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Volatility Spillover in the Turkish Financial Market: A QVAR Analysis

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ABSTRACT

Purpose – The volatility spillover is crucial matter for policy makers and portfolio managers to understand risk transmission between financial markets to understand where potential loss and risk comes from. In this research, it is aimed to investigate the tail risk spillover among the BIST-100 stock index, TR 10-year bonds, USD-TL exchange rate, gold futures, and Brent petroleum in Türkiye.

Design/Methodology/Approach – The quantile vector autoregressive (QVAR) model, recommended by Ando et al., (2022), is used in this study. The QVAR model is proposed method in the literature to capture the tail risk spillovers from very low to very high volatility in financial markets. The data is weekly frequency and spans from January 28, 2010, to December 8, 2023. The weekly volatility data is obtained from a formula that utilize daily maximum and minimum prices as described in Diebold and Yilmaz (2012).

Findings – The output of this study indicates that the volatility spillovers between related markets differs across different quantiles. Other results reveal that stock, bond, and currency markets are net risk spillovers during extremely low and moderately volatile periods, but gold and oil are net risk receivers. However, USD/TL is the only risk-transmitter in times of excessive volatility. Moreover, the time-varying spillover analysis shows that the total spillover index hit records during the COVID-19 outbreaks.

Discussion – The output of this study confirms the findings of previous studies that find the spillover index does not remain constant over different quantiles. The output of this study provides crucial insights to finance authorities and investors on the nature of market risk and strategies for its management.

1. INTRODUCTION

The integration of financial markets has increased the complexity of spillover effects among financial markets. The abrupt price fluctuation in one market often triggers corresponding fluctuations in other markets (i.e., stock market, commodity futures, bond market, real estate market and exchange rate). This phenomenon is commonly referred to as information transmission in financial literature (Maitra and Dawar, 2019). For example, the fear of increased market uncertainty, when investors apply higher discount rates that might result in a decline in bond prices. Consequently, there is a spillover effects from the stock market to the bond market. Conversely, an unexpected rise in commodity prices resulting from territorial disputes might elevate manufacturing expenses, thereby harming business financial statements. Consequently, the equity and dividend returns decrease due to this unexpected event. In this scenario, we expect the transmission of the spillover impact from the commodities market to the stock market. Indeed, a decline in the stock market will eventually affect the bond market, leading to a subsequent widespread impact between the markets, albeit with a certain time lag. Instances in which the spillover effect among all markets intensifies to such a degree typically coincide with periods of economic and financial crisis (Guo et al., 2020; John Wei et al., 1995; Qarni et al., 2019).

Commodities, currencies, bonds, and stock prices exhibit fundamental interconnections with one another (Reboredo et al., 2021). Several academic papers have analyzed the relationship between these financial assets in different combinations. For instance, Baruník et al. (2016) utilize a wavelet method and conduct a time-frequency analysis of dynamic correlations among gold, oil, and stocks throughout periods of recession and financial turmoil. The findings indicate that during periods of economic contraction and financial instability, there is a prominent presence of variations in the relationships between pairs of assets (namely gold, oil, and

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stocks) over different economic conditions. In their study, Y. Zhang et al. (2021) investigate the volatility spillover between gold spots, gold futures, stocks, bonds, and oil by utilizing multivariate VAR-CCC-GARCH and VAR-DCC-GARCH models. Their empirical findings indicate that Chinese gold spots and futures are unable to fulfill the function of hedging due to their weak correlations with Chinese stocks, bonds, and oil price. In addition, Iqbal et al. (2022) examine the transmission of volatility between different equity markets and asset classes using a quantile-based methodology. They observe that the roles of financial assets as transmitters and receivers of volatility alter depending on the degree of volatility level.

