International Journal of Business & Economic Studies
Year: 2023, Vol: 5, No: 4, pp.225-237
https://doi.org/10.54821/uiecd.1392184

# The Volatility Relationship Among Financial Assets: TVP-VAR Model

*Finansal Varlıklar Arasındaki Volatilite İlişkisi: TVP-VAR Modeli*

**Burhan ERDOĞAN**
*Asst. Prof. Dr., Sivas Cumhuriyet University*
burhanerdogan@cumhuriyet.edu.tr
https://orcid.org/0000-0002-6171-0554

Received : 17.11.2023
Revised : 22.12.2023
Accepted : 23.12.2023
Type of Article : Research

***Keywords:***
*Finance,*
*Volatility,*
*TVP-VAR*

***Jel Codes:***
*D53, F65*

**ABSTRACT**

*In the post-pandemic period, intense fluctuations in interest rates, inflation, and prices were observed in many countries around the world. This study was conducted to analyze the dynamic interconnectedness between financial assets during this turbulent period. The study was conducted using TVP-VAR analysis on daily data of one-month deposit interest rate, BIST100 index return, two-year bond interest rate, USDTRY exchange rate, gold ounce price and CDS premiums between 2018 and 2023. The results of the study show that the interaction between variables reached a very high level especially in the post-pandemic period and then decreased over the years. On the other hand, the BIST100 index, gold and CDS premium are net shock emitters, while deposits, USDTRY and bonds are net shock receivers. It is aimed that the results obtained will enable investors to choose the right investment instrument in today's financial markets where prices, returns, and rates fluctuate, and on the other hand, it is aimed to benefit firms and policymakers in terms of macro problems in the current geography.*

***Anahtar Kelimeler:***
*Finans,*
*Oynaklık,*
*TVP-VAR*

***Jel Kodları:***
*D53, F65*

**ÖZET**

*Pandemi sonrası dönemde birçok dünya ülkesinde faiz, enflasyon ve fiyatlarda yoğun dalgalanmalar görülmüştür. Bu çalışma yaşanan bu çalkantılı dönemde finansal varlıklar arasındaki dinamik bağlantılılığın analizi amacıyla gerçekleştirilmiştir. Çalışma 2018-2023 yılları arasındaki bir aylık mevduat faiz oranı, BİST100 endeksi getirisi, iki yıl vadeli tahvil faiz oranı, USDTRY kuru, altın ons fiyatı ve CDS primlerinin günlük verileri üzerinden TVP-VAR analizi kullanılarak gerçekleştirilmiştir. Çalışma sonuçları özellikle pandemi sonrası dönemde değişkenler arasındaki etkileşimin çok yüksek bir seviyeye çıktığını daha sonra yıllar itibariyle azaldığını göstermektedir. Diğer taraftan BİST100 endeksi, altın ve CDS priminin net şok yayıcı varlıklar olurken mevduat, USDTRY ve tahvil değişkenlerinin ise net şok alıcı değişkenler olduğu tespit edilmiştir. Elde edilen sonuçların fiyat, getiri ve oranların dalgalı bir görünüm sergilediği günümüz finansal piyasalarında özellikle yatırımcıların doğru yatırım aracını seçmesine imkan vermesi ve diğer taraftan bulunulan coğrafyadaki makro problemler açısından firmalara ve politika yapıcılara fayda sağlaması amaçlanmaktadır.*

**Suggested Citation:** Erdoğan B. (2023). The volatility relationship among financial assets: TVP-VAR model. *International Journal of Business and Economic Studies*, 5(4), 225-237, Doi: https://doi.org/10.54821/uiecd.1392184

## 1. INTRODUCTION

The concept of volatility refers to the interaction of volatility in one country's markets with volatility in another country's markets (Dornbusch et al., 2000). The need for theoretical and empirical knowledge on volatility is increasing given the continuous development of new and more complex financial instruments that have entered the market as a result of the rapid growth in financial markets (McAleer & Medeiros, 2008:10).

Understanding how volatility occurs and measuring its effects are important to contribute to the functionality of financial markets and to ensure investor confidence. Investors may have problems with their confidence in the market in case of sudden fluctuations in assets, and this may lead to a slowdown in capital flows to the market (Daly, 2008: 2378).

Volatility spillovers generally show their effects in financial markets and, depending on the strength of the resulting effect, are expressed as a guide for investors to make decisions and determine policies. While the policies determined create some results at the point of interaction of states at the macro level, they also show some effects on individuals and institutions (Değirmenci, 2017: 162-163).

The intense mobility of capital in today's economic life has enabled investors to invest anywhere in the world. In addition, as a result of the penetration of information technologies into every aspect of life every day, transaction volumes in financial markets have increased (Şenol & Türkay, 2020: 362).

In this study, we analyze the volatility among financial assets in Turkey by using the TVP-VAR model introduced to the literature by Diebold & Yılmaz (2009) and developed by Antonakakis et al. (2019). The data of the study includes daily data of the variables determined between 2018-2023[1]. The variables used in the study are the 1-month deposit interest rate, 2-year benchmark bond interest rate, USDTRY exchange rate, BIST100 index return, gold ounce return, and CDS premium.

The criteria preferred in the study are expected to enable investors to choose the right investment instrument due to the recent intense price fluctuations, high interest rates, and high inflation figures. This study is very important in terms of monitoring the impact of assets on each other, especially in times of crisis in the financial sector. In addition, it is also aimed to provide guidance on how investors should follow a path in their investment decisions. In today's financial life, individuals and businesses desire to know how financial assets move to make the best investment decision due to reasons such as high capital mobility and increasing competition.

Recently, the number of investors in financial markets, especially in the stock market, has increased in parallel with the returns and the number of firms traded. Official statistics published by TurkStat[2] indicate that the BIST100 index is the investment instrument that provides the highest return with 65% (Turkish Statistical Institute). Investors' preference for instruments with high returns has caused the BIST100 index to spread volatility over other investment instruments.

Especially in developing economies such as Turkey, it is important to analyze the relationship between financial assets and each other in order for investments to support the economic and social development of the country. The study conducted for this purpose offers an original content for the reader in terms of the variables used and the analysis period, although the TVP-VAR method has been widely preferred in the literature in recent years.

