Hacettepe Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi
Hacettepe University Journal of Economics and Administrative Sciences

https://dergipark.org.tr/tr/pub/huniibf
ISSN:1301-8752 E-ISSN:1309-6338

Başvuru Tarihi / Submission Date: 19/04/2025 **DOI: 10.17065/huniibf.1679846**
Kabul Tarihi / Acceptance Date: 07/01/2026 **2026, 44 (1), 47-63**

Araştırma Makalesi / Research Article

Modeling Financial Contagion Between Türkiye and Indonesia: A Multivariate GARCH Approach

Gözde Bozkurt Ateş[1]

Abstract

This study investigates the existence and characteristics of financial contagion between Türkiye and Indonesia,-two emerging economies with similar macroeconomic profiles—through an econometric approach. Using daily USD/TRY and USD/IDR exchange rate return data from January 2, 2008, to April 17, 2025, the research applies Constant Conditional Correlation GARCH (CCC-GARCH) and Dynamic Conditional Correlation GARCH (DCC-GARCH) models to capture volatility dynamics and correlation structures. Logarithmic returns were tested for normality, and volatility clustering was confirmed. The findings reveal a unidirectional and statistically significant short-term influence from Türkiye to Indonesia, indicating asymmetric contagion. Although the conditional correlations are positive and significant, their low levels point to limited financial integration. Furthermore, the dynamic correlation parameters from the DCC model are statistically insignificant, suggesting that correlation remains stable over time rather than reacting sharply to shocks. The results imply a low but persistent interdependence, shaped more by structural economic linkages than by temporary crises. As one of the few empirical studies comparing exchange rate contagion in developing countries, this research contributes to the literature by highlighting contagion asymmetry and evaluating the relative performance of CCC and DCC models in emerging market settings.

Keywords: *Financial Contagion, Exchange Rate, Volatility Spillover, CCC-GARCH, DCC-GARCH, Developing Countries.*

Türkiye ve Endonezya Arasındaki Finansal Bulaşıcılığın Modellenmesi: Çok Değişkenli GARCH Yaklaşımı

Öz

Bu çalışma, benzer makroekonomik özelliklere sahip iki gelişmekte olan ekonomi olan Türkiye ve Endonezya arasındaki finansal bulaşıcılığın varlığını ve niteliğini ekonometrik bir yaklaşımla incelemektedir. 2 Ocak 2008 – 17 Nisan 2025 tarihleri arasındaki günlük USD/TRY ve USD/IDR döviz kuru getirileri kullanılarak, volatilite dinamikleri ve korelasyon yapısını analiz etmek amacıyla Sabit Koşullu Korelasyon GARCH (CCC-GARCH) ve Dinamik Koşullu Korelasyon GARCH (DCC-GARCH) modelleri uygulanmıştır. Logaritmik getiriler normallik açısından test edilmiş ve volatilite kümelenmesi gözlemlenmiştir. Bulgular, Türkiye'den Endonezya'ya doğru tek yönlü ve istatistiksel olarak anlamlı kısa vadeli bir etkinin varlığına işaret etmekte olup, bu durum asimetrik bulaşıcılık hipotezini desteklemektedir. İki piyasa arasındaki koşullu korelasyon katsayıları pozitif ve anlamlı olsa da, düşük düzeyde olmaları finansal entegrasyonun sınırlı olduğunu göstermektedir. Ayrıca, DCC modelindeki dinamik korelasyon parametrelerinin anlamsız çıkması, korelasyon seviyelerinin zaman içinde sabit kaldığını ortaya koymaktadır. Sonuç olarak, güçlü bulaşıcılık yerine düşük düzeyde ve kalıcı bir karşılıklı bağımlılık tespit edilmiştir. Bu çalışma, gelişmekte olan iki ülke arasında döviz kuru bulaşıcılığını karşılaştırmalı olarak ele alması bakımından literatüre önemli bir katkı sunmaktadır.

Anahtar Kelimeler: *Finansal Bulaşma, Döviz Kuru, Volatilite Yayılması, CCC-GARCH, DCC-GARCH, Gelişmekte Olan Ülkeler.*

[1] Dr. Öğr. Üyesi, İstanbul Beykent Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, Yönetim Bilişim Sistemleri Bölümü, gozdebozkurt@beykent.edu.tr, https://orcid.org/0000-0001-8413-1099

Atıf/Cite as: Bozkurt Ateş, G. (2026). Modeling financial contagion between Türkiye and Indonesia: A multivariate GARCH approach, *Hacettepe University Journal of Economics and Administrative Sciences*, 2026, 44 (1), 47-63.

INTRODUCTION

Financial contagion is generally defined as the spread of a financial shock that occurs in a market or country to other markets or countries. However, there are different approaches to defining and measuring this concept in the literature. While some studies evaluate any positive or negative spillover effect from one market to another as financial contagion, some studies define only spillovers that cannot be explained by economic principles as contagion. In this context, the fact that the co-movement between markets increases significantly only in crisis periods is seen as evidence of the existence of contagion. In addition, examining the correlation, volatility and time-dependent dynamic relationships between markets are also among the methods used to analyze contagion. It is frequently emphasized in the literature that analyzes related to volatility spillovers contribute to the successful management of systematic risks and financial stability (Zhang et al., 2020). In addition, correctly defining the spillover effects between financial institutions allows us to better understand the contagion mechanism of financial risks (Li et al., 2021).

