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Volatility and International Interactions in Financial Markets: An Analysis of the Turkish Stock Exchange and G7 Countries

Finansal Piyasalarda Volatilite ve Uluslararası Etkileşimler: Türkiye Borsası ve G7 Ülkeleri Üzerine Bir Analiz

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ABSTRACT

Using mean and variance causality analysis, this study examines the volatility relationship between Turkish and G7 stock markets. Weekly return data from May 29, 2009, to June 6, 2023, is utilized for the analysis. The Hong mean and variance causality analysis method is employed as the methodology. Based on the results of the study, Turkey and Japan's stock markets have a significant mean causality relationship. Moreover, the variance causality analysis demonstrates a strong relationship between Turkey and stock markets of Canada, France, Germany, Japan, and the United States. The findings contribute to portfolio diversification strategies and highlight the importance of understanding the dynamics of international financial markets.

JEL Codes: C58, F30, G15, O16

Keywords: Hong Causality, Mean and Variance Causality, Stock Exchange, G7 Countries, BIST

ÖZ

Ortalama ve varyans nedensellik analizini kullanan bu çalışma, Türkiye ve G7 hisse senedi piyasaları arasındaki oynaklık ilişkisini incelemektedir. Analiz için 29 Mayıs 2009 ile 6 Haziran 2023 arasındaki haftalık getiri verileri kullanılmıştır. Metodoloji olarak Hong ortalama ve varyans nedensellik analizi yöntemi kullanılmıştır. Çalışmanın sonuçlarına göre, Türkiye ve Japonya hisse senedi piyasalarında anlamlı bir ortalama nedensellik ilişkisi bulunmaktadır. Ayrıca varyans nedensellik analizi Türkiye ile Kanada, Fransa, Almanya, Japonya ve ABD borsaları arasında güçlü bir ilişki olduğunu ortaya koymaktadır. Bulgular portföy çeşitlendirme stratejilerine katkıda bulunuyor ve uluslararası finansal piyasaların dinamiklerini anlamanın önemini vurguluyor.

JEL Kodları: C58, F30, G15, O16

Anahtar Kelimeler: Hong Nedensellik, Ortalama ve Varyans Nedensellik, Borsa, G7 Ülkeleri, BIST

Introduction

Portfolio diversification is a fundamental aspect of risk management in financial investments. Harry Markowitz's seminal work, "Portfolio Selection" published in 1952, emphasized the incorporation of risk factors in diversifying portfolios. Markowitz highlighted the significance of considering not only the expected returns but also the associated risks. This entailed considering the variance of securities to be included in the portfolio and the covariance among these securities. Markowitz advocated for the selection of portfolios offering maximum returns when comparing two investments with equal risk levels. Conversely, when comparing two portfolios with equal return levels, the portfolio with minimum risk should be preferred.

For investors, understanding the risks associated with their investments is of paramount importance. Portfolio diversification is commonly employed as a risk mitigation strategy, with a focus on international markets to reduce systematic risk. However, international portfolio diversification necessitates caution due to the effects of globalization. The interconnectedness of capital markets means that fluctuations in one country's stock market can influence the stock markets of other nations. Notably, extraordinary events in international markets can have ripple effects on domestic stock markets.

Investors who want to invest internationally; It wants to reduce systematic risk through diversification by investing in stock markets of different countries. Diversifying the stocks in a portfolio basket with stocks from different countries and allowing these stocks to move independently of each other can help protect against risk. Considering the globalization factor, it is seen that the interrelationships of financial markets limit international diversity. Considering this situation, determining the long-term relationships between stock markets of different countries is very important for investors to diversify their portfolio. The most important point to consider when diversifying is the relationship between the stock exchanges where diversified investment instruments are located. If there is a long-term relationship between stock markets, diversification will not help. Similarly, the risk in one exchange will also be valid in the other exchange. We can compare this situation to putting eggs from different baskets into one big basket. The purpose of portfolio diversification is; is to minimize risk and maximize profit. This is possible in stock markets that do not move for a long time.

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Diversifying portfolios across international capital markets generally leads to lower risk compared to diversification within national capital markets. Nevertheless, the factors influencing risk may vary across countries, attributable to security types, exchange rate risks, political risks, and information risks. Particularly, risk is believed to propagate from developed to emerging markets. Consequently, investors should vigilantly monitor the integration among stock exchanges to minimize risk exposure.

Measuring volatility in financial markets is crucial for comprehending price fluctuations of financial assets and assessing associated risks. Volatility measures play a significant role in the decision-making processes of portfolio managers and investors. Furthermore, analyzing relationships among different markets holds great importance for devising effective portfolio diversification and risk management strategies. These analyses provide valuable insights to investors, aiding in risk management, optimizing return potential, and minimizing potential losses.

Risk optimization comes to the fore by diversifying the risk by distributing the investor's limited savings to various financial assets. While investing in a single financial investment instrument increases the risk, the risk will decrease if the risk is diversified. Accordingly, the rate of return to be obtained will also increase (Bayramoğlu and Başkar, 2019:202). Therefore, in the study, the volatility between Turkey and G7 countries will be determined and it will be beneficial to determine the risk and uncertainty in a market and to diversify in the light of the information obtained about that market. It will help both individual investors and portfolio managers to diversify their portfolio.

Interactions in international capital markets are indicative of the global nature of financial markets. Globalization, accompanied by heightened capital mobility and accelerated information flows, has resulted in deeper financial relationships between countries. Consequently, developments in one country's stock market can reverberate across other countries' stock markets, leading to global risk propagation and increased market volatility. Hence, analyzing volatility across various country stock markets assumes great significance in the context of international portfolio diversification strategies.

This study analyzes the interaction between the Turkish Stock Exchange and stock exchanges of G7 countries. The analysis aims to comprehend both mean-level relationships and assess the variance in price fluctuations and associated risks. The findings from these analyses empower investors with a better understanding of opportunities and risks in global financial markets, enabling informed decision-making processes.

In this context, the introduction of the study emphasizes the importance of volatility and international interactions in financial markets and states the purpose of this study. Then, the contribution of the study to the literature is indicated by referring to the related literature. The data set and the methods used are introduced and the analysis process is explained. Finally, the findings and implications based on the analysis results are presented in the conclusion section. This study supports investors to understand the risks in international markets and manage their portfolios effectively.