The study consists of five sections: introduction where basic information is presented, literature including previous studies, methodology where the proposed method is applied, findings including the results of the study, conclusion, and evaluation.

## 2. LITERATURE REVIEW

Although there are few studies in the domestic literature to analyze the volatility among assets in financial markets, there has been an increasing trend in recent years. In international studies, stock market, oil prices, CDS premium, exchange rates and different country indices are generally preferred. On the other hand, studies conducted in Turkey generally use deposit interest rates, bond interest rates, gold prices, foreign exchange rates and BIST indices. Table 1 below presents some studies from the domestic and foreign literature using the TVP-VAR method.

[1] Until the data on 10.23.2023.
[2] Turkish Statistical Institute

**Table 1.** Literature Review

| Author(s) | Study period and variables | Study results |
|---|---|---|
| Jebabli et al. (2014) | The study was conducted to measure the effects of shocks in world stock markets and oil prices on food prices during the 2008 global financial crisis. Crude oil, MSCI (Morgan Stanley Capital International) and food products such as maize, banana, beef, fish and lamb were used as variables. | The study finds that shocks from crude oil and MSCI variables are transmitted to food products. It was stated that volatility reached higher levels in periods when the effects of the crisis increased. |
| He et al. (2018) | The study was conducted to analyse the relationship between the Chinese housing market and bank loans in the period 2005-2017. | According to the findings of the study, there is a time-varying relationship between house prices and bank loans, and this relationship between the two variables differs on the demand and supply side. In particular, the effect of house prices on bank loans is found to be higher. |
| Liu et al. (2019) | The study was conducted to analyze the volatility of the Chinese stock market on other global stock markets. The data of 28 different stock markets such as Shanghai Composite Index (China), AEX (Netherlands), All Ordinaries (Australia), Bell20 Index (Belgium), Bovespa (Brazil), CAC40 (France), DAX (Germany), Dow Jones Industrial Average (USA), FTSE100 (UK), Hang Seng (Hong Kong), IBEX35 (Spain) were used in the study. | According to the results of the study, it is stated that TVP models produce more accurate results than other models in analyzing the relationship between stock markets and the Chinese stock market has a higher impact on other stock markets. |
| Dahir et al. (2020) | The study was conducted to investigate the volatility between Bitcoin and the stock market in BRICS countries (Brazil, Russia, India, China and South Africa) during the period 2012-2018. | The results of the study show that Bitcoin does not have a significant impact on the stock markets of the BRICS countries, but the stock markets of these countries spread volatility to Bitcoin. |
| Zhou et al. (2020) | The study was conducted to analyze the effects of the geopolitical risk variable (GPR) on the returns of rare metals in China. | The results show that the effects of the GPRs variable on stock returns of rare metals were positive before 2012 and negative in the following years, and the results suggest that China should take hedging-oriented measures for these markets. |
| Adekoya & Oliyide (2021) | The study was conducted to analyze how the COVID-19 pandemic has affected the connectivity between financial markets and commodities. For this purpose, gold, stock market, USDEUR, Bitcoin and oil prices are used as variables. | The results of the study reveal that gold and the dollar are net recipients of shocks, while the other variables stock market, Bitcoin and oil are net shock propagators. It also showed that the COVID-19 pandemic was largely responsible for the risk transmission between financial markets and commodities. |
| Asl et al. (2021) | The study was conducted to analyze the volatility spreads between the cryptocurrencies Bitcoin, Ethereum and Stellar in the period 2018-2021. | According to the findings obtained as a result of the analyzes, it is determined that the negative volatility in the cryptocurrency market is higher and Ethereum is the most shock-emitting variable. On the other hand, while Bitcoin is a shock-spreader in the early periods, it exhibits a shock-receiver outlook in the later periods. |
| Zhang et al. (2021) | The study was conducted to analyze the volatility between the US stock market and the risk of a Chinese stock market crash. The study period covers the period from 2000 to 2019 and Shanghai Composite Index, CSI 300 Index, return of S&P 500 index (SPR) and Dow Jones industrial average (DJIAR) are used as variables. | The results show that the effects between US stock volatility and the risk of a Chinese stock market crash are increasing, and the depreciation of the domestic currency further increases the risk of a stock market crash. |
| Akyıldırım et al. (2022) | The study was conducted to analyze the dynamic interconnectedness among assets in the Turkish | The results of the study show that the level of dynamic interconnectedness between |