In a multi-country comparative study conducted by Akkaya et al. (2022), correlations between stock markets for the pre- and post-COVID-19 periods were examined. While a moderate positive correlation (0.2141) was observed between Türkiye and the US before COVID-19, the correlation between Indonesia and Türkiye remained quite low. In the analysis covering the crisis period, it was observed that the correlation coefficients generally increased, but the estimated correlation between Türkiye and Indonesia was at the lowest level (0.0531). These findings indicate the existence of limited financial integration between Türkiye and Indonesia even during crisis periods and show that possible contagion effects remained low. In another study examining net shock propagation relationships at the stock market level among E7 countries, the direction and magnitude of shocks between countries were visually analyzed using the network analysis method. In the study, Brazilian and Mexican stock markets stood out as the largest net shock emitters, while Indonesia, China, India, Russia and Turkish markets were found to be predominantly net shock receivers. In particular, it was determined that there was a significant shock spillover from Türkiye to Indonesia, and this interaction showed that regional financial ties may have an asymmetric structure (Doğru, 2024). Değirmenci and Abdioğlu (2017) made significant contributions to the financial contagion literature by examining the volatility spillover from developed markets to fragile markets. In the study conducted with the EGARCH model, the volatility spillover from the stock markets of developed countries in America, Europe and Asia to developing countries defined as the Fragile Eight countries was analyzed from January 2006 to June 2015. The findings indicate that there was a statistically significant spillover of volatility from developed economies to these countries. However, this effect was not found to persist for Indonesia; the Indonesian market appeared to have a relatively more independent and strong structure against shocks from developed countries. This is an example that indicates Indonesia may have a lower degree of financial integration than other vulnerable economies. Falianty and Budimanta (2020) examined the contagion effect of the 2018 global financial crisis through exchange rate volatility and financial variables. In Argentina, Türkiye and Indonesia research, a wide comparative analysis was carried out by utilizing the stock markets, exchange rates and balance of payments data of these countries. The findings obtained revealed that the Argentine and Turkish financial crises exercised a contagion effect on the Indonesian economy; Indonesia's exchange rate market and stock market were particularly sensitive to these shocks. In addition, it was confirmed that the effect of Türkiye on the Indonesian financial market was stronger than the effect of Argentina. This example proves that Türkiye is capable of becoming a more forceful shock diffusing country during crisis periods and proves the existence of asymmetric contagion mechanisms between developing countries.

Recent empirical studies focusing on Türkiye also provide important evidence regarding market sensitivity during crisis periods. Yıldırım (2020) examines volatility spillovers among Türkiye, the US, and China during the COVID-19 pandemic and finds that Türkiye exhibited significant contagion effects triggered by extreme global uncertainty. Similarly, Nazlıoğlu and Kök (2021) investigate Türkiye's co-movements with developed and emerging markets using multivariate GARCH models and conclude that Türkiye is particularly vulnerable to external shocks transmitted from major financial centers. These findings highlight the asymmetric and crisis-driven nature of shock transmission involving Türkiye.

Budak (2017), in his study where he examined the literature on financial contagion in detail, emphasizes that the approach that has become more accepted in recent years evaluates the continuation of existing ties due to economic relations during a crisis not as contagion but as interdependence. According to this approach, only crisis spillovers that occur as a result of irrational changes in investor behavior can be truly defined as contagion. Therefore, in order to detect financial contagion, it is necessary to analyze whether the relationship between markets shows a significant structural change during crisis periods. In this context, the possibility of financial shocks spreading among developing countries with similar economic vulnerabilities should be carefully examined. At this point, Türkiye and Indonesia are two important example countries that should be evaluated comparatively in terms of financial contagion analyses, both because they have historically gone through similar cycles and because of their common macroeconomic weaknesses such as external financing dependency, exchange rate volatility and current account deficit.

In addition to this perspective, Forbes and Rigobon (2000, 2001, 2002) made a significant conceptual contribution by distinguishing true contagion from simple interdependence. They argue that increases in correlations during crisis periods often stem from higher market volatility rather than a genuine contagion effect. After correcting for heteroskedasticity, many relationships previously interpreted as contagion actually reflect the continuation of pre-crisis linkages. This distinction is highly relevant for emerging markets like Türkiye and Indonesia, where volatility shocks mechanically inflate correlations and may lead to misleading contagion inferences if not properly addressed.

Türkiye and Indonesia are two major developing countries with similar macroeconomic characteristics, and stand out with their dynamic and fragile structures. Both countries implement open economic policies, are exposed to high capital mobility, and occasionally experience common financial vulnerabilities such as exchange rate pressure, foreign trade deficit, and interest rate fluctuations. In addition, both Türkiye and Indonesia are directly affected by international financial fluctuations through portfolio investments during global crisis periods when investor behavior changes rapidly. Both countries experienced serious exchange rate pressures in 2018 due to the tightening of global financial conditions. The depreciation of the Turkish Lira in Türkiye caused fluctuations in other developing country currencies, creating concerns in global markets (The Guardian, 2018). Similarly, the Indonesian Rupiah lost up to 9% in 2018, making the country even more vulnerable due to its twin deficits (VOA News, 2018). These simultaneous exchange rate shocks raise the possibility of a potential financial contagion mechanism between Türkiye and Indonesia.

In this context, the question of the extent to which the financial ties between two countries are sensitive to each other, especially through the exchange rate market, is important in terms of the financial contagion literature. In the existing literature, financial contagion between developing countries has generally been examined through relations with large developed economies, and direct comparative studies between two developing countries have been given less space. In this study, the evaluation of the contagion between Türkiye and Indonesia in terms of both conditional correlation dynamics and volatility pass-through offers important empirical implications for developing countries with similar structures.

Accordingly, the central research question of this study is whether financial contagion exists between Türkiye and Indonesia, and if so, what the direction, magnitude, and temporal behavior of this contagion are. More specifically, the study asks whether short-term shocks in one exchange rate market are transmitted to the other, whether these effects are asymmetric, and whether the correlation structure between the two markets changes in response to crisis episodes.

To empirically investigate this relationship, the study employs multivariate GARCH models-specifically the CCC-GARCH and DCC-GARCH frameworks-based on daily exchange rate data for the USD/TRY and USD/IDR pairs, covering the period from January 2, 2008, to April 17, 2025. These models allow for the assessment of both constant and time-varying conditional correlations, enabling a comprehensive analysis of short-term information transmission, volatility spillovers, and the degree of synchronous movements between the two markets. The methodological design of the study provides insights not only into the magnitude of contagion but also into its directionality and temporal nature.