Literature Review

Due to the substantial volatility observed in financial markets during the preceding three decades, alongside their extensive exploitation for speculative gains, a notable inclination has emerged towards prognosticating the trajectory of such markets. Consequently, a multitude of investigations have been undertaken with the objective of comprehending and representing the volatility inherent within financial markets. A subset of these scholarly investigations is displayed in Table 1.

Table 1: *Literature Review*

Authors	Variables / Countries	Method	Period	Conclusion
(Kasa, 1992)	USA, Japan, UK, Germany, Canada	Johansen cointegration	1974-1990 Monthly and Quarterly Data	He concluded that there is a long-run cointegration relationship among the countries included in the study.
(Gilmore & McManus, 2002)	USA, Czech Republic, Hungary and Poland	Johansen Cointegration, Granger Causality	01.07.1995 01.08.2001 Weekly Data	They conclude that portfolio diversification is appropriate due to the low correlation and the absence of long- term causality among the countries considered.
(Tahai, et al., 2004)	G7	Johansen Cointegration	1978-1997 Monthly Data	They concluded that all variables in the study are cointegrated in the long run.
(Maneschiöld, 2005)	S&P 500 and National 100, Egypt Cairo	Johansen cointegration test	09.08.1999 18.03.2005 Daily Data	As a result of the analysis applied to the industrial, Financial and service sectors, the study concluded that although the industrial sectors are co-integrated, the financial and service sector indices are not co-integrated in the long run.
(Marashdeh, 2005)	MENA countries USA, UK and Germany	ARDL Border Test	December 1994-June 2004	In the study, it has been determined that MENA countries have a long-term relationship with each other. However, it has been determined that 3 countries other than Egypt do not have any relationship with the USA, England and Germany.
(Liu & Pan, 1997)	USA, Japan and Hong Kong, Singapore, Taiwan, Thailand	GARCH	03.01.1984 31.12.1991 Daily Data	They conclude that the US affects Asian countries more than Japan in terms of both returns and volatility.
(Bhar & Nikolova, 2007)	BRIC	GARCH-M	1995-2004	In the study, they investigated the relationship between BRIC countries. As a result, they found that there is a high degree of volatility spillover effect among BRIC countries.
(Chittedi, 2009)	BRIC with the United States, England, Japan	Granger causality and cointegration	January 1998- August 2009 Daily Data	The study finds that BRIC economies and developed countries are highly co- integrated.
(Chang & Tzeng, 2009)	With the United States Canada, Japan, Germany and	Bierons Cointegration	2000-2008 Daily Data	They concluded that there is no bilateral co-integration between the US and the stock markets of the other three countries except Mexico.
(An & Brown, 2010)	USA, Brazil, Russia, India and China (BRIC Countries)	Johansen Cointegration	1995-2009 Weekly And Monthly Data	They concluded that there is a significant co-integration between the US stock market and the Chinese stock market, while there is no significant relationship with the Brazilian, Russian and Indian
(Yonis, 2011)	USA and South Africa	GARCH	2005-2011 Daily Data	The study reveals that there is a unidirectional volatility in both returns and volatility from the US market to the South African market.

Table 1 Cont.: *Literature Review*

Authors	Variables / Countries	Method	Period	Conclusion
(Menezes, et al., 2012)	G7	Johansen Co- integration, Granger Causality	1973-1979 Daily Data	The results of the study show that all seven countries are closely related in terms of prices and returns.
(Yildiz &Aksoy, 2014)	BIST, MSCI	Granger cointegration	1990-2011 Monthly Data	They concluded that MSCI and BIST are cointegrated both in the long run and in the short run.
(Dasgupta, 2013)	USA and BRIC	Cointegration and Granger causality	01.01.1998 31.12.2012 Daily Data	The results of the study, it has been determined that there is a short- and long-term cointegration relationship between the stock markets of India and Brazil. He also concluded that the Indian stock market has a strong effect on the Brazilian and Russian stock markets.
(Li & Giles, 2015)	US-Japan and China, India, ndonesia, Malaysia, the Philippines and Thailand	MGARCH	01.01.1993 31.12.2012 Daily Data	They conclude that there is unidirectional volatility from the US to both Japan and emerging Asian stock markets and that there is a mutual volatility spillover between the US and Asian markets.
(Zhang & Jaffry, 2015)	China and Hong Kong	BEKK-GARCH	2002-2013 Daily Data	The results of the study; It was carried out by considering the pre-crisis and post-crisis period. They concluded that there was no volatility before the crisis and there was a bidirectional volatility after the crisis.
(Yağlı, 2016)	With the United States BRIC and South Africa, BIST fundamental	Johansen cointegration	January 2001- December 2016 Weekly Data	As a result of the study, the US is not cointegrated with the six emerging economies included in the study.
(Polat & Gemici, 2017)	Turkey, BRIC and South Africa	ARDL bounds test, EKK	2003-2017 Monthly Data	In the long run, Turkey is cointegrated with India and Brazil and in the short run with Russia. However, they concluded that China and South Africa are not cointegrated in the short and long run.
(Kula & Baykut, 2017)	Turkey Russia Brazil, India, China Mexico	ARCH, GARCH, TGARCH, EGARCH	30.05.2001 31.12.2016 Daily Data	As a result of the study, China has the highest volatility in the long run, while Mexico has the lowest volatility. When the indices are analyzed on a daily basis, the stock market with the highest volatility is Turkey and the stock market with the lowest volatility is Russia.
(Özşahin, 2017)	Turkey, BRICS	Maki multiple structural break cointegration method	2000-2016 Montly Data	The study concluded that there is no simultaneous relationship between Turkey and Brazil. However, it has been determined that Turkey acts simultaneously with the other 4 country groups in the long term.
(Kanat & Öget, 2018)	Bitcoin, Turkey and G7 Countries	Engle-Granger Causality Johansen and Jeselius (1992)	01.01.2013 26.01.2018 Daily Data	In the study, they concluded that Bitcoin and the stock exchanges of G7 countries can be used for portfolio diversification.
(Başar & Bozma 2018)	Turkey, Romania, Poland, Hungary and Ukraine	M-GARCH-BEKK	2011-2016 Daily Data	In the study, they determined that the conditional variance of BIST-100 was affected by long-term fluctuations in the Romanian stock market. They found that the Hungarian and Polish stock markets were affected by both long-term volatility and short-term shocks.
(Gültekin & Çekiç, 2019)	Turkey ile BRICS	MF-X-DMA	3 February 2012-1 June 2018 Daily Data	As a result of the study, it was determined that a shock occurring in one of the BRICS countries would have a long-term impact on Turkey.
(Eyüboğlu & Eyüboğlu, 2019)	BIST, Dow Jones, Dax, CAC	Engle Granger cointegration, Granger causality	2010-2018 Daily Data	In the study, both cointegration and causality analyses did not reveal a relationship.
(Ulusoy, 2019)	Turkey and G7 Country Stock Exchanges	Johansen cointegration, Granger Causality	October 2009- September 2019	The study concludes that although there is a long-run relationship between Turkey and the UK, the other 6 countries do not have any long-run relationship both among themselves and with the Turkish stock market.
(Aladesanmi 2020)	UK and US stock market indices (FT-30 and Dow Jones-30)	Asymmetric GARCH-BEKK	01.07.1935 31.12.2020 Daily Data	Shocks and volatility interactions between the indices discussed in the study were investigated. It has been found that the interdependence between the markets of the two countries is stronger after the establishment of the European monetary union.
(Ayaydın, et al., 2020)	BIST 100, NASDAQ, S&P500, Dow Jones, FTSE100, DAX, S&P/TSX, FTSEMIB, Nikkei 225	Tado and Yamamoto and Fourier ADL cointegration analysis	2000-2018 Montly Data	While the study detected one-way causality from the Italian stock exchange to BIST100; Bidirectional causality was detected between the stock markets of Germany, France, England and the USA and BIST100. They detected a cointegration relationship between the US and German stock exchanges and BIST100.
(Münyas 2020)	BIST100, Dow Jones, Dax, FTSE Italia, CAC40, Ose Benchmark, S&p/ASX 200	Johansen Cointegration	09.01.2019- 05.06.2020 Daily Data	In the study, a long-term relationship was found between BIST100 and all other variables.
(Güçlü, 2020)	Both general and Islamic indices for Turkey, the US, the UK and Malaysia were used.	Hong Test for Causality in Mean and Variance	06.01.2011 28.02.2018 Daily Data	As a result of the analysis, no causality relationship was found between the Islamic stock markets of anycountry except Malaysia and conventional stock markets in both mean returns and variances.
(Ustalar & Şanlısoy, 2021)	Turkey and G7 Country Stock Exchanges	EGARCH	11.03.2020 15.012021 Daily Data	The study covers the Covid-19 period. During this period, Covid-19 increased the volatility in the equity markets of France, Japan, Canada and Turkey.
(Uçar & Alsu 2022)	BIST100, AEX , DAX, CAC 40, İBEX35, İtaly40,UK100	Hafner&Herwatz causality in variance, ARDL	2006-2021 Montly Data	The study concluded that there is a causal relationship from BIST100 to AEX and UK100, and from FCHI to BIST100. It also concluded that there is no long-term relationship between BIST100 and developed country indices.

