60840000	0.54292103
A{1}(4,1)	0.00789055	0.00999703	0.78929000	0.42994294
A{1}(4,2)	0.00772614	0.00965917	0.79988000	0.42378247
A{1}(4,3)	-0.00691108	0.01255084	-0.55065000	0.58187561
A{1}(4,4)	0.10229423	0.02423951	4.22015000	0.00002441
A{2}(1,1)	0.09738611	0.03473654	2.80356000	0.00505412
A{2}(1,2)	-0.12532327	0.03374589	-3.71373000	0.00020422
A{2}(1,3)	-0.14428197	0.03501670	-4.12038000	0.00003783
A{2}(1,4)	-0.03868653	0.03528264	-1.09647000	0.27287098
A{2}(2,1)	-0.05581529	0.02780036	-2.00772000	0.04467323
A{2}(2,2)	-0.00594261	0.03233554	-0.18378000	0.85418640
A{2}(2,3)	-0.06065717	0.03302896	-1.83648000	0.06628603
A{2}(2,4)	-0.13721934	0.04162462	-3.29659000	0.00097866
A{2}(3,1)	0.08387441	0.02343468	3.57907000	0.00034482
A{2}(3,2)	0.16314800	0.02879948	5.66496000	0.00000001
A{2}(3,3)	0.23022694	0.03054093	7.53831000	0.00000000
A{2}(3,4)	0.12252100	0.03843410	3.18782000	0.00143350
A{2}(4,1)	-0.01345111	0.01105365	-1.21689000	0.22364463
A{2}(4,2)	0.00017864	0.01040838	0.01716000	0.98630660
A{2}(4,3)	-0.00510446	0.01243870	-0.41037000	0.68153519
A{2}(4,4)	0.14455439	0.02493559	5.79711000	0.00000001
A{3}(1,1)	0.00446831	0.03963816	0.11273000	0.91024657
A{3}(1,2)	0.02981285	0.02497899	1.19352000	0.23266690
A{3}(1,3)	-0.00794859	0.03283907	-0.24205000	0.80874400
A{3}(1,4)	0.02978345	0.03265975	0.91193000	0.36180492
A{3}(2,1)	0.12365532	0.02932749	4.21636000	0.00002483
A{3}(2,2)	0.07461945	0.02665664	2.79928000	0.00512163
A{3}(2,3)	-0.01902826	0.03188735	-0.59673000	0.55068508
A{3}(2,4)	-0.02194777	0.04391617	-0.49977000	0.61724052
A{3}(3,1)	0.03740373	0.02549296	1.46722000	0.14231671

A{3}(3,2)	0.13233531	0.02452503	5.39593000	0.00000007
A{3}(3,3)	0.26567305	0.03041612	8.73461000	0.00000000
A{3}(3,4)	0.16212982	0.03906205	4.15057000	0.00003316
A{3}(4,1)	-0.00688004	0.01242262	-0.55383000	0.57969435
A{3}(4,2)	-0.02151241	0.01095621	-1.96349000	0.04958927
A{3}(4,3)	-0.02485896	0.01313464	-1.89263000	0.05840751
A{3}(4,4)	-0.10569763	0.03781915	-2.79482000	0.00519290
A{4}(1,1)	-0.07704311	0.03244767	-2.37438000	0.01757843
A{4}(1,2)	-0.08879574	0.02685021	-3.30708000	0.00094275
A{4}(1,3)	-0.10893367	0.03244647	-3.35733000	0.00078698
A{4}(1,4)	-0.05926329	0.03324096	-1.78284000	0.07461250
A{4}(2,1)	0.14649244	0.03218736	4.55124000	0.00000533
A{4}(2,2)	0.22605660	0.03759840	6.01240000	0.00000000
A{4}(2,3)	0.30514980	0.04295236	7.10438000	0.00000000
A{4}(2,4)	0.16149212	0.05567845	2.90044000	0.00372637
A{4}(3,1)	0.07750352	0.02520278	3.07520000	0.00210363
A{4}(3,2)	0.05383048	0.03254119	1.65423000	0.09808158
A{4}(3,3)	0.03744396	0.04138866	0.90469000	0.36562893
A{4}(3,4)	-0.02043996	0.04732231	-0.43193000	0.66579182
A{4}(4,1)	0.00035721	0.01324596	0.02697000	0.97848546
A{4}(4,2)	-0.02008979	0.01244345	-1.61449000	0.10642172
A{4}(4,3)	-0.01433976	0.01429451	-1.00317000	0.31578124
A{4}(4,4)	0.02112910	0.03377324	0.62562000	0.53156642
A{5}(1,1)	0.05840022	0.04567486	1.27861000	0.20103531
A{5}(1,2)	-0.04459692	0.03160642	-1.41101000	0.15824222
A{5}(1,3)	-0.06495488	0.03669626	-1.77007000	0.07671582
A{5}(1,4)	0.01559819	0.04029921	0.38706000	0.69871231
A{5}(2,1)	-0.05819659	0.05571644	-1.04451000	0.29624775
A{5}(2,2)	-0.01123931	0.05757395	-0.19522000	0.84522446
A{5}(2,3)	-0.05730847	0.04830766	-1.18632000	0.23549491
A{5}(2,4)	-0.05709157	0.05636765	-1.01284000	0.31113522

A{5}(3,1)	0.06465600	0.03667236	1.76307000	0.07788836
A{5}(3,2)	0.12294524	0.04092556	3.00412000	0.00266351
A{5}(3,3)	0.21396284	0.03870297	5.52833000	0.00000003
A{5}(3,4)	0.07888736	0.04868049	1.62051000	0.10512214
A{5}(4,1)	-0.02785810	0.01310241	-2.12618000	0.03348809
A{5}(4,2)	-0.01025040	0.01297418	-0.79006000	0.42949174
A{5}(4,3)	-0.02839906	0.01542579	-1.84101000	0.06561987
A{5}(4,4)	0.00035466	0.03468407	0.01023000	0.99184141
B{1}(1,1)	-0.64921785	0.13387121	-4.84957000	0.00000124
B{1}(1,2)	-0.33512503	0.06319148	-5.30333000	0.00000011
B{1}(1,3)	-0.44016447	0.06676213	-6.59303000	0.00000000
B{1}(1,4)	-0.31403682	0.06528358	-4.81035000	0.00000151
B{1}(2,1)	0.01189477	0.09559398	0.12443000	0.90097472
B{1}(2,2)	-0.47878979	0.11808318	-4.05468000	0.00005020
B{1}(2,3)	-0.35105519	0.14519653	-2.41779000	0.01561494
B{1}(2,4)	-0.22168290	0.11969824	-1.85201000	0.06402371
B{1}(3,1)	0.25955503	0.06165846	4.20956000	0.00002559
B{1}(3,2)	0.50191997	0.07133563	7.03603000	0.00000000
B{1}(3,3)	0.56395736	0.20958541	2.69082000	0.00712759
B{1}(3,4)	0.03531685	0.09824640	0.35947000	0.71924189
B{1}(4,1)	-0.00237435	0.02743012	-0.08656000	0.93102143
B{1}(4,2)	0.03146348	0.02538521	1.23944000	0.21518199
B{1}(4,3)	0.02246313	0.02440945	0.92026000	0.35743504
B{1}(4,4)	0.78522755	0.05095959	15.40883000	0.00000000
B{2}(1,1)	0.70150617	0.09495013	7.38815000	0.00000000
B{2}(1,2)	0.04687958	0.04720868	0.99303000	0.32069592
B{2}(1,3)	0.18661662	0.06441685	2.89702000	0.00376731
B{2}(1,4)	0.12271399	0.05846282	2.09901000	0.03581608
B{2}(2,1)	-0.14367393	0.08677315	-1.65574000	0.09777413
B{2}(2,2)	0.56626134	0.11263088	5.02758000	0.00000050
B{2}(2,3)	0.14878420	0.13786386	1.07921000	0.28049364