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|---|---|---|
| | financial markets. The study period is 2008-2021 and the variables of deposit rate, BIST100 index, USDTRY exchange rate, bonds, commodities, CDS premium are used. | assets increases during periods of stress in the analyzed period. In addition, it is stated that the exchange rate and the CDS premium are shock emitters while the deposit rate, bond and commodity markets are shock absorbers. The BIST100 index, on the other hand, exhibits both shock-receiving and shock-spreading characteristics over time. |
| Arı (2022) | The study was conducted to analyze the impact of the Russia-Ukraine war on global markets. The study analyzed data from 2018-2022 and included 20 different stock market indices such as Dow Jones Industrial Average (USA), Shanghai Composite (CHN), EuroNext 100 (EUR), Nikkei 225 (JPN), United Kingdom 100 (GBR), DAX Index (DEU), MOEX Russia (RUS). | The results of the study show that the total interconnectedness was 79.91% in the first case when Russia was included and 81.44% in the second case, and that there was a fluctuation from Western markets to Eastern markets. It was also stated that the war affected all markets except the Chinese stock market. |
| Cao & Xie (2022) | The study was conducted to analyze the dynamic interconnectedness between the cryptocurrency market and the financial market. In this context, Bitcoin, Ethereum and Ripple, which are cryptocurrencies, and China's foreign exchange, commodity and foreign exchange market are preferred as variables. | The results of the study show that there is a negative volatility among assets in general and that cryptocurrencies have a similar impact on Chinese markets, but have a greater impact on commodity and exchange rate markets. In addition, Bitcoin and Ripple have positive volatility spillovers while Ethereum has a negative volatility spillover. |
| Chatziantoniou et al. (2022) | The study was conducted to analyze the volatility between crude oil and stock markets of G7 countries. American S&P500, Canadian S&P/TSX, British FTSE100, German DAX30, French CAC40, Italian FTSE MIB and Japanese Nikkei225 variables were included in the study for the period 2007-2021. | The results show that crude oil was a net shock emitter during the 2014 price collapse, but became a net shock absorber around 2018. It is also stated that during the Brexit period, the UK stock market became a net shock-spreader and the stock markets of Germany, Italy and Japan became net shock takers. |
| Akkuş & Doğan (2023) | The study was conducted to analyze the dynamic link between cryptocurrency, NFT (Non-fungible token), and DeFi (Decentralized finance). Bitcoin and Ethereum from cryptocurrencies, Tezos and Sandbox from NFTs, Chainlink and Uniswap from DeFi assets were preferred as variables in the study. | The results of the study revealed that Ethereum and Chainlink are volatility emitters while other variables are volatility takers. It was also stated that NFT assets emit less volatility than cryptocurrencies. |
| Erben Yavuz (2023) | The study was conducted to analyze the relationships between the clean energy index, sustainability, and BIST indices. For this purpose, S&P Global Clean Energy Index (GCE), Dow Jones Sustainability Index (DJSWI), and BIST Sustainability Index (BIST) variables between 2014 and 2023 were preferred in the study. | According to the results of the study, it was determined that the S&P Global Clean Energy Index, the Dow Jones Sustainability Index and the BIST Sustainability Index spread volatility to the BIST Sustainability Index, while the S&P Global Clean Energy Index spreads volatility to the Dow Jones Sustainability Index. |
| Gökgöz & Kayahan (2023) | The study was conducted to analyze the volatility between the Bitcoin cryptocurrency and the markets. The years 2017-2022 were selected as the study period and Bitcoin, MSCI (Morgan Stanley Capital International) US index, MSCI Europe index and MSCI emerging markets index were preferred as variables. | As a result of the study, it was determined that Bitcoin cryptocurrency has a structure that takes volatility from MSCI US and MSC Europe variables and emits volatility against MSCI emerging economies. It is also stated that there is a weak link between Bitcoin and the markets. |
| Höl (2023) | The study was conducted to measure the volatility among financial assets in Turkey during the COVID-19 period. For this purpose, gold, Bitcoin, BIST100 index, dollar exchange rate and WTI (West Texas Intermediate) index | According to the results of the analysis, Bitcoin and gold are volatility emitting variables, while BIST100 index, dollar exchange rate and WTI crude oil prices are volatility receiving variables. It is also stated that the BIST100 index is the |

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|---|---|---|
| | variables were preferred in the study between 2020-2022. | variable that emits the most volatility, while the same index is affected by gold, Bitcoin and dollar exchange rate variables. |
| Huang et al. (2023) | In the study analyzing the volatility between energy assets and financial markets in the period between 2018-2022, WTI (West Texas Intermediate), natural gas market (NGS), gold, S&P500, US bond, US dollar and Bitcoin variables were preferred. | As a result of the study, it is stated that the S&P500 index is a net shock emitter, followed by NGS, gold and USD. It is also stated that Bitcoin cryptocurrency is a net shock receiver. |
| Doğan et al. (2023) | The study analyzes the dynamic interconnectedness between BIST sustainability index, BIST100 index, S&P global clean energy index and S&P GSCI carbon emission allowances. The study period is 2014-2022. | As a result of the study, it is determined that the carbon emission variable spreads volatility to the S&P GCEI, BIST 100 and BIST sustainability indices, but this volatility decreased significantly during the COVID-19 period. It is also observed that there is a weak volatility from the S&P GCEI index to the BIST sustainability index and the BIST 100 index. |

## 3. METHODOLOGY

### 3.1. Data

The study was conducted to analyze the dynamic interconnectedness between variables that have the ability to affect Turkey's financial markets. While determining these variables, deposits, foreign currency, gold, stocks, bonds and gold, which are among the most preferred investment instruments, were included in the study, and the changes in CDS premiums over the years were also included in the study to analyze the extent of interaction. While selecting the deposit variable, the most preferred maturities of savers were taken as 1-month maturities by examining the official reports of the Banks Association of Turkey. The USD/TL exchange rate was chosen as the currency type and gold as the commodity. In addition, the BIST100 index (Borsa Istanbul), which has recently reached 8 million investors, has been added to the study as it is the new preference of investors. In addition, bonds with a maturity of 2 years are also included in the study as a different variable. The data used were obtained from the Central Bank, the Banks Association of Turkey and Investing statistics. Graphs of the level values of the variables included in the study are presented in Figure 1 below.