Upon reviewing the relevant literature, it becomes clear that returns, volatility, and the relationship between securities markets have been examined at different time periods, regions, and using different analytical methods. It is noteworthy that studies have employed cointegration and Granger (causality in mean) analysis, as well as models from the GARCH family, to conduct their analyses. In our knowledge, no study has examined the mean and variance of the relationship between the Turkish and G7 securities markets. In this context, it is believed that this study will contribute to the existing literature by providing insights into this unexplored area.

Data Set and Methodology

In this study, we focus on weekly closing price series of Turkey and G7 country stock exchanges for the period from May 29, 2009, to May 6, 2023. The logarithmic return series of these series were calculated and utilized for the analysis. The following formula was employed to calculate the return series:

$$y_{i,t} = ln_{f1}\big(P-(i-t)\big) - ln_{f0}(p-(i,t-1) \quad (1)$$

Here, yi,t represents the returns of the exchanges on day t, and pi,t denotes the weekly closing prices on day t. Table 2 presents the description of the data used for the stock exchanges of Turkey and G7 countries in the study.

Table 2: *Definition of Variables*

Name of the Variable	Abbreviation of the Variable	Period	Source
Turkey	BIST100	29.05.2009 06.05.2023 Weekly Data	https://tr.investing.com/
Canada	S&P/TSX		
France	CAC40		
Germany	DAX		
Italy	FTSE		
Japan	NIKKEI225		
UK	FTSE100		
US	S&P500		

To test the causality of a time series, various analysis methods are available in the literature, considering the spread effect of volatility. Two commonly used tests are proposed by Cheung and Ng (1996) and Hong (2001). These studies are primarily based on estimating the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model. Subsequently, they involve calculating the cross-correlation function of standardized error terms and the squares of standardized error terms. While Cheung and Ng (1996) assign equal weights to all lagged values (similar to the Granger causality models) when computing the test statistic, Hong (2001) emphasizes giving more weight to lagged values. Therefore, this study applies the variance causality proposed by Hong (2001), an extension of Cheung and Ng (1996) that allows for greater flexibility.

Classical causality tests are believed to yield misleading results if the series have conditional heteroskedasticity, assuming the variances of the error terms to be constant. Hence, employing Hong's (2001) method to test variance causality is expected to provide more consistent results.