1. RESEARCH HYPOTHESES

The empirical patterns documented in the international contagion literature, as well as the preliminary dynamics observed in the exchange rate series of Türkiye and Indonesia, suggest several testable hypotheses regarding return spillovers, conditional correlations, and volatility transmission mechanisms. In line with the theoretical framework and the purpose of this study, the following hypotheses are formulated:

H_1: Türkiye's lagged exchange rate returns exert a statistically significant and positive influence on Indonesia's current exchange rate returns.

This hypothesis reflects the possibility of a unidirectional short-term information transmission from Türkiye to Indonesia and allows the analysis to capture potential return spillovers between the two emerging markets.

H_2:The conditional correlation between Türkiye and Indonesia remains low and does not display statistically significant time variation.

This hypothesis enables the empirical comparison of CCC and DCC-GARCH specifications and evaluates whether a constant-correlation structure sufficiently explains the interaction between the two markets.

H_3: Volatility shocks in both markets are positive and significant, while volatility persistence is higher in Türkiye.

This hypothesis focuses on the dynamics of volatility transmission and allows the study to assess whether the magnitude and persistence of volatility differ across the two economies. The hypotheses above guide the model selection and provide a structured basis for examining the extent and direction of financial linkages between the two markets. They also form the foundation for interpreting the empirical results within the broader contagion–interdependence framework used in the existing literature.

In order to empirically test these hypotheses and evaluate the nature of the financial interactions between Türkiye and Indonesia, the study employs multivariate GARCH models that capture both return dynamics and volatility transmission mechanisms. The following section outlines the methodological framework, model specifications, estimation procedures, and diagnostic analyses used to assess return spillovers, conditional correlations, and volatility persistence across the two exchange rate markets.

2. METHODS

The general objective of this study is to reveal whether or not there is financial contagion among two emerging economies with similar economic structures, such as Türkiye and Indonesia. Financial contagion is commonly called statistically significant and persistent transmission of financial shocks within one country to other nations' markets. To this end, in this research, the multivariate GARCH models that are used are powerful analytical tools both for the volatility pass-through and the joint correlation dynamics' measurement of contagion.

CCC-GARCH by Bollerslev (1990) and DCC-GARCH by Engle (2002) and Tse and Tsui (2002) were used in this research to analyze the volatility dynamics of multivariate financial time series. Both models have the time-varying variance structure; however, the models are different as far as whether correlations change over time is concerned. While CCC-GARCH maintains the correlation structure as fixed, DCC-GARCH allows modeling of time-varying correlations.

2.1. Constant Conditional Correlation GARCH (CCC-GARCH) Model

CCC-GARCH is one of the first applications of multivariate GARCH models and takes the form where the conditional variances between variables are defined with GARCH processes and the conditional correlation matrix is assumed to remain constant over time. The general form of the model for a two-dimensional series of returns is provided below.

$$r_t = \mu + \varepsilon_t, \varepsilon_t(0, H_t) \quad (1)$$

Here; $r_t = [r_{1t}, r_{2t}]'$ represents the observed return vector at time t; μ represents the constant mean vector; ε_t represents the zero-mean error terms vector; and H_t represents the conditional variance-covariance matrix. The variance-covariance structure is formulated as follows.

$$H_t = D_t R D_t \quad (2)$$

Here; $D_t = diag\left(\sqrt{h_{1t}}, \sqrt{h_{2t}}\right)$ is the diagonal matrix of the conditional standard deviations of the individual series; R is a time-invariant correlation matrix. Such a structure takes into account that the variances of the variables may vary over time, but the correlation between them is time-invariant. The conditional variance of every series is as shown below.

$$h \quad = w_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1}, i = 1,2 \quad (3)$$

Here; $w_i > 0$ represents the constant term of the variance process; $\alpha_i \geq 0$ represents the effect of the square of the error term of the previous period; $\beta_i \geq 0$ represents the effect of the variance of the previous period; $\alpha_i + \beta_i < 1$ represents the stationarity condition. While the CCC-GARCH model allows modeling of individual variances in multidimensional series, it is limited in dynamic relationship analyses because it assumes the correlation structure is constant over time.

2.2. Dynamic Conditional Correlation GARCH (DCC-GARCH) Model

The DCC-GARCH model takes into account the time-dependent changes in correlations by adding a dynamic correlation component to the CCC-GARCH structure. This model, developed by Engle (2002) and Tse&Tsui (2002), allows estimating both individual variances and correlations between variables in high-dimensional data sets. The averaging process is as in the CCC-GARCH model.

$$r_t = \mu + \varepsilon_t, \varepsilon_t(0, H_t) \quad (4)$$

The conditional variance-covariance matrix is again decomposed as follows.

$$H_t = D_t R_t D_t \quad (5)$$

Here; $D_t = diag\left(\sqrt{h_{1t}}, \sqrt{h_{2t}}\right)$ represents the diagonal matrix derived from individual variances; R_t represents the conditional correlation matrix that varies depending on time. Variance processes are defined exactly as in the CCC-GARCH model.

$$h \quad = w_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1}, i = 1,2 \quad (6)$$

The dynamic structure of the correlation matrix is created in three steps.

(1) Standardized Residuals:

$$z_t = D_t^{-1} \varepsilon_t \quad (7)$$

Each residual error term is standardized by dividing it by its variance.

(2) Temporal Covariance Matrix:

$$Q_t = (1 - a - b)\overline{Q} + \alpha z_{t-1} z_{t-1}' + b Q_{t-1} \quad (8)$$

Here: $\overline{Q}$ is the long-term covariance matrix of standardized residuals; $a \geq 0$ is the DCC parameter showing the sensitivity to shocks; $b \geq 0$ is the persistence of the correlation; $a + b < 1$ is the stationarity condition.