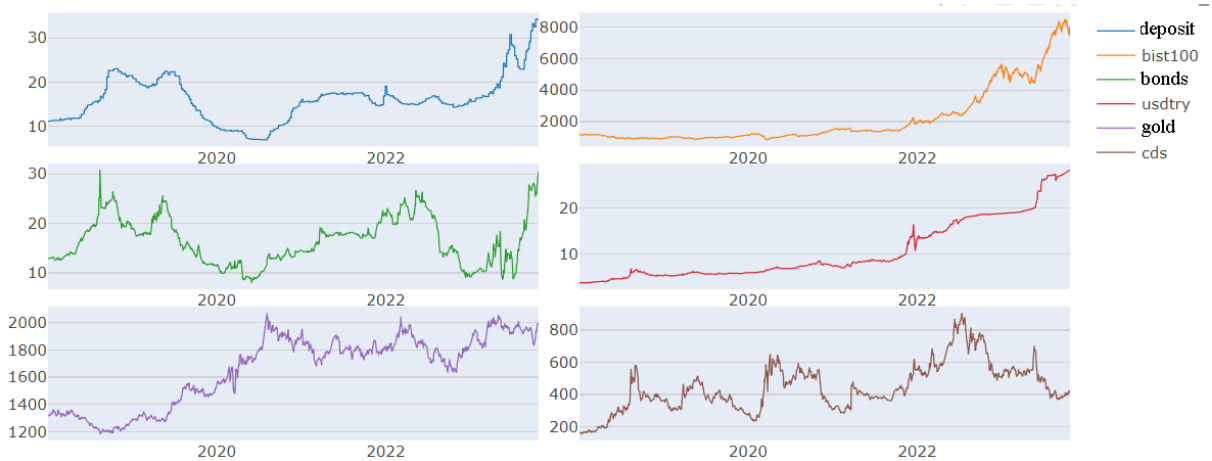


**Figure 1.** Time Path Indicators for Variables

When the values presented in Figure 1 are analyzed, it is seen that 1-month term bank deposit rates, which were slightly above 10% in early 2018, approached 40% as of October 2023 and experienced a sudden increase as of December 2021, when the decision on currency-protected deposits was taken; the number of investors in the BIST100 index reached approximately 8.5 million people in the last two years and many enterprises started to be traded on the stock exchange. 1.121 levels, the index reached 8 thousand levels as of October 2023 and moved downwards due to the recent Israeli-Palestinian tension, 2-year bond interest rates followed a highly fluctuating course as of the periods analyzed, but hovered slightly above 30 points as of October 2023. While the USDTRY exchange rate was 3.7 at the beginning of 2018, it decreased from 16 to 11 levels in one day with the announcement of the currency-protected deposit system in December 2020, but then rose to 28 levels due to the negative

developments in the markets. 300 $ at the beginning of 2018 and reached approximately 2.000 $ as of October 2023. It is observed from the graphs that there have been increases in the returns of all investment instruments as of the analyzed period. In addition, while the Credit Default Swap variable, which is expressed as the CDS premium, was at 163 levels in early 2018, it reached its highest level in the July 2020 period and exceeded 900 points and declined to 400 levels as of October 2023.

### 3.2. Method

In this study, the vector autoregression model (Time Varying Parameter- TVP-VAR) model developed by Antonakakis et al. (2019) was used to determine the interconnectedness between variables. The TVP-VAR model has advantages over other nonlinear models in that it does not require a transition variable, time-varying parameters can detect gradual changes between variables, and the time-varying variance-covariance matrix of the error terms takes into account the effect of sudden exogenous shocks (Koop et al., 2009; Caporale et al., 2021:7).

The implementation stages of the TVP-VAR model can be expressed as follows (Antonakakis et al., 2020).

$$x_t = B_t z_{t-1} + u_t \qquad u_t \sim N(0,S_t) \tag{1}$$

$$vec\,(B_t) = vec(B_{t-1}) + v_t, \qquad v_t \sim N(0,R_t) \tag{2}$$

Here, x$t$, x$t$-1 and $ut$ are N × 1 dimensional vectors. $Bt$ and $St$ are N × N dimensional matrices. Time-varying coefficients and error covariances have been developed by Koop et al. (1996); Pesaran & Shin (1998); Diebold & Yilmaz (2014) to estimate the generalized connectedness procedure. The following formula is applied to perform this estimation.

$$C_t(H) = \frac{\sum_{i,j=1,i\neq j}^{m} \tilde{\Phi}_{ij,t}\,(H)}{\sum_{i,j=1}^{m} \tilde{\Phi}_{ij,t}\,(H)} * 100 \tag{3}$$

$$= \frac{\sum_{i,j=1,i\neq j}^{m} \tilde{\Phi}_{ij,t}\,(H)}{m} *100 \tag{4}$$

This approach to interconnectedness shows how a shock to one variable propagates to other variables. We first look at the case where variable i transmits its shock to all other variables j. This is called total directional interconnectedness and is expressed as follows;

$$C_{i\rightarrow j,t}\,(H) = \frac{\sum_{i,j=1,i\neq j}^{m} \tilde{\Phi}_{ji,t}\,(H)}{\sum_{i=1}^{m} \tilde{\Phi}_{ij,t}\,(H)} * 100 \tag{5}$$

Finally, we subtract the total directional connectedness to others from the total directional connectedness from others to obtain the net total directional connectedness, which can be interpreted as the effect of variable i on the analyzed network.

$$\mathrm{C}_{i,t} = \mathrm{C}_{i\rightarrow j,t}\,(H) - \mathrm{C}_{i\leftarrow j,t}\,(H) \tag{6}$$

If C$i,t$ If positive, it means that variable i affects the network more than the network itself. Conversely, if the value C$i,t$ is negative, it means that variable *i* is directed by the network.

Finally, we compute net pairwise connectedness, further reducing net total directional connectedness to examine pairwise relationships,

$$NPDC_{ij}\,(H) = \left(\tilde{\Phi}_{jit}\,(H) - \tilde{\Phi}_{ijt}\,(H)\right) * 100 \tag{7}$$

If $NPDCij\,(H) > 0$($NPDCij\,(H)<0$) means that variable *i* dominates variable *j*.

## 4. FINDINGS

In this part of the study, the TVP-VAR model was used and the results are presented in tables and graphs below. Figure 2 presents the volatility series of the variables. When the results in the graph are analyzed, changes in all variables are clearly visible.