This study uniquely explores the spillover effect among the four primary financial markets and assets, an area that has received limited attention in academic literature. While many papers have examined dual and triple relationships among these variables, this study refrains from delving into theoretical discussions. For instance, Yaya et al. (2016) utilized the Constant Conditional Correlation (CCC) approach to analyze volatility and returns spillovers between oil and gold markets. Their findings reveal that gold market volatility is consistently lower than that of the oil market, both before and after crisis periods. They also note bidirectional returns spillover before crises, which shifts to unidirectional from gold to oil markets post-crisis. Aboura and Chevallier (2015) similarly identified significant evidence of return and volatility spillovers between commodity and financial markets. Employing the asymmetric DCC with one exogenous variable (ADCCX) framework, their research underscores the substantial impact these markets have on each other.

Moreover, Yoon et al. (2019) quantified the net pairwise spillover return connectedness among stock, currency, bond, and commodity markets. Their empirical findings reveal that the SandP 500 is the primary contributor of return spillover shocks for Asia-Pacific stock markets, while several other indices are significant recipients of these shocks. Additionally, several other notable studies (Abuzayed and Al-Fayoumi, 2021; Chevallier and Ielpo, 2013; Karim and Naeem, 2022; Yang and Zhou, 2017; Zha et al., 2023) have focused on return and volatility spillovers in financial markets.

There is a scarcity of literature about the volatility spillover across distinct financial markets in Turkey. Gencer and Musoglu (2014) examine the volatility spillover between gold, the Turkish stock market, and government bond indexes. The empirical findings demonstrate that there is a two-way transfer of shocks and volatility between gold prices and the Turkish stock market, but there is only a one-way transfer from gold to Turkish government bonds. In their study, Alkan and Çiçek (2020) investigate the impact of global markets on Turkish financial markets by using the VAR-BEKK-GARCH model. The empirical findings provide substantial evidence of a significant spillover effect between pairs of financial markets. The most closely related study to the topic of this study is undertaken by Karabıyık (2020), who aims to quantify the spillover effects across commodities, bond, exchange rate, and stock markets in Turkey. However, they take into consideration mean-based model to measure a relationship. Unfortunately, these models fail to accurately estimate spillover effects during severe market conditions as they disregard the tail distribution. Additional studies such as Abioğlu (2021), Akkoc and Civcir (2019), Alola et al. (2019), Bajo-Rubio et al. (2017), Can Ergün and Karabıyık (2020), Cevik et al. (2020), Coskun and Taspinar (2022), Dursun et al. (2021), Gürbüz and Şahbaz (2022), Kara et al. (2022), Karakaya and Kutlu (2023), Özdemir et al. (2018), Ustaoğlu (2022), and Vardar and Aydogan (2019) have been conducted to investigate the return and/or volatility spillovers between major financial markets, with a particular emphasis on the Turkish economy.

Prior research has predominantly relied on mean-based estimates to measure connectedness among financial assets/markets. However, these estimates may not be appropriate for evaluating connectedness during severe market conditions, especially in the tails of the conditional distribution (Dai et al., 2023). During such extreme volatile times, focusing the quantile approach provides more benefits and information compared to emphasizing mean-based models (Balcilar et al., 2017, 2022; Tiwari et al., 2022) As an illustration, Mensi et al. (2022) investigate the transmission of returns at different quantiles and the interconnectedness among these markets. The findings indicate that the return spillover between the markets under investigation is more prominent under bearish market conditions than during bullish conditions. Moreover, Mensi et al. (2023) investigate the spillovers and connectedness of oil and African stock markets during bearish, normal, and bullish market conditions. By employing the quantile connectedness method, they reach evidence to support higher spillovers exist under bearish market conditions than in both tranquil and bullish market conditions. In addition, Liu et al. (2021) examine the spillover of extreme downside risks from the crude oil market to the stock markets of twelve major oil-importing and seven oil-exporting countries. They find that the spillover effects among oil and stock markets are different at the left and right volatility distributions.