(3) Normalizing the Correlation Matrix:

$$R_t = diag(Q_t)^{-1/2} Q_t diag(Q_t)^{-1/2}$$

Thanks to this transformation, R_t becomes a symmetric, positive definite matrix with all correlation coefficients in the range [-1, 1]. In order to preserve these structural features, certain parametric conditions must be met during model estimation (Hepsağ and Akçalı, 2016). For individual GARCH components, each of the ARCH (α) and GARCH (β) parameters should be greater than zero and their sum is expected to be less than one ($a + b < 1$). Similarly, for the parameters specific to the DCC-GARCH model, the conditions $a \geq 0$, $b \geq 0$ and $a + b < 1$ should be met. These conditions ensure that the conditional variance and correlation matrices generated by the model are positive definite and the series are stationary. The CCC-GARCH model is less complex in structure due to the constant correlation assumption, and offers simplicity in terms of estimation and interpretation. The DCC-GARCH model has the potential to describe the dynamic relationships between financial series more realistically by allowing for the time-varying correlations. Here, in line with the purpose of the study, both models were estimated separately and comparative analysis was made, and model performances were evaluated in terms of both statistical adequacy and econometric validity.

However, the applicability of both models is directly related not only to their theoretical advantages but also to how they respond to empirical conditions. At this point, the sensitivity of the DCC-GARCH model's estimation performance to sample size is emphasized in many academic studies (Aielli, 2013; Engle & Sheppard, 2001; Hafner & Laurent, 2007). One of the fundamental limitations of the model is that it is based on the assumption that all conditional correlations follow the same dynamic structure. This assumption limits the structural flexibility of the model, especially in the case of high-dimensional data sets, and has a negative influence on estimation precision. The estimable parameters for the DCC-GARCH model are determined via the formula $\frac{(N+1)(N+4)}{2}$, where N represents the amount of variables utilised in the model. The more parameters are included, the more variables there are, and this exponentially increases the number of variables, which makes it difficult for the model to converge and be statistically significant, especially in low-sample-size studies. This is the reason why a two-stage procedure is used in the estimation process of the DCC-GARCH, and the procedure reduces computational complexity and makes the modeling process easier (Su & Huang, 2010).

However, literature evidence suggests that discrepancies, especially the correlation parameters discrepancies, will be produced by the DCC-GARCH model at small sample sizes. Caporin and McAleer (2008) and Su and Huang (2010) make the point that the CCC-GARCH model whose less parametric nature can be used in a case of having an insufficient sample size. The constant conditional correlation assumption of CCC-GARCH model reduces the parametric complexity and potentially provides more robust results with smaller samples. The sensitivity of the DCC-GARCH models to the sample size was studied in more depth by Hafner and Reznikova (2012). From the authors, it appears that the maximum likelihood estimator has drastically aberrant results, especially where the sample size of the time series approaches the number of observations. One of the main reasons for this deviation is that the sample covariance matrix used within the scope of the variance targeting technique is ill-conditioned. As a solution to this problem, the authors suggest that estimations can be improved with different target structures (e.g., identity matrix, single factor model or co-correlation assumption) by applying the shrinkage method to the sample covariance matrix. The findings obtained with this applied method show that the bias decreases as the sample size increases and the obtained estimator becomes asymptotically equivalent to the classical maximum likelihood estimator. Similarly, Aielli (2013) revealed that the classical DCC estimator can be inconsistent and biased in small samples; in order to overcome this problem, he proposed a new estimator that includes correction, the "corrected DCC" (cDCC) approach. According to Aielli's theoretical analysis and simulation results, the cDCC estimator produces more consistent and low-bias results in limited sample conditions. In particular, it provides a more reliable estimation of dynamic correlation structures.

As a result, although the DCC-GARCH model is structurally flexible and has an advantageous structure in terms of monitoring dynamic relationships, the statistical reliability of this model depends largely on the sample size. Therefore, a sufficient number of observations are needed for the DCC structure to produce reliable estimates; in cases where the sample size is limited, methods adapted to the model's estimation process should be preferred.

3. RESULTS

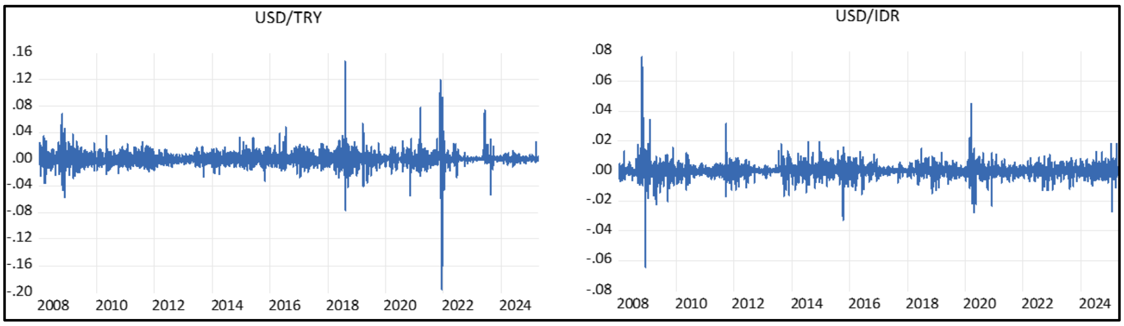
This part presents the empirical findings of the analysis conducted in order to test for the presence of exchange rate contagion between Türkiye and Indonesia. The findings are presented in terms of the results of the econometric model and interpreted in the context of the financial contagion literature.

3.1. Data Sources

This study is designed to examine whether there is financial contagion between Türkiye and Indonesia through the foreign exchange market. The data used in the analysis is obtained at a daily frequency covering the period between January 2, 2008 and April 17, 2025. The variable used in the study is the official exchange rate, which reflects the value of the national currencies of both countries against the US dollar. For Türkiye, the USD/TRY exchange rate and for Indonesia, the USD/IDR exchange rate are taken into account.