In Hong's (2001) framework, a univariate causality test is conducted, while for Granger causality, two stationary time series {yi,t , t=1, …., T}, i = 1, 2 are considered, where T represents the sample size. Therefore, Equation (2) is presented as follows:

$$E\{((y_{t+1}-\mu_{Y,t+1})^2|I_t)\} \neq \ E\{((y_{t+1}-\mu_{Y,t+1})^2|J_t)\} \quad (2)$$

In Equation (2), $\mu_{Y,t}$ represents the mean of Y_t. I_t and J_t represent the information sets defined as $I_t = \{Y_{t-j}; j \geq 0\}$ and $J_t = \{Y_{t-j}, X_{t-j}; j \geq 0\}$. The Equation (2) expresses the variance causality from X_t to Y_t. To conduct a variance causality test, the squares of standardized errors obtained from the univariate GARCH model need to be calculated. Thus, the squared standardized errors are given by Equation (3).

$$\left\{\frac{(Y_t-\mu_{Y,t})^2}{h_{Y,t}}\right\} v_t = \left\{\frac{(X_t-\mu_{X,t})^2}{h_{X,t}}\right\} \quad (3)$$

(Hong, 2001), causality in the variance between X_t and Y_t at a given number of lags (M) is determined using the test statistic in Equation (4):

$$= \left\{\frac{T\sum_{J=1}^{T-1} k^2\left(\frac{j}{M}\right) p_{uv}^2(j) - \ C_T(k)}{\sqrt{2D_t(k)}}\right\} \quad (4)$$

Equation (4) $p_{uv}^2(j)$ j, denotes the cross-correlations between u_t and v_t at lag j and T is the sample size. The calculation of sample cross-correlations and equation p_uv^2 is shown in Equation (5).

$$p_{uv}^2(j) = \left\{C_{uu}(0)C_{vv}(0)\right\}^{-1/2} \quad C_{uv}(j) \quad (5)$$

$C_{uu}(0)C_{vv}(0)$ are the sample variances of u_t and v_t, respectively. Their definition is presented in equation (6).

$$C_{uu}(0) = T^{-1}\sum_t^T = 1\ u_t^2 \quad ve\ C_{vv}(0) = \ T^{-1}\sum_t^T = 1\ v_t^2 \quad (6)$$

The sample cross covariance function between $C_{uv}(j)u_t\ and\ v_t$ is represented by Equation (7).

$$C_{uv}(j) = \begin{cases} T^{-1}\sum_{t=1+j}^{T} u_t v_{t-j}\,, & j \geq 0 \\ T^{-1}\sum_{t=1-j}^{T} u_t v_{t-j}\,, & j < 0 \end{cases} \quad (7)$$

The equations (8) and (9) respectively represent $C_T(k)$ and $D_T(k)$, which indicate the mean and variance. These equations provide the expressions for the respective quantities mentioned in equation (7).

$$C_T(k) = \sum_{j=1}^{T-1}\left(1-\frac{j}{T}\right)k^2(\frac{j}{M}) \quad (8)$$

$$D_T(k) = \sum_{j=1}^{T-1}\left(1-\frac{j}{T}\right)\left\{1-\frac{(j+1)}{T}\right\}k^4(\frac{j}{M})\Big\} \quad (9)$$

The test analysis proposed by Hong (2001) can be summarized as follows:

1. Firstly, the estimation of the univariate GARCH (p,q) model is performed, and the standardized errors of the two variables are determined.
2. The cross-correlation function of the standardized errors, puv(j), is calculated.
3. After determining the lag number M, the functions $C_{1T}(k)$ and $D_{1T}(k)$ are computed.
4. The test statistic Q is calculated and compared with the critical value at the chosen significance level. If the Q statistic is greater than the critical value, the null hypothesis is rejected, indicating no causality relationship.

Figure 1 presents the graphical representation of the return series for Turkey and G7 Stock Exchanges.