This study examines the risk spillover across BIST-100, TR 10-year bonds, USD-TL, gold futures, and Brent petroleum at different quantiles in Turkey by using quantile connectedness method conducted by Ando et al. (2022). Our analysis encompasses gold and crude oil, which are often regarded as the primary benchmarks in the extensive commodities markets (Balcilar et al., 2019; Trabelsi, 2019; Y. J. Zhang and Wei, 2010). We utilize weekly data from January 28, 2010, to December 8, 2023. We contribute to the existing body of literature in three distinct manners. To get insight into the risk transmission within the Turkish economy, we analyze the interconnections among the major financial markets. The observation periods encompass significant economic events, like the European debt crisis, the 2016 coup attempt and Brexit, the 2018 currency crisis, and the 2020 COVID-19 health crisis. These extreme financial crises provide an opportunity to comprehend alterations in risk spillover. Furthermore, we employ the quantile vector autoregressive (QVAR) model to gain a more precise understanding of how volatility is transmitted during times of economic crises. Additionally, we have incorporated gold and oil into the research as significant external factors affecting Turkish financial markets. Oil is crucial for industry, whereas gold is renowned among portfolio investors as a hedging strategy against risky assets.

The empirical findings show the average value of the dynamic total spillover index across stocks, bonds, currencies, gold, and oil is 36% at 0.50 quantile. However, the total spillover takes value of 62% and 79% under the left tail and right tail estimations, respectively. Secondly, under extreme market conditions, only the exchange rate is a net transmitter of systemic shocks, while the remaining markets analyzed are net receivers. Thirdly, the level of connectedness fluctuates over time in all cases, and the transmission of risk between financial markets undergoes significant variations during periods of very low and high volatility. Finally, recent unexpected economic events in Türkiye can intensify the risk spillover. An intriguing discovery is that the COVID-19 health crisis, among others, had a significantly larger impact on spillovers throughout the observation period.

The remaining parts of the paper are structured in the following manner: Section 2 provides an in-depth analysis of the econometric methodology. Section 3 provides an overview of the dataset and examines its descriptive statistics. Section 4 presents and analyzes the empirical findings, whilst Section 5 and Section 6 provide the discussions and conclusions of the paper.

2. METHOD

The analysis of the spillover effect between financial assets or markets is commonly addressed in the literature. Various econometric models can be used to analyze the spillover effect, and the method developed by Diebold and Yilmaz (2009) has come into prominence in recent academic papers (Balcilar et al., 2019, 2020; Baruńik et al., 2015; Geng et al., 2021; Koutmos, 2018; Le et al., 2022; Qarni et al., 2019; Sabkha et al., 2019). First, DY relies on Cholesky-factor identification of VARs, so the resulting variance decompositions can be dependent on variable ordering. Then Diebold and Yilmaz (2012) extended DY index to utilize a generalized vector autoregressive framework in which forecast-error variance decompositions are invariant to variable ordering. Standard VAR models estimate the mean value of the distribution while determining the coefficients of the model. However, if the distribution of the time series is not elliptical, the accuracy of the model's predictions is called into doubt (Balcilar et al., 2019). If the average shock hits the system, we may expect to estimate average network structure. But systemic shocks create larger shocks, and we can't expect those large shocks to propagate in the same way as smaller shocks. To address this issue, Ando et al. (2022) proposed a novel model that utilizes regression quantiles to analyze the connectedness at various quantiles. In this study, we use their approach.

Here, we offer an explanation of a quantile VAR model, QVAR (p), using an infinite-order vector moving average (MA) representation as follows:

$$y_t = \mu(q) + \sum_{j}^{p} \Phi_j(q) y_{t-j} + u_t(q) = \mu(q) + \sum_{i=0}^{\infty} \Omega_i(q) u_{t-i}, \tag{1}$$

where the quantile value (q) ranges from 0 to 1, inclusive. The specification of the generalized forecast error variance decomposition (GFEVD) with a forecast horizon H is based on the study of Koop et al. (1996) and Pesaran and Shin (1998).

$$\Theta_{ij}^{g}(H) = \frac{\Sigma(q)_{jj}^{-1}\sum_{h=0}^{H-1}\left(e_i'\Omega_h(q)\Sigma(q)e_j\right)^2}{\sum_{h=0}^{H-1}(e_i'\Omega_h(q)\Sigma(\tau)\Omega_h(q)'e_i)} \tag{2}$$

where the symbol e_i denotes a zero vector with a value of 1 in the i[th] position. The normalization of each element in the decomposition matrix can be expressed as follows:

$$\widetilde{\Theta}_{ij}^{g}(H) = \frac{\Theta_{ij}^{g}(H)}{\sum_{j=1}^{k}\Theta_{ij}^{g}(H)}, \text{with} \sum_{j=1}^{k}\widetilde{\Theta}_{ij}^{g} = 1 \text{and} \sum_{i,j=1}^{k}\widetilde{\Theta}_{ij}^{g}(H) = 1 \tag{3}$$