The data was obtained from Investing.com, one of the reliable sources of international financial statistics. The data was filtered according to business days before the analysis, and holidays and missing observations were appropriately removed. Before starting the analysis, logarithmic return series were calculated over the obtained exchange rate levels. This process was done to ensure that the time series was structured appropriately for volatility analyses. Logarithmic returns were calculated using the formula $r_t = ln(P_t) - ln(P_{t-1})$. Here, P_t represents the exchange rate value of the relevant day. Thanks to this transformation, symmetrical and comparable returns were obtained for both Türkiye (USD/TRY) and Indonesia (USD/IDR). Figure 1 visualizes the fluctuation structure of exchange rate returns of Türkiye and Indonesia over time. The first impressions obtained from the graphs show that volatility clusters emerge clearly, especially during crisis periods.

Figure 1: Time Series Graph of Exchange Rate Returns of Türkiye and Indonesia (01.01.2008 – 18.04.2025)



When the fluctuations in Türkiye's daily exchange rate returns against the US dollar are examined over time, high volatility and extreme outliers are particularly striking in the return series after 2018. This situation can be associated with the controlled free-floating structure of Türkiye's exchange rate regime, macroeconomic uncertainties and interventions in the foreign exchange market. The high variance clusters observed in the series indicate the existence of the ARCH effect and necessitate econometric modeling of conditional variance structures that change over time. In this context, ARCH LM test results confirm the presence of conditional heteroskedasticity in the series ($F=315.56$, $p<0.01$; LM $\chi^2=295.05$, $p<0.01$). This finding reveals that the variance structure of the series is not constant over time and exhibits time-varying volatility characteristics. Therefore, the use of GARCH family models is methodologically justified.

When Indonesia's daily return series against the US dollar is examined, it has a structure that includes lower but significant volatility waves compared to Türkiye. Although sudden jumps in returns were observed during periods such as the 2008 Global Financial Crisis and the 2020 COVID-19 pandemic, it is observed that volatility exhibits a more stable structure in general. This structure overlaps with the free-floating exchange rate regime in which the Central Bank of Indonesia intervenes from time to time. The presence of a distinct but more limited number of volatility clusters in the return series indicates that both the CCC-GARCH and DCC-GARCH models are applicable.

In the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests conducted on the stationarity of the series, it was determined that the log-return series belonging to Türkiye and Indonesia were stationary for both. According to the ADF test results, the test statistic for the Türkiye (USD/TRY) series was -61.41 and for the Indonesia (USD/IDR) series -25.57, and in both cases the test statistics were well below the critical value *($p<0.01$).* Similarly, the PP test results also support these findings; the test statistic for Türkiye was calculated as -61.22 and for Indonesia as -64.51, and the *p-value* of both tests was found to be *0.0000*. In line with these results, the series do not contain a unit root and have a stationary structure. This means that the statistical properties of the series do not change over time and that a methodological requirement is met in terms of the applicability of GARCH type models.

3.2. Descriptive Statistics

In this section, the basic statistical properties of the exchange rate log-return series of Türkiye and Indonesia are examined through descriptive statistics; the distribution structures of the series, volatility properties and their suitability to traditional models are evaluated. Table 1 presents the descriptive statistics for USD/TRY and USD/IDR returns.

Table 1: Descriptive Statistics

Statistics	USD/TRY	USD/IDR
Mean	0.0007	0.0001
Median	0.0004	0.000005
Maximum	0.1482	0.0761
Minimum	-0.1950	-0.0647
Std. Dev.	0.0101	0.0043
Skewness	-0.2134	0.7853
Kurtosis	57.0422	46.0479
Jarque-Bera	549221.5*	348928.8*
Number of Observations	4513	4513

*Note: * sign indicates statistically significant results at 5% significance level.*

The USD/TRY log-return series for Türkiye has a structure that exhibits high kurtosis and negative skewness, deviates from normality and contains extreme values. Normality is rejected as a result of the Jarque-Bera test, which indicates that the series should be analyzed with time-series-based conditional variance models rather than traditional regression models. This structure methodologically justifies the use of GARCH family models, which can model situations where volatility changes over time. The USD/IDR log-return series for Indonesia is characterized by positive skewness and high kurtosis values. The fact that the mean return is close to zero and the standard deviation is lower than in Türkiye indicates that the exchange rate dynamics exhibit a more stable structure. However, the rejection of the normality assumption with the Jarque-Bera test reveals that this series should also be analyzed with GARCH-based variance models instead of traditional models. The presence of volatility clusters and extreme values supports the applicability of models that include a time-dependent correlation structure such as the DCC-GARCH model. The deviation from normality of the log-return series, the high skewness and kurtosis values and the volatility clusters require the modeling of exchange rate returns with dynamic structures for both countries. In this context, the CCC-GARCH model, in which the conditional variance is considered under the constant correlation structure, is first estimated.

3.3. CCC-GARCH Model Estimation Results

The CCC-GARCH model allows the independent modeling of volatility components and evaluates the financial interaction between countries over the constant correlation coefficient. Table 2 presents the results of the CCC-GARCH model estimated for the USD-based exchange rate returns of Türkiye and Indonesia.

Table 2: Estimation Results of the CCC-GARCH Model (January 2, 2008 – April 17, 2025)

Parameter	Coefficient	Standard Error	z-Statistics
L.USD/TRY	0.0302	0.0202	1.5
L.USD/IDR	0.0287	0.0306	0.94
ARCH_USD/TRY (α1)	0.4735*	0.0347	13.65
GARCH_USD/TRY (β1)	0.4999*	0.0445	11.23
ω_USD/TRY	0.000004	0.0000	1.4
ARCH_USD/IDR (α2)	0.5177*	0.0389	13.32
GARCH_ USD/IDR (β2)	0.2984*	0.0417	7.15
ω_ USD/IDR	0.000006*	0.0000	9.07
ρ(USD/TRY, USD/IDR)	0.0822*	0.0170	4.84
Number of Observations		4513	
AIC		-53967.8	
BIC		-53899.7	
Wald χ^2		113.63*	

All variance equation parameters satisfy the stationarity constraint ($\alpha_i + \beta_i < 1$). Specifically, $\alpha_1+\beta_1=0.9734$ for Türkiye and $\alpha_2+\beta_2=0.8161$ for Indonesia.