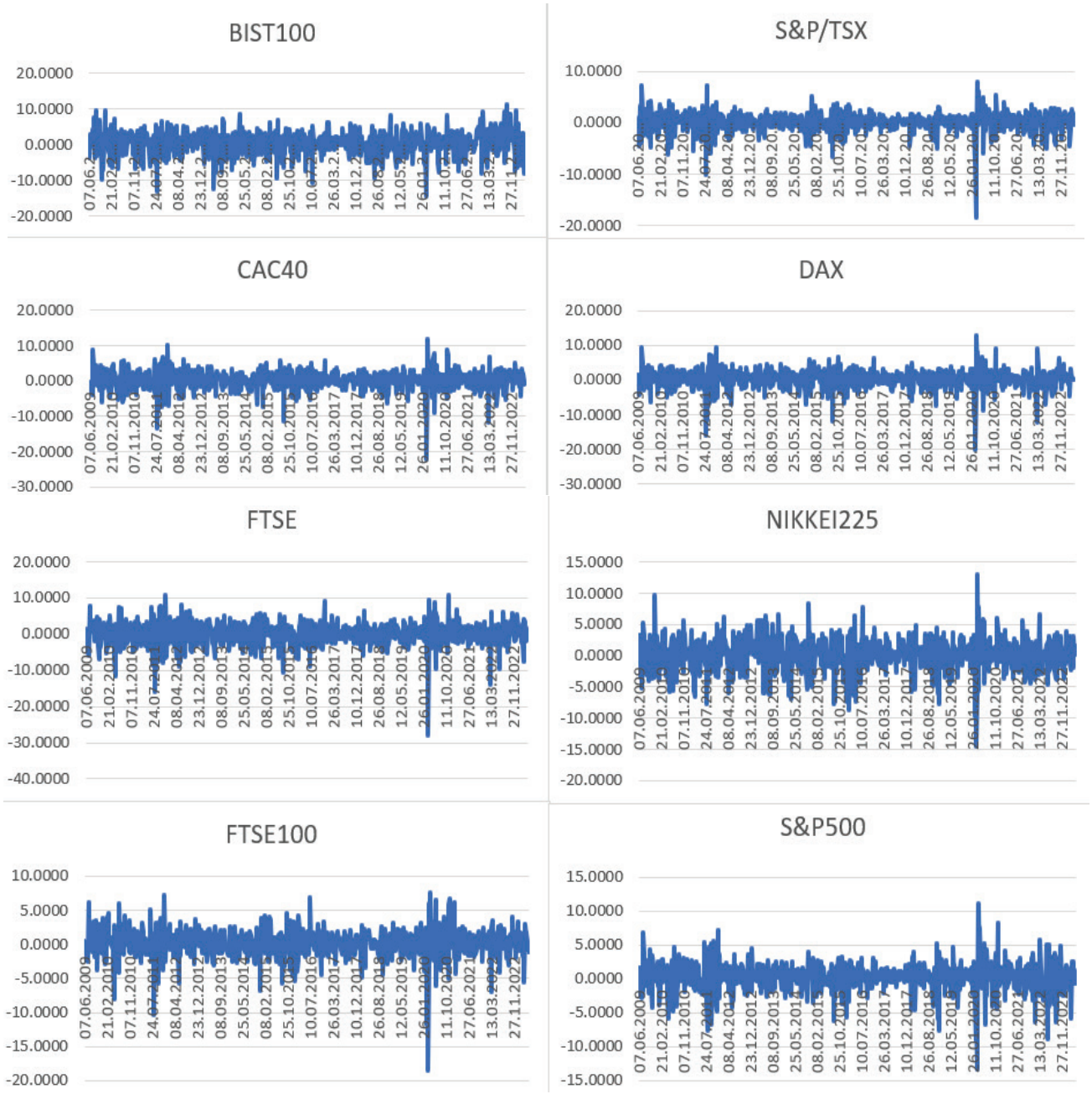

Figure 1: *Graph of Return Series for Turkey and G7 Countries*

Figure 1 displays the graphs illustrating the return series of the variables. Upon closer examination of the graphs, it can be observed that there are common periods characterized by significant volatility across the variables. Particularly, in 2020, it is evident that the volatility clusters resulting from the negative impact of the Covid-19 pandemic have both a shared and notably high magnitude across all countries. These findings indicate the presence of synchronized and pronounced volatility clustering among the countries during the period influenced by the global health crisis.

Analysis and Findings

In this section, descriptive statistics and correlation coefficients are presented to provide an overview of the variables. Subsequently, the findings related to the GARCH model and the Hong test are discussed.

The descriptive statistics offer insights into the characteristics of the variables, including measures such as mean, variance, and other summary statistics. These statistics help in understanding the central tendencies, dispersions, and distributions of the variables under consideration.

Table 3: *Descriptive Statistics of Return Series*

	BIST100	S&P/TSX	CAC40	DAX	FTSE	NIKKEI225	FTSE100	S&P500
Observation	727	727	727	727	727	727	727	727
Average	0.3461	0.0922	0.11006	0.1599	0.0439	0.1558	0.0779	0.2063
Median	0.6053	0.2327	0.2604	0.3213	0.3189	0.2963	0.2205	0.3116
Max.	11.1870	7.9618	11.9952	13.0459	10.9894	13.0690	7.5921	11.0747
Min.	-14.3866	-18.5173	-22.0412	-20.2725	-28.0533	-14.5644	-18.5921	-13.2460
Std Deviation	3.4482	2.0279	2.8851	2.9345	3.4083	2.7342	2.2040	2.2404
Skewness	-0.3965	-1.5222	-0.9402	-0.9622	-1.1114	-0.3272	-1.1908	-0.6315
Kurtosis	4.0223	1.4486	9.3591	9.0990	1.0164	5.1789	1.2046	7.1038
Jarque-Bera	50.7086 (0.0000)	4.2769 (0.0000)	1.3321 (0.0000)	1.2389 (0.0000)	1.7041 (0.0000)	1.5679 (0.0000)	2.6503 (0.0000)	5.5848 (0.0000)
ARCH(1)	8.877 (0.003)	66.06059 (0.000)	34.08122 (0.000)	38.76892 (0.000)	4.907600 (0.0271)	14.43471 (0.002)	2.3002 (0.1298)	101.4561 (0.000)
Q(25)	19.268 (0.155)	18.029 (0.387)	19.675 (0.661)	12.444 (0.963)	20.867 (0.589)	18.353 (0.627)	23.479 (0.074)	12.654 (0.856)
Qs(25)	34.468 (0.098)	115.88 (0.000)	112.09 (0.000)	172.97 (0.000)	34.475 (0.098)	163.91 (0.000)	107.08 (0.000)	267.89 (0.000)
ADF	-263.278 ***	-261.517 ***	-270.991 ***	-266.344 ***	-270.906 ***	-269.746 ***	-277.899 ***	-281.057 ***
PP	-263.288 ***	-268.014 ***	-275.835 ***	-269.817 ***	-273.360 ***	-270.630 ***	-285.892 ***	-293.121 ***

Note: ARCH (1) shows the LM test results for conditional variance, Q (25) and Qs (25) show the Ljung-Box autocorrelation test results for the series and the squares of the series. *** indicates stationarity at the 1% significance level, and parentheses indicate probability values used to reject H0.

Upon examining the Descriptive Statistics Table 3, it can be observed that during the period considered, the highest weekly return was obtained from BIST100 (0.3461) in Turkey, while the lowest weekly return was obtained from FTSE (0.0439) in Italy. Following BIST100, the next highest weekly returns were observed in S&P500 (0.2063), DAX (0.1599), NIKKEI225 (0.1558), and subsequently in France, Canada, and the UK.

The standard deviation represents the volatility of the series, and it can be noted that the highest volatility, with a value of 3.4482, is observed in BIST100. Furthermore, the negative skewness values for all the stock market series indicate that the distributions are left-skewed. The kurtosis values for Turkey, France, Germany, Japan, and the USA are greater than 3, indicating that these series exhibit fat-tailed characteristics. On the other hand, the kurtosis values for Canada, Italy, and the UK are less than 3, suggesting that these series have thin-tailed characteristics.

The Jarque-Bera test results indicate that the series do not follow a normal distribution. The ARCH test confirms the presence of conditional heteroskedasticity in the series, implying that the variance is not constant over time. The ADF and PP unit root tests indicate that the series are stationary at a 1% significance level. There is no evidence of autocorrelation issues in the series, and the presence of ARCH effects is detected at a 1% significance level.

The correlation coefficients examine the relationships between the variables and provide information about the strength and direction of their linear associations. These coefficients assist in identifying the interdependencies and potential linkages among the variables. Table 4 presents the correlation coefficients for the variables, providing insights into the relationships among them.

Table 4: *Correlation Coefficients between Returns of Variables*

	BIST100	S&P/TSX	CAC40	DAX	FTSE	NİKKEİ225	FTSE100	S&P500
BIST100	1							
S&P/TSX	0.3567***	1						
CAC40	0.4352***	0.7329***	1					
DAX	0.4189***	0.6981***	0.9256***	1				
FTSE	0.4243***	0.6487***	0.8959***	0.8519***	1			
NİKKEİ225	0.1989***	0.3922***	0.4967***	0.4899***	0.4435***	1		
FTSE100	0.4288***	0.71834***	0.7976***	0.7603***	0.7212***	0.4019***	1	
S&P500	0.3764***	0.7857***	0.7745***	0.7583***	0.6911***	0.4197***	0.7361***	1

Note: *** denotes significance at 1% significance level.