B{2}(2,4)	0.06890998	0.08934393	0.77129000	0.44053571
B{2}(3,1)	-0.16479043	0.07234326	-2.27790000	0.02273276
B{2}(3,2)	-0.25493819	0.10378116	-2.45650000	0.01402987
B{2}(3,3)	-0.04326262	0.14147819	-0.30579000	0.75976455
B{2}(3,4)	-0.08231195	0.08336759	-0.98734000	0.32347723
B{2}(4,1)	0.03008104	0.03518453	0.85495000	0.39257846
B{2}(4,2)	-0.00605732	0.03005832	-0.20152000	0.84029295
B{2}(4,3)	0.00909370	0.03417353	0.26610000	0.79015943
B{2}(4,4)	0.12998229	0.14220578	0.91404000	0.36069390
B{3}(1,1)	0.13374954	0.13250138	1.00942000	0.31277326
B{3}(1,2)	-0.00302989	0.05819149	-0.05207000	0.95847489
B{3}(1,3)	-0.05037497	0.07055515	-0.71398000	0.47523953
B{3}(1,4)	-0.01167579	0.06113434	-0.19099000	0.84853679
B{3}(2,1)	0.03368272	0.10008244	0.33655000	0.73645634
B{3}(2,2)	0.35703782	0.14861886	2.40237000	0.01628913
B{3}(2,3)	-0.01185220	0.12387917	-0.09568000	0.92377834
B{3}(2,4)	0.02642154	0.08439111	0.31308000	0.75421651
B{3}(3,1)	0.02218692	0.06207343	0.35743000	0.72076973
B{3}(3,2)	-0.05120499	0.11024224	-0.46448000	0.64230601
B{3}(3,3)	0.35004610	0.12350626	2.83424000	0.00459352
B{3}(3,4)	0.05912066	0.08120672	0.72803000	0.46659723
B{3}(4,1)	-0.02868824	0.04715060	-0.60844000	0.54289670
B{3}(4,2)	-0.00003564	0.03093668	-0.00115000	0.99908085
B{3}(4,3)	-0.00617224	0.03670578	-0.16815000	0.86646169
B{3}(4,4)	0.07620292	0.11575534	0.65831000	0.51033883
B{4}(1,1)	0.00026655	0.18347654	0.00145000	0.99884083
B{4}(1,2)	-0.00002595	0.07335009	-0.00035378	0.99971773
B{4}(1,3)	0.00014511	0.08302971	0.00175000	0.99860556
B{4}(1,4)	0.00008737	0.07631877	0.00114000	0.99908662
B{4}(2,1)	-0.00032540	0.13893861	-0.00234000	0.99813132
B{4}(2,2)	-0.00026630	0.18530116	-0.00144000	0.99885335

B{4}(2,3)	0.00005157	0.13413440	0.00038444	0.99969326
B{4}(2,4)	-0.00005905	0.09649998	-0.00061195	0.99951174
B{4}(3,1)	-0.00000856	0.08153265	-0.00010504	0.99991619
B{4}(3,2)	0.00005042	0.12257178	0.00041133	0.99967181
B{4}(3,3)	-0.00042866	0.13075603	-0.00328000	0.99738429
B{4}(3,4)	-0.00003033	0.08499671	-0.00035687	0.99971526
B{4}(4,1)	0.00006371	0.08414687	0.00075710	0.99939592
B{4}(4,2)	-0.00002664	0.04301124	-0.00061935	0.99950583
B{4}(4,3)	-0.00000538	0.03537255	-0.00015201	0.99987871
B{4}(4,4)	-0.00017978	0.20420615	-0.00088037	0.99929757
B{5}(1,1)	0.04776972	0.09623571	0.49638000	0.61962463
B{5}(1,2)	-0.14043982	0.06076028	-2.31138000	0.02081213
B{5}(1,3)	-0.20390819	0.07243732	-2.81496000	0.00487832
B{5}(1,4)	-0.10909100	0.05716070	-1.90850000	0.05632704
B{5}(2,1)	-0.03137192	0.08734586	-0.35917000	0.71946875
B{5}(2,2)	0.26204907	0.09726312	2.69423000	0.00705518
B{5}(2,3)	-0.41093368	0.10973169	-3.74490000	0.00018047
B{5}(2,4)	-0.09850956	0.08504738	-1.15829000	0.24674553
B{5}(3,1)	0.11718479	0.04904864	2.38915000	0.01688719
B{5}(3,2)	0.09418320	0.08221585	1.14556000	0.25197723
B{5}(3,3)	0.81172192	0.14013879	5.79227000	0.00000001
B{5}(3,4)	0.05156252	0.06578729	0.78378000	0.43317134
B{5}(4,1)	0.04014866	0.04326037	0.92807000	0.35337120
B{5}(4,2)	0.01630647	0.03023194	0.53938000	0.58962546
B{5}(4,3)	0.02673319	0.03060120	0.87360000	0.38233647
B{5}(4,4)	0.48659550	0.06273930	7.75583000	0.00000000
Shape (GED)	1.921151508	0.03003056	63.97321000	0.00000000