*Note: The model covers the period between January 1, 2008 and April 17, 2025. Conditional mean equations are defined as a first-order vector autoregressive (VAR(1)) process without a constant term, and the conditional variance equation of each series is modeled in the form of GARCH(1,1). The correlation structure between markets is assumed to be constant over time. * sign indicates statistically significant results at 5% significance level.*

According to the estimation results of conditional mean equations, Türkiye's past returns have no statistically significant effect on its own returns or Indonesia's returns *($p=0.134$ & $p=0.348$).* In contrast, Indonesia's returns are significantly and positively affected by Türkiye's one-period lagged returns *($p<0.01$).* This indicates a one-way, short-term information transfer from Türkiye to Indonesia. Indonesia's own past returns have no significant effect *($p=0.543$).*

The conditional variance equations confirm that the GARCH(1,1) model is suitable for both countries. For Türkiye, the ARCH(1) coefficient is estimated as 0.4735 and the GARCH(1) coefficient is 0.4999; both parameters are significant at the 1% level of significance. The sum of these two parameters is 0.9734, which is less than one, indicating that the model is stationary but the volatility shocks are quite persistent. For Indonesia, the ARCH(1) and GARCH(1) coefficients are estimated as 0.5177 and 0.2984, respectively, and their sum is 0.8161, satisfying the stationarity condition. This result shows that volatility shocks lose their effect in Indonesia in a shorter period of time compared to Türkiye. In addition, while the constant term in the variance equation is significant in Indonesia *($p<0.01$),* this parameter is not found to be statistically significant for Türkiye. This situation shows that a structural volatility level is more pronounced in Indonesia. The constant conditional correlation coefficient estimated in the model is 0.0822, which is statistically significant at the 1% level. This finding reveals a weak but significant positive simultaneous relationship between the Turkish and Indonesian stock markets. In general, the CCC-GARCH model meets basic econometric assumptions such as positivity and stationarity of conditional variance processes.

The findings obtained from the CCC-GARCH model reveal that there is a positive and statistically significant correlation between the exchange rate returns of Türkiye and Indonesia, but this model assumes that the correlation coefficient remains constant over time. However, it is known that market relations can strengthen and weaken, especially during crisis periods, due to the structure of financial markets. Therefore, the dynamic conditional correlation (DCC-GARCH) model was estimated in order to analyze the change in correlation over time.

3.4. DCC-GARCH Model Estimation Results

The DCC-GARCH model both takes into account the volatility structure of each series and offers the opportunity to analyze financial interactions between countries more flexibly through the correlation coefficient that changes over time. Table 3 presents the estimation results of the model in question.

Table 3 reports the estimation outcomes of the DCC-GARCH model for the USD/TRY and USD/IDR exchange rates.

The findings regarding the conditional mean equations indicate that Türkiye's own lagged return is statistically insignificant (L.USD/TRY, $p = 0.148$), as is Indonesia's own lagged return (L.USD/IDR, $p = 0.592$). However, Türkiye's lagged returns significantly and positively affect Indonesia's current returns, while the reverse effect from Indonesia to Türkiye is not statistically significant. This suggests a unidirectional return response from Türkiye to Indonesia at the mean equation level.

In the conditional variance equations, both the ARCH(1) and GARCH(1) parameters are positive and statistically significant. For Türkiye, the ARCH (α_1) and GARCH (β_1) coefficients sum to 0.9736, while for Indonesia the sum of α_2 and β_2 equals 0.8162, indicating that the $\alpha + \beta < 1$ stationarity condition holds for both markets. This demonstrates that the conditional variance processes are stable and past shocks gradually decay over time. Volatility persistence is higher in Türkiye, whereas Indonesia displays a less persistent structure. The constant variance term (ω) is statistically significant for Indonesia ($p < 0.01$) but not for Türkiye.

The DCC model estimates a mean conditional correlation of 0.0828, which is positive and statistically significant at the 5% level. However, the dynamic correlation parameters Λ_1 ($p = 0.266$) and Λ_2 ($p = 0.878$) are statistically insignificant, indicating that the model does not detect meaningful time variation in correlations. This suggests that the correlation structure remains essentially constant throughout the sample period. Consequently, the constant conditional correlation assumption of the CCC-GARCH model is not restrictive within this dataset.

Table 3: Estimation Results of the DCC-GARCH Model (January 2, 2008 – April 17, 2025)

Parameter	Coefficient	Standard Error	z-Statistics
L.USD/TRY	0.0292	0.0202	1.45
L. USD/IDR	0.0271	0.0306	0.88
ARCH_ USD/TRY (α1)	0.472200*	0.0347	13.62
GARCH_ USD/TRY (β1)	0.501400*	0.0446	11.25
ω_ USD/TRY	0.000004	0.000003	1.37
ARCH_ USD/IDR (α2)	0.518900*	0.039	13.32
GARCH_ USD/IDR (β2)	0.297300*	0.0416	7.15
ω_ USD/IDR	0.000006*	0.000001	9.12
ρ(USD/TRY, USD/IDR)	0.082800*	0.0174	4.75
Λ1	0.0195	0.0176	1.11
Λ2	0.0476	0.3113	0.15
Number of Observations	4513		
AIC	-53965.6		
BIC	-53885.1		
Wald χ^2	115.66*		
Are Dynamic Correlation Parameters Meaningful?	λ_1 and λ_2 insignificant		
Parameter Stability Condition	$\alpha_1 + \beta_1 = 0.9736 < 1$ (Türkiye) $\alpha_2 + \beta_2 = 0.8162 < 1$ (Indonesia) $\Lambda_1 + \Lambda_2 = 0.0671 < 1$ (DCC)		