Upon examining the correlation coefficients between the returns of Turkey and G7 country stock markets, it is observed that there is a positive relationship among all variables. In this regard, it can be mentioned that the weakest relationship exists between Turkey and Japan. On the other hand, moderate to strong relationships can be observed among the other variables.

Following the presentation of descriptive statistics and correlation coefficients, the results pertaining to the GARCH model are discussed. The GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model is a widely used framework for modeling and forecasting financial time series, particularly for capturing volatility clustering and persistence. Table 5 presents the results of the ARMA-GARCH model.

Table 5: *ARMA-GARCH (1,1) Model Results*

	BIST100	S&P/TSX	CAC40	DAX	FTSE	NIKKEI225	FTSE100	S&P500
Mean Equation								
C	0.492726 (0.0001)	0.232718 (0.0000)	0.258129 (0.0000)	0.304916 (0.0000)	0.221778 (0.0395)	0.270770 (0.0021)	0.167368 (0.0000)	0.339157 (0.0000)
AR(1)	-0.306313 (0.0000)	-0.734487 (0.0006)	0.843842 (0.0000)	0.874803 (0.0000)	-0.889726 (0.0000)	0.913763 (0.0000)	-0.388784 (0.0911)	-0.933916 (0.0000)
AR(2)	-0.155717 (0.0008)	0.113117 (0.7109)	-	-	-	-0.957656 (0.0000)	0.732766 (0.0000)	0.506104 (0.0000)
AR(3)	-0.118790 (0.0181)	0.481322 (0.0187)	-	-	-	-	0.935040 (0.0000)	0.803821 (0.0000)
AR(4)	-0.158234 (0.0011)	-0.051375 (0.4602)	-	-	-	-	-0.144114 (0.3362)	-
AR(5)	-0.844079 (0.0000)	-0.009693 (0.8376)	-	-	-	-	-0.411188 (0.0053)	-
MA(1)	0.333664 (0.0000)	0.710533 (0.0007)	-0.908582 (0.0000)	-0.930040 (0.0000)	0.873038 (0.0010)	-0.918897 (0.0000)	0.274686 (0.2410)	0.881788 (0.0000)
MA(2)	0.189774 (0.0000)	-0.184659 (0.5325)	-	-	-	0.972376 (0.0000)	-0.858570 (0.0000)	-0.631776 (0.0000)
MA(3)	0.157244 (0.0001)	-0.612270 (0.0003)	-	-	-	-	-0.968775 (0.0000)	-0.908718 (0.0000)
MA(4)	0.232081 (0.0000)	-	-	-	-	-	0.251029 (0.1032)	-
MA(5)	0.930948 (0.0000)	-	-	-	-	-	0.438317 (0.0138)	-
Variance Equation								
ω	22.05492 (0.0000)	0.319787 (0.0003)	1.061605 (0.0027)	1.313268 (0.0150)	2.053744 (0.0000)	1.471857 (0.0268)	0.476020 (0.0205)	0.431693 (0.0022)
α	0.018208 (0.1117)	0.244094 (0.0000)	0.239220 (0.0000)	0.205691 (0.0000)	0.258726 (0.0000)	0.151831 (0.0019)	0.110697 (0.0008)	0.326462 (0.0000)
β	-0.973499 (0.0000)	0.683761 (0.0000)	0.627991 (0.0000)	0.628859 (0.0000)	0.570352 (0.0000)	0.644078 (0.0000)	0.779355 (0.0000)	0.609723 (0.0000)
G1	1.525066 (0.0000)	1.278282 (0.0000)	1.490900 (0.0000)	1.310627 (0.0000)	1.605149 (0.0000)	1.391745 (0.0000)	1.179142 (0.0000)	1.356411 (0.0000)
α + β	-0.955282	0.927855	0.867211	0.83455	0.829078	0.795909	0.890052	0.936185
Ln(L)	-1894.473	-1395.588	-1697.690	-1706.745	-1849.013	-1703.647	-1496.912	-1478.277

Note: The values in parentheses represent the probability values, α represents the alpha value, β represents the beta value, GED represents the Generalized Error Distribution, and Ln(L) represents the maximum likelihood value of the model.

In the conducted models for the given series, the presence of ARCH effect and deviation from normal distribution can result in biased predictions. Therefore, it is necessary to use methods that consider the departure from normal distribution and the presence of ARCH effect. In this regard, classical causality tests only attempt to determine causality in the first moment of the series. However, in financial return series, it is crucial to determine the causality of the variance in the second moment of the series, due to the relationship between variance changes and information speed, as stated by Cheung and Ng (1996).

ARMA-GARCH models have been constructed for Turkey and G7 country stock markets, and predictions have been made. Firstly, suitable AR and MA processes were estimated. Subsequently, the mean equation was estimated. The model with the smallest information criterion according to the Akaike information criterion was selected to determine the AR and MA structure. The GARCH (1,1) model was identified as the most suitable model for the variance model. Since it was found that the errors in the models did not follow a normal distribution, the Generalized Error Distribution (GED) was used, and the

G1 parameter representing this parameter was found to be significant in all models. In all three models, except for BIST100, the alpha and beta parameters were found to be significant at the 1% significance level, and the sum of alpha and beta was less than one. BIST100 index was found to be significant at the 5% significance level. The alpha parameter in the GARCH model represents persistence in shocks, while the beta parameter represents volatility clustering. Additionally, since the sum of alpha and beta coefficients is less than one, it can be inferred that the conditional variance is stationary and volatility persistence is high.

After determining the GARCH model, the Hong test was conducted. The Hong test is employed to investigate causality between variables by examining the change in variance with a specified lag. This test helps in assessing whether there is evidence of causality and provides insights into the direction and significance of the causal relationship. The results obtained for the return and variance equations are presented in Table 6 and Table 7.