Table A.2: VAR Coefficients

Model(RSPX)				
RSPX{1}	-0.04373632	0.01882066	-2.32385000	0.02013377
RSPX{2}	-0.00387186	0.01857993	-0.20839000	0.83492480
RSPX{3}	-0.03952981	0.01924405	-2.05413000	0.03996294
RSPX{4}	-0.05350072	0.01896968	-2.82033000	0.00479747
RSPX{5}	-0.00064323	0.01865244	-0.03449000	0.97249020
RSPX{6}	-0.03828889	0.01769706	-2.16357000	0.03049713
RSPX{7}	0.01476380	0.01829166	0.80713000	0.41959007
RSPX{8}	0.00472960	0.01801898	0.26248000	0.79295233
RFTSE{1}	-0.04089121	0.01836329	-2.22679000	0.02596126
RFTSE{2}	-0.01620403	0.01895344	-0.85494000	0.39258499
RFTSE{3}	0.07442776	0.01868443	3.98341000	0.00006793
RFTSE{4}	-0.03030018	0.01654234	-1.83167000	0.06699988
RFTSE{5}	0.01977160	0.01885052	1.04886000	0.29424147
RFTSE{6}	-0.03751459	0.01867726	-2.00857000	0.04458277
RFTSE{7}	-0.00567307	0.01786858	-0.31749000	0.75087278
RFTSE{8}	0.02687043	0.01881974	1.42778000	0.15335551
RDAX{1}	0.00687154	0.01523798	0.45095000	0.65202699
RDAX{2}	0.01904282	0.01516599	1.25563000	0.20925142
RDAX{3}	-0.04035241	0.01485495	-2.71643000	0.00659904
RDAX{4}	0.03648790	0.01424565	2.56134000	0.01042707
RDAX{5}	-0.01866484	0.01525388	-1.22361000	0.22109854
RDAX{6}	0.05139980	0.01492956	3.44282000	0.00057568
RDAX{7}	-0.00294547	0.01455141	-0.20242000	0.83958975
RDAX{8}	-0.02585066	0.01585934	-1.63000000	0.10310248
RBITS{1}	-0.00422633	0.00839352	-0.50352000	0.61459642
RBITS{2}	-0.00712105	0.00827250	-0.86081000	0.38934276
RBITS{3}	-0.00795201	0.00792614	-1.00326000	0.31573366
RBITS{4}	-0.01389699	0.00798349	-1.74072000	0.08173328
RBITS{5}	0.00584358	0.00812886	0.71887000	0.47222204

RBITS{6}	0.01825228	0.00801998	2.27585000	0.02285492
RBITS{7}	-0.00397263	0.00818084	-0.48560000	0.62724978
RBITS{8}	-0.00973879	0.00789396	-1.23370000	0.21731399
Constant	0.00107411	0.00012853	8.35725000	0.00000000
Model(RFTSE)				
RSPX{1}	0.25224065	0.01632414	15.45201000	0.00000000
RSPX{2}	0.07242192	0.01778289	4.07256000	0.00004650
RSPX{3}	-0.00737177	0.01711471	-0.43073000	0.66666694
RSPX{4}	-0.00858167	0.01747713	-0.49102000	0.62341021
RSPX{5}	0.01477209	0.01716076	0.86081000	0.38934465
RSPX{6}	-0.03689678	0.01656088	-2.22795000	0.02588400
RSPX{7}	-0.00135741	0.01708890	-0.07943000	0.93668872
RSPX{8}	0.01060806	0.01676835	0.63262000	0.52697908
RFTSE{1}	-0.05098887	0.01981651	-2.57305000	0.01008067
RFTSE{2}	-0.04673303	0.01884022	-2.48049000	0.01312009
RFTSE{3}	0.05755351	0.01980822	2.90554000	0.00366624
RFTSE{4}	-0.02131353	0.01734576	-1.22875000	0.21916725
RFTSE{5}	0.00581968	0.01819464	0.31986000	0.74907700
RFTSE{6}	-0.02879533	0.02056994	-1.39987000	0.16155103
RFTSE{7}	0.00377259	0.01775799	0.21244000	0.83176001
RFTSE{8}	0.00032968	0.01897668	0.01737000	0.98613927
RDAX{1}	-0.09868749	0.01562405	-6.31638000	0.00000000
RDAX{2}	-0.03959024	0.01571005	-2.52006000	0.01173354
RDAX{3}	-0.05800830	0.01589851	-3.64866000	0.00026361
RDAX{4}	0.00060749	0.01364846	0.04451000	0.96449790
RDAX{5}	-0.00646470	0.01565025	-0.41307000	0.67955300
RDAX{6}	0.06049392	0.01573283	3.84508000	0.00012052
RDAX{7}	-0.00619078	0.01420342	-0.43587000	0.66293459
RDAX{8}	0.00734457	0.01638938	0.44813000	0.65405938
RBITS{1}	-0.00435202	0.00776375	-0.56056000	0.57509984
RBITS{2}	0.00678403	0.00752003	0.90213000	0.36698880

RBITS{3}	0.00507643	0.00717116	0.70790000	0.47901007
RBITS{4}	-0.02192968	0.00742534	-2.95336000	0.00314337
RBITS{5}	-0.00936268	0.00738750	-1.26737000	0.20502418
RBITS{6}	-0.01051903	0.00726840	-1.44723000	0.14783346
RBITS{7}	-0.00444235	0.00716710	-0.61983000	0.53537295
RBITS{8}	0.00670428	0.00734353	0.91295000	0.36126829
Constant	0.00027503	0.00011774	2.33590000	0.01949632
Model(RDAX)				
RSPX{1}	0.26764655	0.02047761	13.07020000	0.00000000
RSPX{2}	0.07305894	0.02205105	3.31317000	0.00092244
RSPX{3}	-0.00148393	0.02198931	-0.06748000	0.94619614
RSPX{4}	-0.02922401	0.02187186	-1.33615000	0.18150141
RSPX{5}	0.01718996	0.02171670	0.79155000	0.42862026
RSPX{6}	-0.04104650	0.02080550	-1.97287000	0.04851061
RSPX{7}	0.02039352	0.02192820	0.93001000	0.35236419
RSPX{8}	0.02788644	0.02179375	1.27956000	0.20069952
RFTSE{1}	-0.09098486	0.02463890	-3.69273000	0.00022186
RFTSE{2}	-0.06788255	0.02284358	-2.97162000	0.00296229
RFTSE{3}	0.04020564	0.02476139	1.62372000	0.10443493
RFTSE{4}	0.01264293	0.02050952	0.61644000	0.53760287
RFTSE{5}	-0.02222159	0.02240450	-0.99184000	0.32127763
RFTSE{6}	-0.04966746	0.02554113	-1.94461000	0.05182232
RFTSE{7}	0.03643354	0.02213066	1.64629000	0.09970362
RFTSE{8}	0.04860736	0.02385668	2.03747000	0.04160259
RDAX{1}	-0.08511655	0.02023896	-4.20558000	0.00002604
RDAX{2}	-0.01329094	0.01944484	-0.68352000	0.49427834
RDAX{3}	-0.05225642	0.02170052	-2.40807000	0.01603699
RDAX{4}	-0.00369326	0.01692173	-0.21826000	0.82723002
RDAX{5}	0.01319297	0.01986753	0.66405000	0.50666036
RDAX{6}	0.07376533	0.01981659	3.72240000	0.00019734
RDAX{7}	-0.04344955	0.01825021	-2.38077000	0.01727652