*Note: Mean equations were modeled with a fixed first-order vector autoregressive (VAR(1)) structure, and conditional variance equations were modeled with GARCH(1,1) processes; it was assumed that the correlation between countries could change over time. * sign indicates statistically significant results at 5% significance level.*

Table 4: LM Test for Autocorrelation in CCC and DCC-GARCH Model Residuals

Lag (p)	χ² Statistic	df	p-value	Interpretation	Model
1	3.189	1	0.0741	No autocorrelation (at 5% level)	
2	3.266	2	0.1953	No autocorrelation	
3	3.266	3	0.3524	No autocorrelation	CCC-GARCH
4	3.266	4	0.5143	No autocorrelation	
5	4.161	5	0.5265	No autocorrelation	
1	2.954	1	0.0854	No autocorrelation (at 5% level)	
2	3.112	2	0.2107	No autocorrelation	
3	3.268	3	0.3520	No autocorrelation	DCC-GARCH
4	3.487	4	0.4791	No autocorrelation	
5	4.019	5	0.5433	No autocorrelation	

Furthermore, model diagnostics based on residual analysis confirm the robustness of these results. Breusch–Godfrey LM test outcomes indicate that the standardized residuals exhibit no significant autocorrelation up to the 5th lag for both CCC and DCC-GARCH specifications ($p > 0.05$), as reported in Table 4.

4. DISCUSSION

The empirical findings provide several insights into the nature of financial linkages between Türkiye and Indonesia. First, the significant positive effect of Türkiye's lagged returns on Indonesia's current returns indicates a unidirectional short-term information transmission, consistent with asymmetric interactions commonly observed among emerging markets. Indonesia does not exert a similar effect on Türkiye, implying that spillovers are not reciprocal.

Second, although the correlation between the two exchange rate markets is statistically significant, its magnitude remains low (approximately 0.08) and does not exhibit meaningful time variation. The insignificance of the DCC parameters (Λ_1 and Λ_2) suggests that correlation remains stable across crisis and non-crisis periods. In theoretical terms, this pattern aligns more with interdependence - a structural co-movement arising from common macroeconomic conditions - rather than pure contagion, which requires a crisis-specific increase in correlations or sudden non-fundamental transmission driven by investor behavior.

Third, volatility dynamics reveal further asymmetries. Indonesia shows a stronger reaction to immediate shocks (higher ARCH component), whereas Türkiye's volatility is more persistent over time (higher GARCH component). These differences illustrate that the two markets do not share a synchronized volatility process, limiting the channels through which contagion could manifest.

Finally, the failure of the DCC model to capture dynamic correlation suggests that the CCC-GARCH model may be a more appropriate specification for this particular dataset. In environments where correlations display structural stability - especially among markets with limited integration - the parsimony of the CCC framework can provide more reliable and interpretable results than DCC-type models with multiple additional parameters.

5. CONCLUSION

This study investigates the existence of financial contagion and interdependence between Türkiye and Indonesia by employing multivariate GARCH models. The empirical findings indicate that information transmission between the two exchange rate markets occurs asymmetrically, with shocks originating from Türkiye affecting Indonesia in the short run, while the reverse transmission is not observed. This result suggests that the Turkish foreign exchange market may play a more influential role in transmitting short-term information within this bilateral framework. In addition, the estimated correlation between the two markets is found to be low, positive, and relatively stable over time. Such a pattern indicates the presence of structural interdependence rather than crisis-driven contagion effects.

The volatility dynamics further reveal important differences between the two economies. While volatility persistence is stronger in Türkiye, indicating that shocks tend to remain in the market for a longer period, Indonesia appears to respond more strongly to immediate shocks. This asymmetric volatility structure suggests that the two exchange rate markets react differently to external disturbances and macroeconomic developments. Moreover, the results show that the dynamic conditional correlation (DCC) model does not capture significant time-varying correlation between the markets. Instead, the constant conditional correlation (CCC-GARCH) model provides a more appropriate representation of the relationship between the two exchange rates, implying that the degree of co-movement remains largely stable throughout the sample period.

Overall, the findings suggest that although weak but statistically significant linkages exist between the Turkish and Indonesian exchange rate markets, these linkages do not intensify during periods of market stress and therefore cannot be interpreted as pure financial contagion. From a policy perspective, these results imply that policymakers in both countries should focus on strengthening domestic financial stability mechanisms rather than assuming strong external contagion channels between the two markets. In particular, maintaining credible monetary policy frameworks, enhancing foreign exchange market transparency, and strengthening macroprudential regulations may help reduce the vulnerability of exchange rates to external shocks. Furthermore, given the asymmetric volatility responses observed in the analysis, policymakers should adopt country-specific risk management strategies that account for the distinct volatility structures of their financial markets. Such measures may contribute to improving financial resilience and limiting the potential transmission of external financial disturbances.

6. LIMITATIONS AND FUTURE RESEARCH

The analysis relies solely on daily exchange rate data and does not incorporate other potential contagion channels such as equity markets, interest rate spreads, or capital flow indicators. Moreover, only GARCH-based models are utilized, and nonlinear or regime-switching transmission mechanisms may not be fully captured. Future research could integrate macroeconomic variables, expand the set of emerging markets studied, or employ alternative frameworks such as TVP-VAR, wavelet coherence, machine learning-based volatility models, and event-driven sub-period analyses to better identify regime shifts in contagion dynamics.

AUTHOR STATEMENT

Statement of Research and Publication Ethics

This study has been prepared in accordance with scientific research and publication ethics.