Table 6: *Turkey and G7 Stock Indexes Hong Causality Test Results in Mean Equation*

	Lag Length				
	M=1	**M=2**	**M=3**	**M=4**	**M=5**
Causality in Mean					
BIST100 → S&P/TSX	-0.1842 (0.5731)	-0.0543 (0.5217)	-0.0167 (0.5067)	-0.0590 (0.5235)	-0.1303 (0.5518)
S&P/TSX → BIST100	-0.6594 (0.7452)	-0.7405 (0.7705)	-0.8371 (0.7987)	-0.9386 (0.8260)	-1.0367 (0.8501)
BIST100 → CAC40	-0.7074 (0.7603)	-0.8217 (0.7944)	-0.9321 (0.8244)	-0.9592 (0.8313)	-0.9220 (0.8217)
CAC40 → BIST100	-0.3935 (0.6530)	-0.5425 (0.7063)	-0.6574 (0.7445)	-0.7549 (0.7749)	-0.8027 (0.7889)
BIST100 → DAX	-0.3355 (0.6314)	-0.4765 (0.6831)	-0.5922 (0.7232)	-0.6633 (0.7464)	-0.7142 (0.7624)
DAX → BIST100	-0.5489 (0.7085)	-0.6805 (0.7519)	-0.6890 (0.7546)	-0.6686 (0.7481)	-0.6141 (0.7304)
BIST100 → FTSE	-0.6180 (0.7317)	-0.7596 (0.7763)	-0.8682 (0.8074)	-0.9097 (0.8185)	-0.9300 (0.8238)
FTSE → BIST100	-0.3756 (0.6464)	-0.5353 (0.7038)	-0.5260 (0.7005)	-0.4749 (0.6826)	-0.4360 (0.6686)
BIST100 → NIKKEI225	-0.6549 (0.7437)	-0.7841 (0.7835)	-0.9143 (0.8197)	-0.9520 (0.8295)	-0.8922 (0.8139)
NIKKEI225 → BIST100	5.2567*** **(0.0000)**	4.9723*** **(0.0000)**	4.5036*** **(0.0000)**	4.0559*** **(0.0000)**	3.6569*** **(0.0001)**
BIST100 → FTSE100	-0.6394 (0.7387)	-0.7898 (0.7852)	-0.9293 (0.8236)	-0.9800 (0.8365)	-0.9905 (0.8390)
FTSE100 → BIST100	-0.4109 (0.6594)	-0.3822 (0.6488)	-0.3143 (0.6233)	-0.2850 (0.6122)	-0.2835 (0.6116)
BIST100 → S&P500	-0.6139 (0.7304)	-0.7138 (0.7623)	-0.7649 (0.7778)	-0.7970 (0.7873)	-0.8371 (0.7987)
S&P500 → BIST100	-0.6297 (0.7356)	-0.3689 (0.6439)	-0.2292 (0.5906)	-0.2203 (0.5872)	-0.2129 (0.5843)

Note: The values in parentheses indicate probability values. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 6 presents the results of the Hong causality test for the stock markets of Turkey and G7 countries. When examining the average return relationships, it was found that there is a significant causality at the 1% level from the stock market of Japan to the stock market of Turkey in terms of average returns. Therefore, the stock market of Japan is considered to be a Granger cause for the stock market of Turkey. However, there is no causality relationship affecting the average return between the stock markets of the remaining six countries and the stock market of Turkey.

Table 7 presents the results of the Hong causality test for variance between the stock markets of Turkey and G7 countries. The test examines the causality relationship in terms of variance. The results indicate whether the variance in one market can be considered a Granger cause for the variance in another market.

Table 7: *Turkey and G7 Stock Indices Hong Variance Causality Test Results*

	Lag Length				
	M=1	**M=2**	**M=3**	**M=4**	**M=5**
	Causality in Variance				
BIST100 → S&P/TSX	1.2647 (0.1030)	2.0812** **(0.0187)**	2.5957*** **(0.0047)**	2.7740*** **(0.0028)**	2.7812*** **(0.0027)**
S&P/TSX → BIST100	-0.5089 (0.6946)	-0.3103 (0.6218)	-0.0903 (0.5360)	0.0511 (0.4796)	0.1083 (0.4569)
BIST100 → CAC40	-0.7075 (0.7604)	-0.7894 (0.7851)	-0.8639 (0.8062)	-0.9246 (0.8224)	-0.9452 (0.8277)
CAC40 → BIST100	0.9443 (0.1725)	3.2402*** **(0.0006)**	4.6986*** **(0.0000)**	5.2889*** **(0.0000)**	5.4681*** **(0.0000)**
BIST100 → DAX	-0.4756 (0.6828)	-0.2798 (0.6102)	-0.1999 (0.5792)	-0.2182 (0.5864)	-0.2606 (0.6028)
DAX → BIST100	0.4940 (0.3107)	1.3526 **(0.0881)**	1.8601 **(0.0314)**	2.0605 **(0.0197)**	2.1150 **(0.0172)**
BIST100 → FTSE	-0.6111 (0.7294)	-0.6588 (0.7450)	-0.7368 (0.7694)	-0.8365 (0.7986)	-0.9238 (0.8222)
FTSE → BIST100	0.2162 (0.4144)	0.1897 (0.4248)	0.0978 (0.4610)	-0.0282 (0.5112)	-0.1575 (0.5626)
BIST100 → NIKKEI225	-0.7061 (0.7599)	-0.4982 (0.6908)	-0.3452 (0.6530)	-0.2254 (5892)	-0.1442 (0.5573)
NIKKEI225 → BIST100	18.4392*** **(0.0000)**	17.7247*** **(0.0000)**	17.4476*** **(0.0000)**	17.3347*** **(0.0000)**	17.0296*** **(0.0000)**
BIST100 → FTSE100	-0.6394 (0.7387)	-0.7898 (0.7852)	-0.9293 (0.8236)	-0.9800 (0.8365)	-0.9905 (0.8390)
FTSE100 → BIST100	-0.4109 (0.6594)	-0.3822 (0.6488)	-0.3143 (0.6233)	-0.2850 (0.6122)	-0.2835 (0.6116)
BIST100 → S&P500	-0.5560 (0.7109)	-0.6871 (0.7540)	-0.7554 (0.7750)	-0.8012 (0.7885)	-0.8107 (0.7912)
S&P500 → BIST100	-0.4230 (0.6639)	1.5691** **(0.0583)**	3.2609*** **(0.0006)**	4.2400*** **(0.0000)**	4.7604*** **(0.0000)**

Note: The values in parentheses represent the probability values. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

When examining the causality results for variance between the stock markets of Turkey and G7 countries, it is found that there is a causal relationship in variance between the stock markets of Canada, France, Germany, Japan, and the United States with the stock market of Turkey. However, no causal relationship in variance is detected between the stock markets of Italy and the United Kingdom with the stock market of Turkey. Therefore, for a Turkish investor who engages in international market investments and aims to diversify their portfolio, adding stocks from the BIST100 along with stocks from the Italian and UK markets can be considered. However, it is crucial for the investor to refrain from including stocks from the Canadian, French, German, Japanese, and US markets in order to maximize the benefits of diversification.