Therefore, we can represent the measurements of risk spillover and connectedness based on a particular 'q' quantile basis as:

$$TO_{j,t} = \sum_{i=1, i\neq j}^{k}\widetilde{\Theta}_{ij,t}^{g}(H) \tag{4}$$

$$FROM_{j,t} = \sum_{i=1, i\neq j}^{k}\widetilde{\Theta}_{ji,t}^{g}(H) \tag{5}$$

$$NET_{j,t} = TO_{j,t} - FROM_{j,t} \tag{6}$$

$$TCI_t = \frac{\sum_{i,j=1, i\neq j}^{k}\widetilde{\Theta}_{ij}^{g}(H)}{k-1} \tag{7}$$

$$NPDC_{ij,t} = \widetilde{\Theta}_{ij,t}(H) - \widetilde{\Theta}_{ji,t}(H) \tag{8}$$

where $TO_{j,t}$ shows the overall effect from financial market *j TO* all other financial markets, while $FROM_{j,t}$ indicates the overall effect *FROM* all other variables to financial market *j*. Moreover, $NET_{j,t}$ represents the difference between *TO* and *FROM*. The positive value indicates that the financial market *j* is a net transmitter in the market, whereas a negative value indicates its net receiver role. TCI_t represents the total connectedness index in the market. $NPDC_{ij,t}$ determines the dominant market relative to other single market. If $NPDC_{ij,t}$ is greater than zero, the volatility spillover effect from market *i* to market *j* is dominant to the volatility spillover effect from market *j* to market *i*. In case of $NPDC_{ij,t}$ is less than zero, the inverse is true.

3. DATA AND DESCRIPTIVE STATISTICS

This study examines the spillover of risk between BIST-100, TR 10-year bonds, USD-TL, gold futures, and Brent petroleum at various quantiles. To determine the volatility of the data, we analyze daily data from January 28, 2010, to December 8, 2023. The future prices of gold and oil are denominated in U.S. dollars. Following Diebold and Yilmaz (2012), we estimate the daily variance for financial market *i* on day *t* as follows:

$$\tilde{\sigma}_{it}^2 = 0.361[ln(P_{it}^{\max}) - ln(P_{it}^{\min})]^2, \tag{9}$$

where $P_{it}^{\max}$ represents the maximum price observed in the market on day *t*, whereas $P_{it}^{\min}$ represents the minimum price observed on the same day. To get annualized historical volatility, we use $\hat{\sigma}_{it} = 100\sqrt{365 \bullet \hat{\sigma}_{it}^2}$ formula. Furthermore, as illustrated in Fig. 1, market prices appear to be highly volatile, so we prefer to use weekly data rather than daily data. When calculating the weekly volatility series, we derive it by averaging the daily volatility. Fig. 1 displays the volatilities of the five financial markets, while Table 1 presents the summary statistics of the logarithmic volatility. Some noteworthy conclusion emerges from these observations: (1) Both the oil market and 10-year Turkish government bonds display significantly higher levels of volatility compared to other series. (2) Our analysis indicates that volatility persistence is evident across all markets. (3) Marked increases in the volatility of oil and gold coincide with major global economic events, such as the 2008 Global Financial Crisis, the Covid-19 pandemic, and the Ukrainian War. In contrast, substantial increases in the volatilities of the Turkish financial markets are observed in response to local events, including the 2018 Foreign Exchange Crisis and the 2023 Great Earthquake. Moreover, according to Philip-Perron unit root test statistics (Phillips and Perron, 1988), all series are stationary.