Author Contributions

Gözde Bozkurt: Contribution rate (100%)

Conflict of Interest

There is no conflict of interest for the authors or third parties arising from the study.

REFERENCES

Aielli, G. P. (2013). Dynamic conditional correlations: On properties and estimation. *Journal of Business & Economic Statistics*, *31*(3), 282–299. https://doi.org/10.1080/07350015.2013.771360

Akkaya, M., Kantar, L., & Azimova, T. (2022). COVID-19 pandemisi ve hisse senedi borsalarında bulaşma etkisi: VCC-MGARCH analizi. *25. Finans Sempozyumu Bildiri Kitabı*, 175–191. Burdur, Türkiye.

Bollerslev, T. (1990). Modeling the coherence in short-run nominal exchange rates: A multivariate generalized ARCH model. *The Review of Economics and Statistics*, *72*(3), 498–505.

Budak, H. Z. (2017). Finansal bulaşma üzerine bir literatür incelemesi. *Marmara Üniversitesi İktisadi ve İdari Bilimler Dergisi*, *39*(2), 451–472. https://doi.org/10.14780/muiibd.384138

Caporin, M., & McAleer, M. (2008). Scalar dynamic conditional correlation (DCC) GARCH models: Theoretical and empirical analysis. *Econometric Reviews*, *27*(3), 254–272.

Değirmenci, N., & Abdioğlu, Z. (2017). Finansal piyasalar arasındaki oynaklık yayılımı. *Dumlupınar Üniversitesi Sosyal Bilimler Dergisi*, 54, 107–125.

Doğru, E. (2024). Finansal türbülans dönemlerinde gelişmekte olan hisse senedi piyasaları arasında dinamik getiri bağlantılılığı. *Alanya Akademik Bakış*, *8*(2), 441–457. https://doi.org/10.29023/alanyaakademik.1314233

Eichengreen, B., Rose, A. K., & Wyplosz, C. (1996). *Contagious currency crises* (NBER Working Paper No. 5681). National Bureau of Economic Research. https://doi.org/10.3386/w5681

Engle, R. (2002). Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroskedasticity models. *Journal of Business & Economic Statistics*, *20*(3), 339–350.

Engle, R. F., & Sheppard, K. (2001). *Theoretical and empirical properties of dynamic conditional correlation multivariate GARCH* (NBER Working Paper No. 8554). National Bureau of Economic Research.

Falianty, T., & Budimanta, A. (2020). Contagion, exchange rate, and financial volatility: Indonesian case in global financial turbulence. In A. Rozanov, A. Barannikov, O. Belyaeva, & M. Smirnov (Eds.), *Public sector crisis management*. IntechOpen. https://doi.org/10.5772/intechopen.92275

Forbes, K. J., & Rigobon, R. (2002). No contagion, only interdependence: Measuring stock market comovements. *The Journal of Finance*, *57*(5), 2223–2261. https://doi.org/10.1111/0022-1082.00494

Forbes, K., & Rigobon, R. (2000). *Contagion in Latin America: Definitions, measurement, and policy implications* (NBER Working Paper No. 7885). National Bureau of Economic Research.

Forbes, K., & Rigobon, R. (2001). Measuring contagion: Conceptual and empirical issues. In S. Claessens & K. J. Forbes (Eds.), *International financial contagion* (pp. 43–66). Springer US.

Hafner, C. M., & Laurent, S. (2007). A note on the estimation of dynamic conditional correlation models. *International Statistical Review*, *75*(3), 338–350.

Hafner, C. M., & Reznikova, O. (2012). On the estimation of dynamic conditional correlation models. *Computational Statistics & Data Analysis*, *56*(11), 3533–3545. https://doi.org/10.1016/j.csda.2010.09.02

Hepsağ, A., & Akçalı, B. Y. (2016). Dinamik koşullu korelasyon modelleri: BIST 30 üzerine bir uygulama. *Ege Akademik Bakış*, *16*(1), 51–62.

Li, Y., Zhuang, X., & Wang, J. (2021). Analysis of the cross-region risk contagion effect in stock market based on volatility spillover networks: Evidence from China. *The North American Journal of Economics and Finance*, 56, 101359. https://doi.org/10.1016/j.najef.2020.101359

Nazlıoğlu, E. H., & Kök, D. (2021). Contagion in Turkish stock market: Evidences from developed and emerging markets. *Ege Academic Review*, *21*(4), 407–425. https://doi.org/10.21121/eab.1015640

Sachs, J., Tornell, A., & Velasco, A. (1996). Financial crises in emerging markets: The lessons from 1995. *Brookings Papers on Economic Activity*, 1996(1), 147–215.

Su, W., & Huang, Y. (2010). *Comparison of multivariate GARCH models with application to zero coupon bond volatility*. [Unpublished thesis]. Lund University.

The Guardian. (2018, August 13). Turkish lira crash ripples through global currency markets. Retrieved on December 27, 2025 from https://www.theguardian.com/business/2018/aug/13/turkish-lira-record-low-ripples-through-global-currency-markets

Tse, Y. K., & Tsui, A. K. C. (2002). A multivariate generalized autoregressive conditional heteroscedasticity model with time-varying correlations. *Journal of Business & Economic Statistics*, *20*(3), 351–362.

Voice of America (VOA). (2018, September 5). Indonesia battles currency woes. Retrieved on December 27, 2025 from https://www.voanews.com/a/indonesia-battles-currency-woes-/4566516.html

Yıldırım, E. U. (2020). The impact of COVID-19 pandemic on the financial contagion among Turkey, US, and China stock markets. *İşletme Araştırmaları Dergisi*, *12*(3), 2764–2773.

Zhang, W., Zhuang, X., Lu, Y., & Wang, J. (2020). Spatial linkage of volatility spillovers and its explanation across G20 stock markets: A network framework. *International Review of Financial Analysis*, 71, 101454. https://doi.org/10.1016/j.irfa.2020.101454