RDAX{8}	-0.03976750	0.02100795	-1.89297000	0.05836136
RBITS{1}	-0.00057895	0.00951492	-0.06085000	0.95148121
RBITS{2}	-0.00613518	0.00928519	-0.66075000	0.50877342
RBITS{3}	-0.00420939	0.00874567	-0.48131000	0.63029562
RBITS{4}	-0.02398250	0.00896848	-2.67409000	0.00749330
RBITS{5}	-0.00990868	0.00896170	-1.10567000	0.26886952
RBITS{6}	0.00368263	0.00870763	0.42292000	0.67235317
RBITS{7}	-0.00740683	0.00885192	-0.83675000	0.40273363
RBITS{8}	0.02825570	0.00881921	3.20388000	0.00135588
Constant	0.00066994	0.00014761	4.53849000	0.00000567
Model(RBITS)				
RSPX{1}	0.13339057	0.02807115	4.75187000	0.00000202
RSPX{2}	0.02074811	0.02870908	0.72270000	0.46986293
RSPX{3}	0.06599691	0.02892359	2.28177000	0.02250308
RSPX{4}	0.03105175	0.02937754	1.05699000	0.29051636
RSPX{5}	0.08118641	0.02864458	2.83427000	0.00459308
RSPX{6}	0.00976758	0.02977964	0.32800000	0.74291540
RSPX{7}	0.04137063	0.02935018	1.40955000	0.15867175
RSPX{8}	-0.01758585	0.02880234	-0.61057000	0.54148424
RFTSE{1}	0.05638043	0.03456346	1.63121000	0.10284500
RFTSE{2}	-0.01882438	0.03342210	-0.56323000	0.57327733
RFTSE{3}	0.02064546	0.03223820	0.64040000	0.52191013
RFTSE{4}	-0.07048922	0.03372815	-2.08992000	0.03662477
RFTSE{5}	0.06628877	0.03394134	1.95304000	0.05081495
RFTSE{6}	0.01821349	0.03533306	0.51548000	0.60621757
RFTSE{7}	0.05090091	0.03291042	1.54665000	0.12194758
RFTSE{8}	0.11418421	0.03451588	3.30816000	0.00093910
RDAX{1}	-0.05181180	0.02809835	-1.84394000	0.06519126
RDAX{2}	0.01824013	0.02620150	0.69615000	0.48633587
RDAX{3}	-0.05929380	0.02738074	-2.16553000	0.03034715
RDAX{4}	0.03432790	0.02671208	1.28511000	0.19875472

RDAX{5}	-0.07703246	0.02792923	-2.75813000	0.00581330
RDAX{6}	-0.02864437	0.02975326	-0.96273000	0.33568279
RDAX{7}	-0.05160501	0.02734250	-1.88736000	0.05911256
RDAX{8}	-0.05217064	0.02875595	-1.81426000	0.06963843
RBITS{1}	-0.02083570	0.01764457	-1.18086000	0.23765979
RBITS{2}	0.01123433	0.01756813	0.63947000	0.52251576
RBITS{3}	0.03540695	0.01736294	2.03923000	0.04142753
RBITS{4}	-0.01308407	0.01792304	-0.73001000	0.46538179
RBITS{5}	-0.01410765	0.01820552	-0.77491000	0.43839264
RBITS{6}	-0.01542091	0.01847182	-0.83483000	0.40381076
RBITS{7}	0.00088171	0.01851268	0.04763000	0.96201308
RBITS{8}	0.00096033	0.01846823	0.05200000	0.95852934
Constant	0.00115372	0.00026832	4.29977000	0.00001710

B. TURKISH SUMMARY / TÜRKE ÖZET

BORSA İSTANBUL ENDEKSİNİN GETİRİ HAREKETLERİNİN BAŞLICA BORSA ENDEKSLERİ İLE VAR-GARCH-BEKK MODELLERİ KULLANARAK ANALİZİ

Giriş ve Literatür Özeti

Ekonomilerin küresel ticaret ağları ve serbest sermaye akışı yoluyla bütünleşmesi, coğrafi konumların çeşitliliği ve ülke bazlı ekonomik farklılıklar belirgin özellikler taşısa da küresel piyasaların birlikte hareket etmesini teşvik etmektedir. Türkiye'de son yıllarda piyasa hareketleri çalkantılı olmuştur ve tarihsel olarak, hiperenflasyon, yüksek faiz oranları ve dolarizasyon Türk ekonomisinin yapışkan sorunları olmuştur. 2001 finansal krizinden sonra bu sorunlarla mücadele etmek için yapısal değişiklikler yapılmıştır. TCMB'nin özerkliğini sağlamak için Merkez Bankası kanununda değişiklikler yapılmış ve fiyat istikrarının korunması, reel ekonominin büyümesini, istihdamı ve kalkmayı desteklemek için Merkez Bankası'nın sorumlulukları olarak verilmiştir. 2003'ten 2018'e kadar süren bu istikrar döneminde, Türkiye piyasasının büyük ekonomiler ve finansal piyasalarla bağlarını güçlendiren bu gelişmeler, ortak hareketlerin incelenmesini daha önemli hale getirmiş ve önemli miktarda doğrudan yabancı yatırım ve sermaye girişi yaşanmasını sağlamıştır.

2021 sonrasında para politikaları, yüksek faiz oranlarının yüksek enflasyona neden olduğu ve bu nedenle yüksek enflasyon oranlarını düşürmek ve ekonomik kalkınmayı sağlamak için daha düşük faiz oranlarının kullanılması gerektiği iddiasıyla yönlendirilmiştir. Bu geleneksel olmayan iddia TCMB'nin özerkliğine ilişkin tartışmaları alevlendirmiş ve kredibilitesinde bir miktar bozulmaya yol açmıştır. Dolayısıyla bu durum, fiyat istikrarının para politikası için önceliğini kaybettiğini, büyüme ve istihdamı teşvik etmeye yönelik ikincil rolünün ön plana çıktığını göstermiştir. Ekonomik çalkantıların yaşandığı bu dönemde, Türkiye'deki piyasa

hareketlerinin niteliğinde ve büyük piyasalarla olan ortak hareketlerinin incelenmesi daha da önem kazanmıştır. Bu bağlamda, bu tezin amacı, geleneksel ve geleneksel olmayan politikalarla karakterize edilen bir dönemde Türkiye'deki finansal piyasaların dinamiklerinin nasıl ve ne ölçüde geliştiğini araştırmaktır.

Bu tez, finansal piyasa getirilerinin etkileşiminin yanı sıra Türkiye'nin finansal piyasa oynaklığının başlıca hisse senedi piyasalarının oynaklıkları ile birlikte hareketlerini analiz etmeyi amaçlamaktadır. Seçilen getirilerin etkileşimleri Vektör Otoregresif (VAR) Modelleri ile analiz edilmiştir. Ayrıca, seçilen oynaklıkların birlikte hareketleri Çok Değişkenli Genelleştirilmiş Otoregresif Değişen Varyans (MGARCH) modelleri ile incelenmiştir.