Conclusion

Volatility in financial markets serves as an important indicator for economic decision-makers, financial investments, and regulatory decisions. Volatility provides a means to calculate the risk and uncertainty level of a market, offering valuable information about that market. This information assists individual investors, fund managers, financial sector regulators, and policymakers in their decision-making processes. For individual investors, the volatility of financial markets aids in making informed investment decisions. Investors can consider that in a more volatile market environment, the risk may increase, necessitating careful portfolio diversification.

This study examined the volatility relationship between Turkey and G7 countries through mean and variance causality analysis within the scope of international portfolio diversification. The data used in the study was obtained from the Investing website, and weekly data from the period of 29.05.2009 to 06.05.2023 was utilized. The study employed the ARMA-GARCH model, and mean and variance causality analyses proposed by Hong (2001) were applied.

The findings of the mean and variance causality analyses provide valuable insights for investors and portfolio managers seeking to optimize their investment strategies. The results of the study indicate that there is a causal relationship in terms of average returns only between Turkey and the stock market of Japan among the G7 countries. Additionally, the variance causality analysis reveals that there is a transmission of volatility between Turkey and the stock markets of Canada, France, Germany, Japan, and the United States.

Based on these results, the following advice can be offered to investors and portfolio managers:

Pay attention to the volatility transmission between Turkey and the stock markets of Canada, France, Germany, Japan, and the United States. The findings indicate that changes in volatility in these markets can impact the volatility of the Turkish stock market. As a result, portfolio managers should carefully evaluate the risk implications and adjust their portfolio allocations accordingly.

When constructing international portfolios, investors may consider including stocks from the Italian and UK markets, as there is no evidence of causal relationships in either average returns or volatility

transmission between Turkey and these markets. This can enhance diversification benefits and potentially reduce overall portfolio risk.

Exercise caution when incorporating stocks from the stock markets of Canada, France, Germany, Japan, and the United States. The presence of volatility transmission suggests a potential interdependence between these markets and the Turkish stock market, which may increase portfolio risk. Conduct thorough analysis and consider alternative investment strategies to mitigate potential risks associated with these markets.

By taking into account these recommendations and considering the causal relationships and volatility transmission identified in the study, investors and portfolio managers can make more informed decisions when diversifying their portfolios and managing risks effectively. It is crucial to regularly monitor market dynamics and adjust investment strategies based on changing conditions in order to maximize returns and minimize potential downside risks.

When the results are compared with the studies on Türkiye and G7 countries in the literature; It is seen that it differs from the studies of (Ulusoy, 2019), (Ustalar & Şanlısoy, 2021), (Uçar & Alsu 2022), (Münyas 2020), (Ayaydın, et al., 2020). According to the results of this study; It has been determined that Turkey, Italy and the UK stock markets can be put in the same basket and portfolio diversification can be achieved.

In future studies on international portfolio diversification, the variables are not limited to stocks only, but sectoral indices and international can be examined. Additionally, new studies that will contribute to the literature can be conducted using various analyzes by including the foreign exchange market, commodity market, and crypto values in the study.

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Genişletilmiş Özet

Amaç: Finansal piyasalardaki oynaklık, ekonomik karar vericiler, finansal yatırım ve regülasyon kararları açısından önemli bir gösterge niteliği taşır. Oynaklık, bir piyasanın risk ve belirsizlik düzeyini hesaplama imkânı sunarak, bu piyasaya dair bilgi sağlar. Bu bilgi, bireysel yatırımcılar, yatırım fonu yöneticileri, finans sektörü düzenleyicileri ve politika yapıcılarının karar süreçlerine yardımcı olmaktadır. Yatırımcılar, daha oynak bir piyasa ortamında riskin artabileceğini bildiklerinden portföy çeşitlendirmesi yapılmasına ihtiyaç duymaktadırlar. Bu çalışmanın amacı Türkiye ve G7 hisse senedi piyasaları arasındaki oynaklıkların tespit edilmesi ve ortalamada ve varyansda nedensellik ilişkisini incelemektedir.

Veri Seti ve Yöntem: Çalışmada kullanılan veri seti 29.05.2009-06.05.2023 dönemine ait Türkiye ile G7 ülke borsalarına ait haftalık kapanış fiyat serileri üzerinde çalışılmıştır. Serilerin logaritmik getiri serileri hesaplanmış ve çalışmada getiri serileri kullanılmıştır. Yöntem olarak; ilk olarak Genelleştirilmiş Otoregrsif Koşullu Değişen Varyans (GARCH) modelinin tahmmin edlilmesi gerçekleştirilmiştir. Ardından GARCH modelinden belirlenmiş olan standardize hata terimleri ve standardize hata terimlerinin karelerinin çapraz korelasyon fonksiyonun hesaplanması ile serilerin ortalama ve varyans nedensellik analizi gerçekleştirilmektedir.

Sonuç: Çalışmanın sonucu incelendiğinde, Ortalamada Nedensellik analizine göre; Türkiye ile G7 ülkeri arasında sadece Japonya hisse senedi piyasaları arasında ortalama getirilerinde bir nedensellik ilişkisi olduğu sonucuna ulaşılmıştır. Varyansta nedensellik analizine göre ise sadece Türkiye ile Kanada, Fransa, Almanya, Japonya ve Abd hisse senedi piyasaları arasında oynaklık yayılımı olduğunun sonucuna ulaşılmıştır. Dolayısıyla uluslararası piyasalarda yatırım yapan bir yatırımcı, BIST100 hisseleri ile İtalya ve İngiltere borsasında bulunan hisseler ile portföy çeşitlendirmesi yapabileceği söylenebilir. Ancak Kanada, Fransa, Almanya, Japonya ve ABD borsalarına ait hisseleri portföyüne eklememesi maksimum faydası elde edebilmesi açısından önem arz etmektedir.