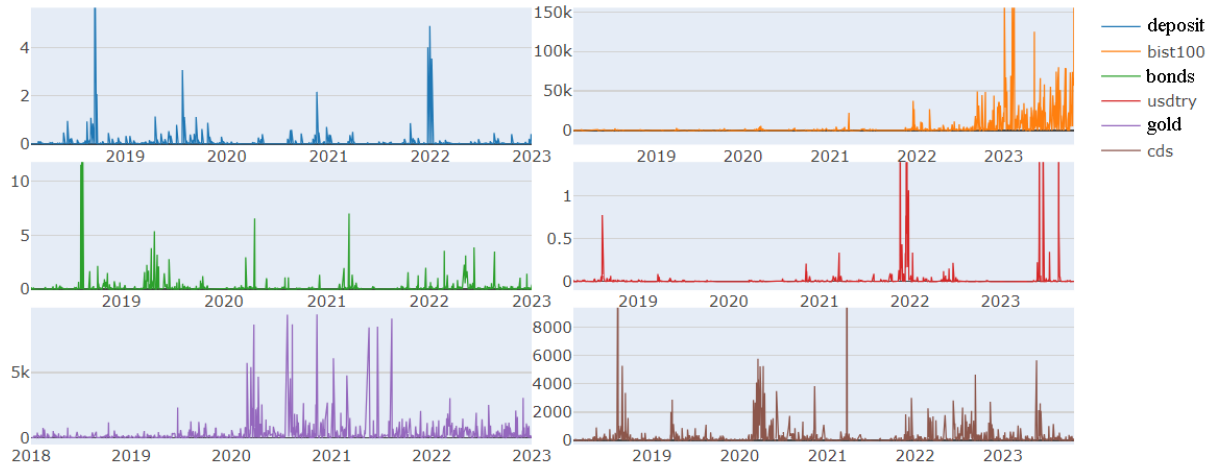


**Figure 2.** Series of Variables

Table 2. shows the descriptive statistics of volatility series. According to the Jarque-Bera test results, the variables are not normally distributed. According to the ADF test results, all variables are stationary at level 1. Q and Q2 test statistics contain autocorrelation at various levels. The autocorrelation of the series indicates that it is appropriate to use the TVP-VAR model.

**Table 2.** Descriptive Statistics of Variables

| | Deposit | Bist100 | Bonds | USDTRY | Gold | CDS |
|---|---|---|---|---|---|---|
| **Mean** | 0.1 | 4.057.177 | 0.291 | 0.026 | 302.753 | 253.446 |
| **Variance** | 0.455 | 263.886.517.881 | 3.139 | 0.068 | 722.246.435 | 880.996.212 |
| **Skewness** | 11.299*** | 9.787*** | 19.108*** | 26.123*** | 7.021*** | 14.113*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| **Ex. Kurtosis** | 150.653*** | 140.374*** | 446.228*** | 809.419*** | 61.024*** | 286.969*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| **JB** | 1323768.*** | 1145858. *** | 11441408. *** | 37527102. *** | 223664. *** | 4742912. *** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| **ERS** | -11.566 | -3.925 | -13.663 | -12.434 | -10.723 | -11.536 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| **ADF** | -3.434952*** | -3.434998*** | -3.434924*** | -3.434920*** | -3.434920*** | -3.434920*** |
| **Q(10)** | 94.877*** | 436.101*** | 87.081*** | 117.871*** | 71.221*** | 105.016*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| **Q2(10)** | 40.635*** | 29.185*** | 4.080 | 0.966 | 18.641*** | 0.588 |
| | (0.000) | (0.000) | (0.652) | (0.994) | (0.001) | (0.999) |

(*) denotes significance at 10%; (**) denotes significance at 5%; (***) denotes significance at 1%.

Table 3 presents the average dynamic interconnectedness table, which shows how much of the volatility between variables is caused by itself and how much by other variables as a result of the TVP-VAR analysis.

**Table 3.** Average Dynamic Connectedness Table

| | Deposit | BIST100 | Bonds | USDTRY | Gold | CDS | Volatility Spill-over (FROM) |
|---|---|---|---|---|---|---|---|
| **Deposit** | 61.51 | 15.48 | 10.13 | 5.46 | 4.39 | 3.04 | 38.49 |
| **BIST100** | 5.66 | 59.66 | 13.16 | 7.01 | 10.4 | 4.12 | 40.34 |
| **Bonds** | 6.5 | 17.83 | 46.84 | 7.73 | 4.36 | 16.73 | 53.16 |
| **USDTRY** | 5.18 | 17.64 | 12.11 | 52.09 | 5.5 | 7.48 | 47.91 |
| **Gold** | 2.26 | 11.92 | 3.38 | 5.1 | 73.79 | 3.55 | 26.21 |
| **CDS** | 2.97 | 9.63 | 8.48 | 6 | 6.65 | 66.28 | 33.72 |
| **Volatility Spill-over (TO)** | 22.56 | 72.51 | 47.26 | 31.29 | 31.29 | 34.92 | 239.83 |
| **NET** | -15.93 | 32.17 | -5.9 | -16.61 | 5.08 | 1.2 | 47.97 |

The results presented in Table 2 show the levels at which the variables are affected by each other. Volatility Spill-over (TO) indicates how the variables on the vertical axis affect the variables on the horizontal axis. Volatility Spill-over (FROM) shows how the variables on the horizontal axis are affected by other variables on the vertical axis. The explanation of this effect between the variables obtained as a result of the analysis is expressed below.

According to Table 2. the variables most affected by other variables were bonds with 53.16%, USDTRY with 47.91%, BIST100 with 40.34%, deposits with 38.49% and gold with 26.21%. The variables that affect other variables the most are BIST100 with 72.51%, bonds with 47.26%, gold and USDTRY with 31.29% and deposits with 22.56%.

BIST100 with 32.17%. gold with 5.08% and CDS with 1.2% are volatility-spreading variables, while deposits with -15.93%, deposits with -5.9% and USDTRY with -16.61% are volatility-receiving variables. The total dynamic interconnectedness level between the volatility spillovers of the variables is 47.97%. which means that these variables can be included in the same portfolio. Figure 3 illustrates the total level of dynamic interconnectedness between variables.