İlk bakışta hisse senedi piyasaları, her biri farklı coğrafyalarda farklı politikalar altında faaliyet gösteren çeşitli geçmişlere sahip şirketleri içeren bağımsız oluşumlar gibi gözükabilir. Ancak daha yakından incelendiğinde, ortak hareketlerin ve birbiriyle bağlantılı dalgalanmaların daha karmaşık bir dinamiği ortaya çıkmaktadır. Hisse senedi piyasasında "birlikte hareket" terimi, farklı hisse senedi piyasalarının birlikte hareket etme eğilimini tanımlar. Bu olgu, gelişmekte olan ve gelişmiş ekonomilerde farklı derecelerde görülmektedir. Hareketlerin piyasalar arasında aktarılmasında çeşitli unsurlar birlikte çalışmaktadır. Küreselleşme, sermayenin ülkeler arasında rahat bir şekilde hareket etmesini sağlayan ana etkidir. Bunun da ötesinde, teknolojik gelişmeler sayesinde bilgi artık neredeyse anında paylaşılabilen ve bu da piyasa duyarlılığının yayılmasını hızlandırmaktadır. Ayrıca, hisse senedi fiyatlarının ne kadar keskin dalgalandığının bir göstergesi olan volatilitiyi anlamak önemlidir çünkü piyasalar arasında bulaşıcıdır. Bir piyasadaki yüksek volatilitenin diğer bir piyasadaki krizi takip etmesi domino etkisi yaratabilir. ABD konut piyasasındaki çöküşün küresel çapta eşi benzeri görülmemiş düzeyde dalgalanmaya yol açtığı ünlü bir örnek 2008 Küresel Finansal Krizidir.

Hisse senedi piyasaları arasındaki ortak hareketlerin incelenmesi, finansal ekonomi alanındaki ufuk açıcı çalışmalarla başlar. İlk ve önemli çalışmalardan biri olan Grubel (1968) uluslararası portföy çeşitlendirmesi fikrini ortaya atmış ve farklı ulusal piyasalar arasında bir portföy oluşturarak riskin azaltılabileceğini öne sürmüştür. Bu, piyasa etkileşimlerinin incelenmesini teşvik etmiştir. Portföylerin uluslararası

çeşitlendirilmesi Solnik (1974) ve Lessard (1976) tarafından da araştırılmış ve yüksek piyasa oynaklığı dönemlerinin piyasa korelasyonlarını artırma eğiliminde olduğu gözlemlenmiştir. Bu önemli görüş, piyasalar arasında statik değil dinamik bir bağlantı olduğunu ortaya koymuştur. Küreselleşmenin yükselişiyle birlikte bu çalışmalarda yeni bir döneme girilmiştir. King, Sentana ve Wadhvani (1994), özellikle büyük ekonomilerde ortak hareketlerin ekonomi politikalarından nasıl etkilendiğini inceleyerek önemli katkılarda bulunmuştur. Çalışmaları, farklı çalışmalarda tekrarlanan bir bulgu olarak, küreselleşmenin bir sonucu olarak piyasaların karşılıklı bağımlılığının arttığını göstermiştir. Longin ve Solnik (1995) piyasalar arasındaki korelasyon yapılarındaki istikrarsızlığı incelemiştir. King (1994), Ramchand ve Susmel (1998) ve Morana ve Beltratti (2002) ve diğerleri korelasyon ve volatilité arasında pozitif bir ilişki olduğuna dair kanıtlar bulmuşlardır. Forbes ve Rigobon (2002), bir piyasadaki şokların teknoloji gelişmelerin etkisi ile diğer piyasalara yayıldığı 'bulaşma' etkisini vurgulamıştır.

Piyasalar arasındaki bu korelasyonlar gelişmiş ve gelişmekte olan piyasalarda farklı şekillerde ortaya çıkabilmektedir. AB içinde, portföy çeşitlendirmesine izin vermeyen bu ekonomik çerçevede, endeksler arasındaki yüksek korelasyonları gösteren çalışmalar vardır. Avrupa piyasalarında Cappiello, Gerard, Kadareja ve Manganelli, (2006) üye ülkeler ve AB'ye yeni katılan ülkeler arasındaki korelasyonu incelemiştir. Bu çalışmada coğrafyanın rolünü görmekteyiz. AB'deki büyük ekonomilere daha yakın olan Polonya gibi ülkeler katılımdan sonra daha fazla korelasyon gösterme eğilimindedir. Kıbrıs ve Slovenya gibi ülkeler ise daha düşük korelasyon yapıları göstermektedir. Öte yandan, Aslanidis ve Savva'nın (2010) daha sonraki bir çalışması, daha önce belirtildiği gibi bazı düşük korelasyonların arttığını göstermiştir. Genel olarak sonuçlar, korelasyonun AB ile birlikte artma eğiliminde olması nedeniyle portföy çeşitlendirmesinin cazip olmaktan çıktığını göstermektedir. Gelişmekte olan piyasaların küresel finansal sistemdeki rolü de son zamanlarda yazılan yazılara konu olmuştur. Bekaert, Hodrick ve Zhang (2009) küresel ekonomideki dalgalanmalar söz konusu olduğunda gelişmekte olan piyasaların nasıl önem kazanmaya başladığını incelemiştir. Bu, daha çeşitli bir küresel piyasa ortamını göstermektedir.