Since the research data is obtained from the open public sources and the names of the users who shared comments are not publicized, there is no requirement for the ethics committee approval

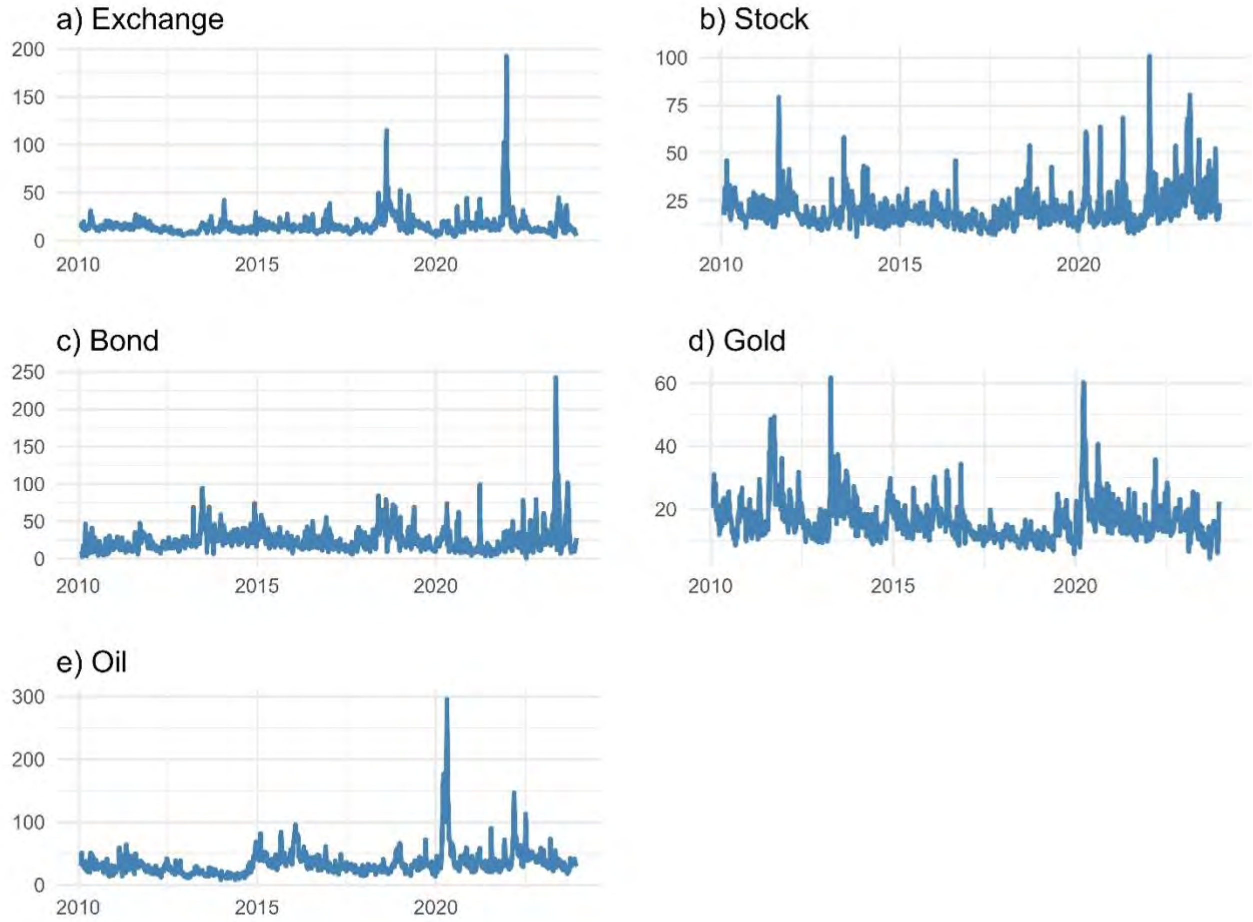

Figure 1. Volatility plot of related five financial markets

Table 1. Descriptive statistics of related five financial markets

	Exchange	Stock	Bond	Gold	Oil
Mean	16.000	20.884	25.070	16.494	33.758
Variance	140.765	101.604	339.156	46.495	447.686
Skewness	7.086	2.607	4.173	2.227	4.783
Ex. Kurtosis	80.958	11.059	34.774	8.793	41.270

Note: The symbols *, **, and *** denote the significance levels of 10%, 5%, and 1%, respectively.