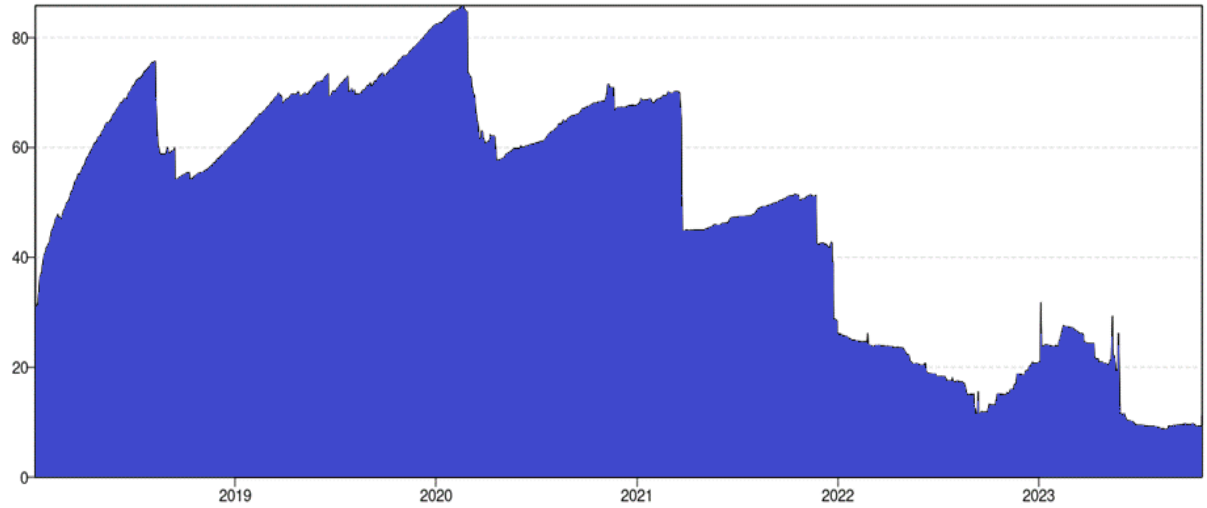


**Figure 3.** Total Dynamic Connectedness Relationship

When examined, the levels of interconnectedness between the variances of the variables remained quite high and although there was a downward trend in the second half of 2018, it reached its highest correlation level of 82.36 on February 3, 2020 with the emergence of the COVID-19 pandemic. Although a fluctuating course was observed in the following years, it is seen that it has reached its lowest levels as of October 2023.

When the information presented in Figure 4 is analyzed, the parts above the zero point indicate the periods when the relevant variable was a net shock emitter, while the parts below the axis indicate the periods when the variable was a net shock receiver.

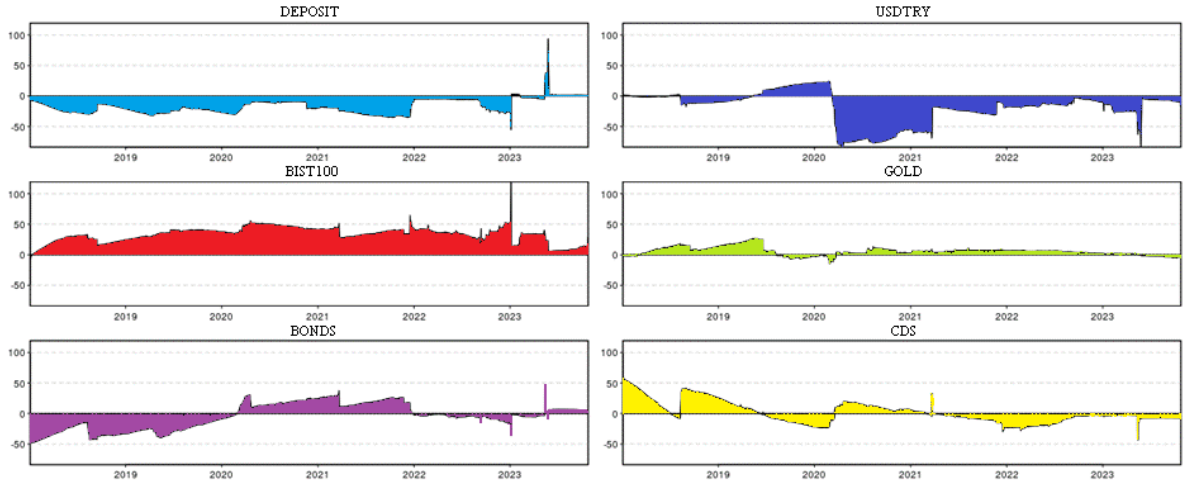


**Figure 4.** Net Volatility Indices

When the variables in Figure 4 are analyzed, it is seen that the deposit variable is a volatility absorbing variable until the last quarter of 2023, the USDTRY variable is a volatility absorbing variable although it shows changes in general, the BIST100 variable is a volatility emitting variable throughout the entire study period, and the Gold variable is a volatility emitting variable in general, It can be stated that the bond variable was a volatile variable until 2020, became a volatility-emitting variable as of 2020 and then followed a volatile outlook, and finally, the CDS variable had a volatility-emitting outlook until mid-2019, a volatility-emitting outlook from this date until April 2020, a volatility-emitting outlook until March 2021 and a volatility-emitting outlook in the following time period.

Figures 5 and 6 illustrate the movements of the bilateral diffusion indices of the variables. According to the information given in the graphs, in the relationship between deposits and the BIST100 index, it is observed that the BIST100 variable has a net shock-spreading structure and maintained this situation throughout the study period. In terms of deposits and CDS variables, it is determined that there is no spillover. When the spillovers between deposits and bonds are analyzed, it is observed that bonds have a net shock-spreading structure in almost all periods.

When the bilateral diffusion between BIST100 and bonds is analyzed, it is seen that the BIST100 variable is the net shock-spreading variable. In the diffusion graph between deposits and USDTRY, it is seen that the USDTRY variable was the net shock-spreading variable until the first quarter of 2020 and in the following periods, the situation reversed and the deposit variable became the net shock-spreading variable. When the bilateral diffusion graph of BIST100 and USDTRY variables is analyzed, it is determined that the USDTRY variable is a net shock propagator in all periods.

When the graphs of deposits and gold variables are analyzed, it is seen that the gold variable is the net shock emitter, albeit to a lesser extent, but the relationship is limited. Although there is a limited relationship between BIST100 and gold, it is observed that the BIST100 variable is a net shock emitter.