Türkiye piyasasının diğer piyasalarla olan ortak hareket ve volatilité ilişkilerine odaklanan çeşitli çalışmalar bulunmaktadır. Taştan, (2005) DCC-GARCH kullanarak Türkiye'yi Almanya, İngiltere, Fransa ve ABD ile ilişkili olarak incelemiş ve piyasalar arasında zaman içinde değişen koşullu korelasyonlar olduğunu ve Türkiye piyasasının 1990'dan 2004'e kadar daha fazla dalgalanma gösterdiğini ortaya koymuştur. Syriopoulos & Roumpis, (2009) iki değişkenli asimetric DCC-GARCH kullanarak 1998-2007 yılları arasında Balkan ülkeleri ile Türkiye'nin de dahil olduğu Almanya ve ABD'yi incelemiş ve güçlü ortak hareketlere rastlamamıştır. Birçok çalışma ABD hisse senedi piyasalarının diğer ülkeler üzerindeki etkisine işaret etmektedir. Bu bağlamda, Ergun ve Nor, (2010) AB'ye katılım durumunda Türkiye ve Amerika Birleşik Devletleri arasındaki volatilité yayılımını iki değişkenli koentegrasyon, ECM ve CGARCH kullanarak incelemişlerdir. Çalışmada 1999'dan 2008'e kadar olan dönem incelenmiş ve özellikle 2005 yılında AB ile resmi müzakerelerin başlamasından sonra NASDAQ'tan Borsa İstanbul'a korelasyon ve volatilité yayılımında bir değişiklik olup olmadığı araştırılmıştır. Çalışmalarının sonuçları, ülke bazı şoklardan etkilenen bağlantıların azalmadığı, alt dönemlerle tutarlı bir şekilde önemli oynaklık yayılımı olduğunu göstermiştir. Var, (2015) tarafından 2009-2014 yılları arasında Türkiye için ABD, Brezilya, Hindistan, Hong Kong, İngiltere, Japonya, Meksika ve Rusya hisse senedi piyasalarına kıyasla finansal bulaşıcılık incelenmiş ve ABD ve Almanya'dan gelebilecek olası şokların Borsa İstanbul üzerinde bir dereceye kadar etkisi olduğu bulunmuştur. Nazlıođlu & Kök, (2021) de gelişmiş, gelişmekte olan ve Türkiye piyasaları arasındaki finansal bulaşıcılığı koentegrasyon ve nedensellik analizleri kullanarak incelemiştir. Graham, Kiviaho & Omran (2012), Türkiye ve ABD'nin de dahil olduğu MENA bölgesindeki ortak hareketleri dalgacık karesel tutarlılık (*wavelet squared coherency*) kullanarak incelemiştir. Öztekin, (2013) 1997-2010 yılları arasında Türkiye'nin portföy çeşitlendirme potansiyelini değerlendirmek için Türkiye, ABD, İngiltere, Fransa ve Almanya arasındaki koşullu korelasyonların dinamik ilişkilerini STCC-GARCH ve DSTCC-GARCH ile incelemiştir. Bu çalışmada, DAX ve BIST 100 arasındaki koşullu korelasyon 0,8 gibi yüksek bir değerle gelişmiş piyasalar arasındaki koşullu korelasyonlara benzerlik göstermiştir. Sonuçlar, özellikle kriz dönemlerinde koşullu korelasyonların 0,8'e kadar çıkabildiği FTSE ve BIST 100 için de benzer sonuçlara işaret etmektedir. S&P 500 ve BIST 100 arasındaki koşullu korelasyon için ortalama seviyeler, 0,5 civarında olan

FTSE 100 ve DAX 40'a kıyasla nispeten daha düşüktür. Tüm bu sonuçlar, portföy çeşitlendirmesi için Türkiye'nin özellikle Avrupa piyasalarına kıyasla en iyi alternatif olmayabileceğini göstermiştir.

Bir önceki bölümde sunulduğu üzere, Borsa İstanbul'un diğer piyasalarla ortak hareketlerine ilişkin birçok çalışma bulunmaktadır. Ancak son yıllarda para politikasında bir değişim yaşanmıştır ve bunun bazı sonuçları vardır. 2000'li yılların başından itibaren Türkiye'nin para politikası, düşük enflasyona ulaşmayı ve bunu sürdürmeyi amaçlayan enflasyon hedeflemesi hedefine dayanmaktadır (Kara, 2012). Ancak, yüksek faiz oranlarının yüksek enflasyona neden olduğu ve bu nedenle dezenflasyon için faiz oranlarının düşürülmesi gerektiği inancı son yılların hikayesi olmuştur (Gürkaynak, Kısacıkoğlu ve Lee, 2023). Yatırım kararlarının kritik bir belirleyicisi olarak faiz oranları çok önemli bir rol oynamaktadır. Faiz oranının hisse senedi fiyatları üzerindeki negatif etkisi Aspren (1989), Geske & Roll (1983), Jaffe & Mandelker (1976) ve Wei (2009) tarafından incelenmiştir. Mouna & Anis'in (2016) analizi, çoğu ülkede döviz kuru, faiz oranları ve hisse senedi getirisi arasında nedensel bir ilişki olduğunu göstermektedir. Dolayısıyla, bu tezin önemli katkılarından biri, Borsa İstanbul'un başlıca endekslerle olan ilişkisinin son yılları kapsayacak şekilde analiz edilmesidir.

1960'ların başında Mandelbrot (1963) ve Fama'nın (1965) çalışmaları, finansal zaman serilerindeki belirsizliğin zaman içinde değişen varyansların bir fonksiyonu olarak tanımlanmasında önemli bir rol oynamıştır. Fama'nın (1965) çalışmasında bu tür serilerde volatilité ve leptokurtosisin yaygın kümelenmesinin varlığından bahsedilmiştir. Ayrıca, Black (1976) tarafından vurgulanan ve bir varlığın değerindeki düşüşün gelecekteki volatilité riskini artırması olarak tanımlanan kaldıraç etkisi Christie (1982) ve Bollerslev, Chou ve Kroner (1992) tarafından yapılan çalışmalarda detaylandırılmıştır. Granger & Andersen (1978) bilineer modeli oluşturmuştur. Bu model, koşullu varyansın serinin önceki gözlemlerine bağlı olmasına izin vermiştir.

Engle (1982) tarafından önerilen Otoregresif Koşullu Değişen Varyans (ARCH) modeli, dinamikleri anlamak için gecikmeli bozuklukları kullanmıştır. Bu ARCH modelinde, varyansın zaman içinde salınımına izin verilen serilerin varyansını

modellemek için gecikmeli hatalar (*lagged errors*) kullanılmıştır. Bu nedenle, koşullu varyans geçmiş karesel hataları (*squared errors*) içeren bir fonksiyon ile karakterize edilmiştir. Pozitif ve negatif şoklardan kaynaklanan volatilitenin asimetrisi modellenemez ve bu durum finansal zaman serilerinin önemli bir yönüdür çünkü hisse senetleri negatif ve pozitif şoklara farklı şekilde tepki verebilir. Bollerslev (1986) modelin zayıflıklarıyla başa çıkmak için ARCH'ın genişletilmiş versiyonu olan Genelleştirilmiş Otoresif Koşullu Heteroskedastisite (GARCH) modelini önermiştir. Ancak, GARCH'ın bu versiyonu, volatilitenin kümelenmesi ve leptokurtosis ile başa çıkmasına rağmen kaldıraç etkileri olarak adlandırılan asimetrik etkilerle başa çıkamıyordu. Bu sorun, modellerin asimetrik artıklara (*residuals*) uygun hale getirilmesiyle aşılmış ve asimetrik GARCH modellerinin yeni versiyonları önerilmiştir. Böylece, GARCH modellerinin uzantıları finansal zaman serisi analizlerinde incelenmiştir. King ve Wadwani (1990) İngiltere, ABD ve Japonya piyasalarını inceleyerek bulaşıcılığı araştırmışlardır. Karolyi ve Stulz'un (1996) araştırması, örnek piyasalarındaki nispeten daha büyük şokların piyasalar arasındaki korelasyonların kalıcılığı üzerinde etkili olduğunu göstermiştir. Literatürde koşullu korelasyonları ele alan çeşitli çalışmalar yapılmıştır. VEC-GARCH, BEKK-GARCH, CCC-GARCH, DCC-GARCH, STCC-GARCH DSTCC-GARCH gibi çeşitli modeller geliştirilmiş ve kullanılmıştır.