4. EMPIRICAL FINDINGS

4.1. Full sample volatility spillover analysis

The international literature has extensively examined the spillovers of return and volatility among financial assets and markets. In the literature, notable studies include Evrim Mandacı et al. (2020), Trabelsi (2019), Wang et al. (2016), and Karabıyık (2020) aim to capture the spillover effects between significant financial markets on a national scale. However, previous studies have largely ignored the spillover of volatility at the extreme ends of the return and volatility distributions. This creates a significant constraint when spillover occurs during extreme periods. To gain a better understanding of the effects of spillovers in Turkey's financial system, we analyze the extent of volatility transmission at different levels of volatility distributions. Specifically, we focus on the lower (0.05), middle (0.50), and upper quantiles (0.95), which correspond to periods of low volatility, moderate volatility, and extreme volatility, respectively.

Table 2 shows the full-sample volatility spillover analysis results. Panels A, B, and C depict the comprehensive analysis of the entire sample for the lower, middle, and upper quantiles. The table shows that the results of volatility-connectedness vary considerably when the QVAR model is carried out at different quantiles. At less volatile times, international markets (i.e., gold and oil markets) are net risk spillover receivers in the Turkish market, while local financial markets (i.e., exchange, stock, and bond markets) are net risk spillover transmitters. In moderate times, all financial markets maintain their roles, but the bond market moves to a more neutral position. Net volatility spillover, which is 1.21 at the 0.05 quantile, reaches approximately zero at the 0.50 quantile. In extreme volatile market conditions, on the other hand, the structure of the market changes completely, and the only the exchange market remains as a source of risk in Turkish financial market. On the other side, the rest of the other financial markets are all net-risk takers.

A better understanding of this phenomenon may be accomplished by examining the network graph. As illustrated in Fig. 2, the network graph approach reveals insights under various economic conditions. The blue nodes represent markets that transmit net risk, whereas the red nodes represent markets that receive net risk. A larger node size indicates that the related market has a higher ability to transmit or receive net risk in the financial market. Moreover, the thickness of the edge lines reflects the magnitude of risk spillover between markets. As the economy transitions from a state of low volatility to one of high volatility, the network structure undergoes significant alterations. A key observation is that bond, stock, and exchange markets act as risk transmitters both in low and moderate volatile conditions. However, during high volatility regime, the exchange market emerges as the sole source of risk. Additionally, empirical findings indicate that changes in the country's economic conditions lead to variations in the degree and direction of connectedness between financial markets. For instance, the foreign exchange market becomes the only net risk source in the country's economy and there is no significant risk relationship between the stock, bond, and commodity markets in the presence of an extreme market conditions.

Table 2. Full sample volatility spillover analysis at different quantiles

	Exchange	Stock	Bond	Gold	Oil	FROM
			Panel A (q=0.05)			
Exchange	36.26	20.21	18.17	14.26	11.1	63.74
Stock	19.4	36.63	18.02	13.92	12.03	63.37
Bond	18.41	18.93	37.04	13.02	12.6	62.96
Gold	14.33	14.79	13.9	38.94	18.04	61.06
Oil	12.84	13.57	14.43	18.79	40.36	59.64
TO	64.97	67.51	64.53	59.99	53.77	310.76
Inc. Own	101.23	104.14	101.57	98.93	94.13	TCI
NET	1.23	4.14	1.57	-1.07	-5.87	62.15
			Panel B (q=0.50)			
	Exchange	Stock	Bond	Gold	Oil	FROM
Exchange	58.96	16.70	13.74	6.26	4.34	41.04
Stock	17.00	60.52	12.23	6.31	3.94	39.48

Bond	14.75	12.44	62.68	5.02	5.12	37.32
Gold	8.11	8.25	5.79	66.47	11.38	33.53
Oil	5.59	4.59	5.63	11.60	72.59	27.41
TO	45.46	41.98	37.38	29.18	24.78	178.78
Inc. Own	104.42	102.50	100.06	95.65	97.37	TCI
NET	4.42	2.50	0.06	-4.35	-2.63	35.76