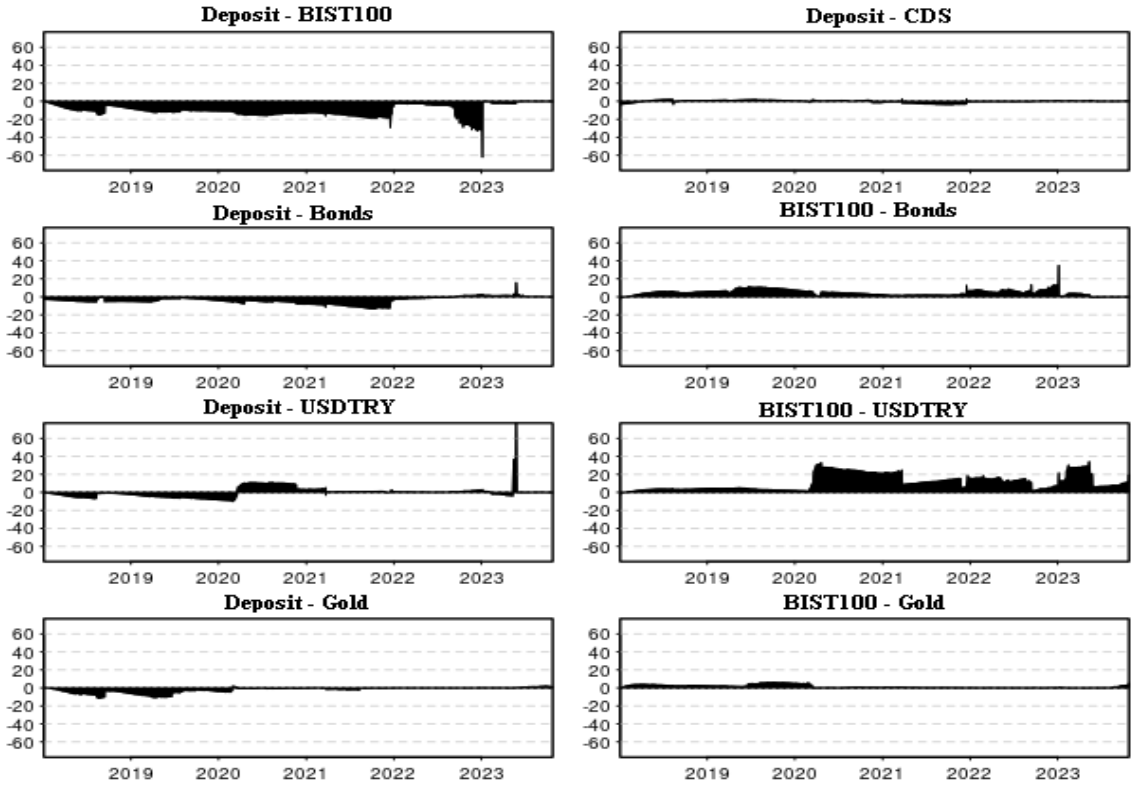


**Figure 5.** Net Bilateral Diffusion Indices among Variables

When the bilateral diffusion results given in Figure 6 are analyzed, it is seen that in the relationship between BIST100 and CDS, the BIST100 variable is the net shock-spreader in all periods. When the bilateral net spillovers between bond and USDTRY variables are analyzed, it is observed that the bond variable is the net shock-spreader in all periods. Looking at the results of the USDTRY and CDS bilateral diffusion graph, it is seen that while the USDTRY variable was the net shock emitter until the first quarter of 2020, the opposite situation emerged after this date.

When the results of gold and CDS bilateral diffusion are analyzed, it is generally determined that the gold variable is the net shock emitter. Finally, when the relationship between bonds and CDS is analyzed, it is seen that the CDS variable was the net shock emitter in 2018 and 2019, while the relationship between the variables weakened in the following periods, but the bond variable was the net shock emitter.

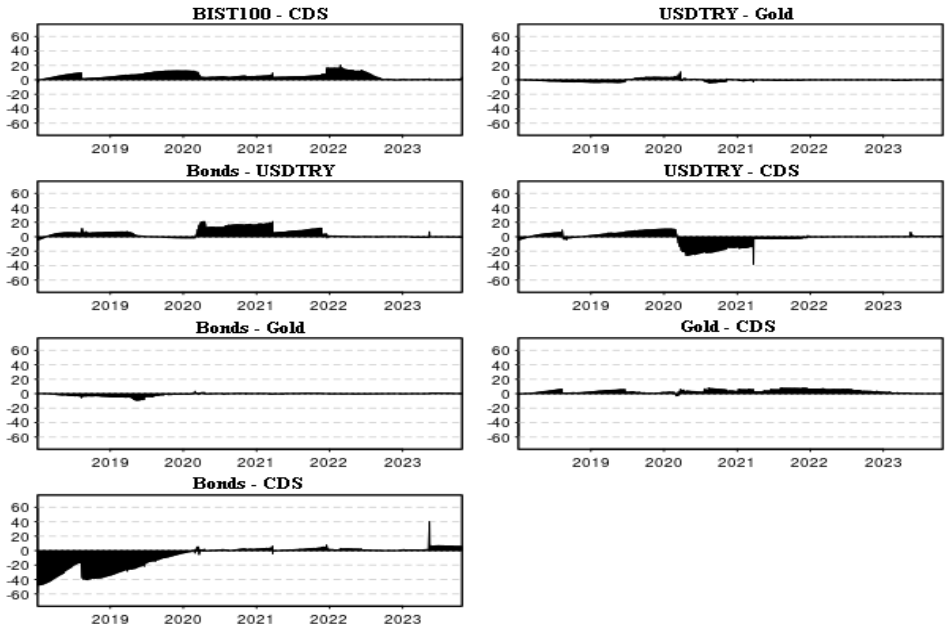


**Figure 6.** Net Bilateral Spillover Indices among Variables -2

The results presented in Figure 5 are constructed to express the strength and direction of the volatility spillovers of the variables. According to the figure, variables in yellow are volatility-receiving variables and variables in blue are volatility-spreading variables.