Engle ve Kroner (1995), koşullu varyans-kovaryans yapısında pozitif tanımlılığı sağlayan BEKK (Baba-Engle-Kraft-Kroner) spesifikasyonlu GARCH modelini önermiştir. Bir dezavantaj olarak, BEKK-GARCH modeli, çıkarımı ağırlaştırarak çok sayıda parametreye sahiptir. Bu sorunu hafifletmek için diyagonal ve skaler BEKK model kısıtlamaları uygulanabilir Pedersen & Rahbek (2012). BEKK-GARCH modeli genellikle finansal piyasalar arasındaki volatilitenin transferini incelemek için kullanılmıştır. Kearney & Patton (2000) döviz kurlarındaki oynaklığın transferini incelemiştir. Li (2007) Hong Kong piyasasından Çin anakarasına volatilitenin transferini incelemek için BEKK-GARCH modelini kullanmıştır. Saleem (2007) Rusya'da yaşanan finansal krizin çeşitli piyasalar üzerindeki etkilerini incelemiştir. Bu nedenle, BEKK-GARCH modeli oynaklığın bir hisse senedi piyasasından diğerine transferini incelemek için öne çıkmaktadır.

Yöntem

Kapsama alınan veri seti BIST endeksi ile ABD'nin S&P 500, Almanya'nın DAX 40, İngiltere'nin FTSE 100 gibi dört hisse senedi endeksinden oluşmaktadır. Analiz için Ocak 2013'ten Aralık 2023'e kadar günlük kapanış fiyatları kullanılmıştır. Tüm endeks verileri Matriks Platform'dan alınmıştır. Endeksler, kendi para birimleriyle kullanılmıştır. Günlük kapanış fiyatları günlük getiri olarak log-farklarına dönüştürülmüştür.

Bu bölümde ilk olarak getiri oranlarının etkileşimlerinin Vektör Oto Regresyon Modelleri ile ampirik olarak modellenmesi sunulmuştur. Ayrıca, gecikme (*lag*) seçimi için bilgi kriterleri, VAR modelinin kararlılığı ve endekslerin getiri oranlarının dürtü tepkileri (*impulse responses*) incelenmiştir. Daha sonra, MGARCH modelleri ve VAR-MGARCH-BEKK modeli ile getiri oranlarının oynaklıklarının birlikte hareketleri sunulmuştur. Son olarak endeksler arasındaki koşullu korelasyonlar incelenmiştir. "Schwarz Bilgi Kriteri (SBIC) ile optimal gecikme uzunluğu 1, Hannan-Quinn Bilgi Kriteri (HQIC) ile 2, Nihai Tahmin Hatası (FPE) ile 9 ve Akaike Bilgi Kriteri (AIC) ile de optimal gecikme uzunluğu 9'dur. Endekslerin getiri oranlarının VAR sisteminin tahmininde sekiz gecikme kullanılmıştır. Tüm özdeğerler birim çemberin içinde yer alır ve böylece VAR modeli kararlılık koşulunu sağlamaktadır

Çok değişkenli ARCH test istatistiği 7400,66'dır ve %1 anlamlılık düzeyinde ARCH etkilerinin yokluğu reddedilmektedir. Bu, VAR modelinin artıklarının zaman içinde değişen varyanslarının varlığına işaret etmektedir. Bu durum, ortalama model olarak 8 gecikmeli VAR modelini kullandığımızda, artıkların varyans denklemleri için GARCH modellerini kullanmamıza yol açmaktadır. Ortalama VAR modeli için 5 gecikmeli ARCH etkileri ve 5 gecikmeli GARCH etkileri ve GED dağılımı ile MGARCH-BEKK modelini seçiyoruz. VAR (8)- MAGARCH (5,5)-BEKK modelinin katsayıları, standart hataları ve t-testleri ile birlikte Ek A.1 ve A.2'de verilmiştir. VAR(8)-MAGARCH(5,5)-BEKK modelinin kalıntıları Çok Değişkenli Q Testinin gösterdiği gibi otokorelasyon göstermemektedir ve ayrıca Çok Değişkenli ARCH Testinin gösterdiği gibi zamanla değişen kalıntı varyansları sergilememektedir:

Bu nedenle, bu tez, Ocak 2013'ten Aralık 2023'e kadar S&P 500, FTSE 100 ve DAX 40 arasındaki finansal piyasa getirilerinin etkileşimini ve Türkiye'nin finansal piyasa volatilitesinin bu büyük borsaların volatiliteleri ile birlikte hareketlerini analiz etmiştir. Seçilen getirilerin etkileşimleri Vektör Otoregresif (VAR) Modelleri ile analiz edilmiştir. Seçilen oynaklıkların birlikte hareketleri Çok Değişkenli Genelleştirilmiş Otoregresif Değişen Varyans (MGARCH) modelleri ile araştırılmıştır. Ortalama VAR modeli için 5 gecikmeli ARCH etkisi ve 5 gecikmeli GARCH etkisi ile GED dağılımına sahip MGARCH-BEKK modeli seçilmiştir.

Bulgular ve Sonuç

Endekslerin grafik üzerinde incelenmesi, BIST 100 ve S&P 500'de daha güçlü görünen bir kazanç göstermektedir. Fama (1965) tarafından belirtildiği gibi finansal zaman serileri için tipik olan volatilitenin kümelenmesinin varlığı getirilerde de görülmektedir. Bunun dışında, benzer ölçeklerle BIST 100'ün diğer endekslere kıyasla yaygın bir şekilde daha büyük dalgalanmalar yaşadığını da iddia edebiliriz. Dolayısıyla grafik üzerinde yapılacak basit bir inceleme, aşırı getiri ve kayıpların Türkiye piyasasındaki dinamiklerin bir parçası olduğunu ortaya koymaktadır.

Ayrıca pandemi dönemi sonrasında İngiltere hariç çoğu piyasanın iyi performans gösterdiğini gözlemliyoruz. BIST 100, 2022 ortalarından sonra 5000 seviyelerinden 8000 seviyelerine önemli bir artışla öne çıkıyor. En büyük standart sapmayı BIST 100'de gözlemliyoruz. DAX 40 da S&P 500 ve FTSE 100'e kıyasla nispeten yüksek standart sapmaya sahip. BIST 100'de de daha yüksek bir varyans gözlemlenmektedir. Her bir getiri oranı serisi yüksek çarpıklık ve basıklık seviyeleri sergilemektedir. Bu nedenle, her bir serinin normalliği %1 anlamlılık düzeyinde reddedilmektedir. Shapiro-Wilk W testi sonuçları Tablo 2.3'te görülebilir. Z değerlerinin oldukça yüksek ve W değerlerinin 0,95'ten küçük olması normallikten önemli ölçüde sapma olduğunu göstermektedir. Sonuç olarak, seçilen endekslerin her bir için günlük getiri serilerinin normalliği reddedilmiştir. ABD, Birleşik Krallık ve Almanya'da dağılımdan daha fazla aykırı değer gözlemlenmektedir. Bu aykırı değerleri spesifik olarak incelediğimizde, hepsinin piyasalardaki pandemi dönemi aşırı hareketlerine denk geldiğini görüyoruz. Sonuç olarak, bu dönemi dışarıda bırakırsak, aşırı getirilere ve büyük miktarda aykırı