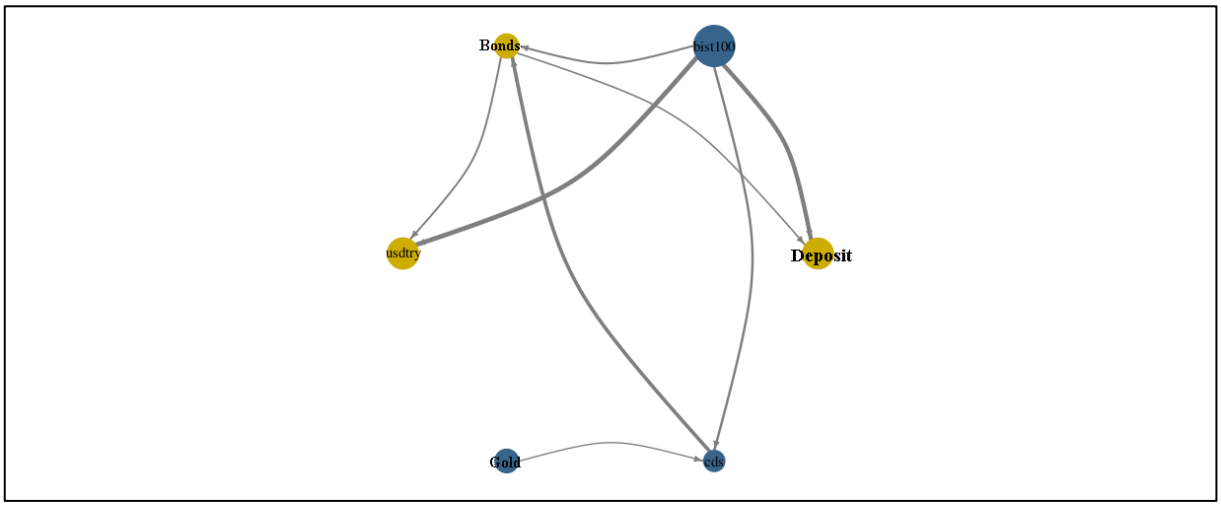


**Figure 7.** Network Plot of Volatility Spillover of Variables

The area covered by the variables indicates the strength of the spillover, and in this respect, it can be stated that the BIST100, gold and CDS variables are the variables that emit the highest volatility, and the deposit, USDTRY and bond variables are the variables that receive the highest volatility, respectively. The arrows between the variables indicate the direction of the influence relationship and the thickness of the arrows indicates the intensity of the relationship. According to the graph, it can be stated that the CDS variable has a stronger effect on bonds than on deposits and BIST100, the BIST100 variable has a stronger effect on deposits than on bonds, and the BIST100 variable has a stronger effect on USDTRY than on bonds.

When the results of the study are compared with the results of the study conducted by Akyıldırım et al. (2022), it is seen that the CDS variable continues to be a variable that emits volatility, but its impact power has weakened.

Höl (2023) has produced a similar result with the gold variable being a shock emitter and the USDTRY variable being a shock receiver, but a different result with the results of the BIST100 variable analysis.

When the results of the study are compared with previous studies, it is seen that there are different results especially for the BIST100 variable. It can be stated that the reason for this situation is the rapid increase in the number of investors and traded firms in the stock exchange in recent years. The rapid increase in the stock market index has led to a decrease in the demand for other investment instruments and resulted in an increase in the effect of the stock market on other variables.

## 5. CONCLUSION

Thanks to the new inventions of information technologies that make life easier every day, humanity has advanced in many areas compared to the past. Especially in today's financial life, competition has become more intense, capital has gained unlimited mobility and consumer preferences are constantly changing. In order to ensure the sustainability of economic growth, institutions are constantly updating their policies and individual investors resort to various measures to minimize risk.

While investors in the Turkish financial market preferred gold and foreign exchange as the main investment instruments in previous years, the fact that approximately 10% of the country's population trades in Borsa Istanbul today can be stated as the biggest example of the change in investment habits (Official Statistics of Central Securities Depository & Trade Repository of Türkiye).

The rapid growth of the BIST index in recent years has been one of the main factors attracting investors' attention. In addition. the UST/TL exchange rate, which has been rising continuously since December 2021, is seen as an important investment instrument. The relationship between investment instruments and their possible effects on each other is also very important when making investments.

In particular, this study aims to investigate the possible effects of these investment instruments on each other and the strength and direction of this effect, if any. The Covid-19 pandemic. especially in recent years, has shown how much risk factors have penetrated into our lives, thus showing once again that investors should act more carefully.

For this study, which aims to analyze the relationship between investment instruments, a daily data set including 1-month deposit interest rate, BIST100 index, 2-year bond interest rate, USDTRY exchange rate, gold ounce price and CDS variables for the period 01.02.2018-10.25.2023 was obtained from Borsa Istanbul, investing platform, CBRT (Central Bank of the Republic of Turkey), TSI (Turkish Statistical Institute), BAT (Banks Association of Turkey) statistics. This data set was analyzed by using TVP-VAR (Time-Varying Parameter) analysis to analyze the spread of investment instruments on each other.

According to the results of the dynamic interconnectedness table obtained through the analyses. the variable that affects other investment instruments the most is the BIST100 index with 72.51%. On the other hand, the variable most affected by other variables was bonded with 53.16%. The 47.97% dynamic interconnectedness level between all variables included in the analysis suggests that these variables can be included in the same portfolio basket.

The results obtained may vary in different periods due to factors such as exchange rate fluctuations in the markets, increase in the number of investors and general economic conditions in the country. In this respect, a different result can be obtained by comparing the period before and after the COVID-19 pandemic period experienced in recent years. In addition. a different perspective can be reached by comparing international and domestic markets in terms of volatility.

### 5.1. Limitations of the Study

This study. which investigates the volatility among financial assets. has some limitations. First of all. the results of the study are interpretable for the years 2018-2023. It should also be kept in mind that the results may vary when the analysis methods are changed. On the other hand. the recent sudden fluctuations in the Turkish financial markets. the fact that the pandemic effect is still passing, the Russian-Ukrainian war and the ongoing war environment in the Middle East may show differences in terms of the results of the study. In future studies. different results can be obtained by choosing a different analysis period.

### 5.2. Implications of the Study

The results of the study provide important insights for both policymakers and investors. In particular, the recent sudden fluctuations in the markets and high inflation figures have shown that many people have turned to

investment to protect their assets or to gain from rising asset prices. In this environment, policymakers need to provide a healthier environment by cleansing the markets from speculative and manipulative actions to protect investors' assets, and at the same time, they should take the necessary initiatives to ensure that investors can make informed transactions in these periods when the number of investors is increasing. For investors, the findings of the study show that bonds, foreign exchange and deposit assets are more volatile variables while the stock market is a volatility-emitting variable, which provides important information on asset selection while investing.

**AUTHORS' DECLARATION**

This paper complies with Research and Publication Ethics, has no conflict of interest to declare, and has received no financial support.

**AUTHORS' CONTRIBUTIONS**

All sections are written by the author.

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