değerlere sahip olmak bu piyasaların özellikleri olmayabilir. Ayrıca, daha önce de belirttiğimiz gibi, Shapiro-Wilk Testi sonuçlarının 0,001'den küçük p-değerlerine sahip olması, tüm endeksler için verilerin normal dağılmadığını göstermektedir. Tablo 2.4, 2.5 ve 2.6'daki korelasyon matrisleri endeksler arasındaki korelasyonları her bir korelasyon için Pearson's r değeri ile göstermektedir. 2013'ten 2023'e ve özellikle 2021'den 2023'e kadar olan korelasyonları incelediğimizde, yabancı endeksler arasındaki korelasyonların genellikle daha yüksek olduğu görülmektedir. Örneklem büyüklüğü 2021-2023 için daha küçüktür ancak bu dönemde endeksler arasındaki tüm korelasyonlar 2013-2021 dönemine kıyasla daha küçüktür. Ayrıca, BIST'in S&P 500'e kıyasla FTSE 100 ve DAX 40 ile daha yüksek korelasyona sahip olduğu görülmektedir.

Etki tepki fonksiyonlarını incelediğimizde, tüm getiri oranlarının ABD'de S&P'deki bir dönemlik şoklara duyarlı olduğunu gözlemliyoruz. Öte yandan, S&P'nin getiri oranları diğer ülkelerin hisse senedi piyasalarındaki şoklara tepki vermemektedir. DAX'ın getiri oranları hem ABD hem de İngiltere piyasalarındaki şoklara tepki vermektedir. BIST'in getiri oranları ise diğer ülke borsalarındaki şoklardan ziyade kendi şoklarına duyarlıdır.

Etki tepki fonksiyonlarının analizleri, tüm getiri oranlarının endekslerdeki bir dönemlik şoklara duyarlı olduğunu göstermiştir. Amerikan endeksi S&P'nin getiri oranları diğer ülkelerin hisse senedi piyasalarındaki şoklara tepki vermemektedir. DAX'ın getiri oranları ise hem ABD hem de İngiltere piyasalarındaki şoklara tepki vermektedir. BIST'in getiri oranları incelendiğinde, diğer ülke borsalarındaki şoklardan ziyade kendi şoklarına duyarlı olduğu görülmektedir.

Endeksler arasındaki koşullu korelasyonlar incelendiğinde, Avrupa piyasalarından FTSE 100, DAX 40 ve BIST 100'ün görece yüksek koşullu korelasyona sahip olduğu görülmektedir. Özellikle DAX 40 ile BIST 100 arasındaki korelasyon güçlüdür. Bu Avrupa endeksleri aynı zamanda sıfırdan farklı korelasyonlara sahiptir, bu da daha yakın ekonomik ortamda daha benzer hareketlere işaret etmektedir. Öte yandan, tüm endeksler S&P 500 ile negatif koşullu korelasyon dönemlerine sahiptir. Bu durum son döneme özgü olmamakla birlikte özellikle 2021 sonrasında sıkça negatif sonuçlar

görmekteyiz. Ayrıca 2021 sonrasında BIST 100 ile İngiltere ve Almanya'nın diğer iki endeksinin S&P 500 ile negatif olduğu dönemler dışında daha düşük pozitif korelasyona sahip olduğu görülüyor. DAX 40 ve FTSE 100'ün korelasyonlarında BIST 100'e göre bir değişiklik görmüyoruz.

Sonuç olarak, para politikası ve makroekonomik değişim dönemlerini içeren analiz, BIST 100 endeksinin diğer ülke borsalarındaki şoklara karşı diğer endeksler kadar duyarlı olmadığını ortaya koymaktadır. Sonuçlar BIST'in kendi şoklarına duyarlı olduğunu göstermiştir. Ayrıca, Türkiye piyasası Almanya ve Birleşik Krallık ile olan yüksek koşullu korelasyonunu korumaktadır. Öztekin (2013)'in sonuçlarına benzer şekilde, BIST 100, DAX 40 ve FTSE 100 arasındaki koşullu korelasyonlar yüksektir. Bu koşullu korelasyon, son yıllarda BIST'i S&P ile karşılaştırdığımızda daha küçük ve daha sıklıkla negatif görünmektedir. Ancak bu ayrışma DAX ve FTSE için de geçerlidir. Dolayısıyla, Avrupa piyasaları ile yüksek korelasyona sahip olan Türkiye piyasasının benzer dinamikler gösterdiği ve Avrupa piyasalarından ayrılmadığı sonucuna varabiliriz.

C.THESIS PERMISSION FORM / TEZ İZİN FORMU

ENSTİTÜ / INSTITUTE

- Fen Bilimleri Enstitüsü / Graduate School of Natural and Applied Sciences**
- Sosyal Bilimler Enstitüsü / Graduate School of Social Sciences**
- Uygulamalı Matematik Enstitüsü / Graduate School of Applied Mathematics**
- Enformatik Enstitüsü / Graduate School of Informatics**
- Deniz Bilimleri Enstitüsü / Graduate School of Marine Sciences**

YAZARIN / AUTHOR

Soyadı / Surname : Esen
Adı / Name : Cenk Buğra
Bölümü / Department : İktisat / Economics

TEZİN ADI / TITLE OF THE THESIS (İngilizce / English): ANALYSES OF BORSA ISTANBUL INDEX RETURN CO-MOVEMENTS WITH MAJOR STOCK MARKET INDICES USING VAR-GARCH-BEKK MODELS

TEZİN TÜRÜ / DEGREE: **Yüksek Lisans / Master** **Doktora / PhD**

- 1. Tezin tamamı dünya çapında erişime açılacaktır. / Release the entire work immediately for access worldwide.**
- 2. Tez iki yıl süreyle erişime kapalı olacaktır. / Secure the entire work for patent and/or proprietary purposes for a period of two years. ***
- 3. Tez altı ay süreyle erişime kapalı olacaktır. / Secure the entire work for period of six months. ***

** Enstitü Yönetim Kurulu kararının basılı kopyası teze birlikte kütüphaneye teslim edilecektir. / A copy of the decision of the Institute Administrative Committee will be delivered to the library together with the printed thesis.*

Yazarın imzası / Signature **Tarih / Date**

*(Kütüphaneye teslim ettiğiniz tarih. Elle doldurulacaktır.)
(Library submission date. Please fill out by hand.)*

Tezin son sayfasıdır. / This is the last page of the thesis/dissertation.