Panel C (q=0.95)

	Exchange	Stock	Bond	Gold	Oil	FROM
Exchange	26.30	18.42	18.60	18.38	18.30	73.70
Stock	24.88	20.06	18.63	17.82	18.61	79.94
Bond	24.68	18.43	19.78	18.46	18.65	80.22
Gold	24.59	18.76	18.30	19.57	18.78	80.43
Oil	24.55	18.12	18.11	18.38	20.85	79.15
TO	98.69	73.73	73.65	73.04	74.34	393.44
Inc. Own	125.00	93.78	93.43	92.61	95.18	TCI
NET	25.00	-6.22	-6.57	-7.39	-4.82	78.69

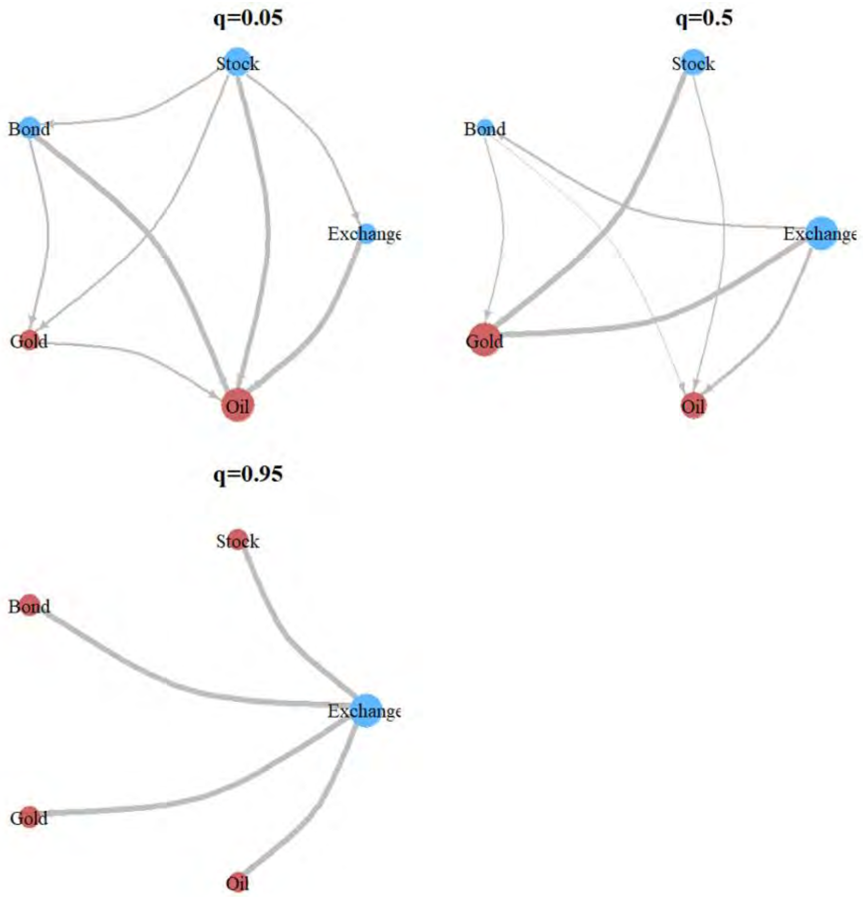

Figure 2. Network analysis results at different quantiles

4.2. Spillover effects at various quantiles

To see the big picture, we employ the QVAR model, which encompasses all quantiles ranging from q = 0.05 to q = 0.95, with increments of 0.05. We calculated the risk spillover indices of the financial markets being studied throughout a range of quantiles, starting with the lowest and going up to the highest. The primary objective of this section's investigation is to determine if the risk transfer among significant financial markets in Turkey varies across different quantiles (that is, in different economic conditions). As previously stated, traditional VAR models that consider the mean of the distribution provide accurate outcomes during moderate volatile periods but generate misleading results during periods of very low and very high volatile market conditions. This leads researchers to draw inaccurate political and financial conclusions from empirical findings.

Fig. 3 deploys the volatility spillover from one specific financial market to another specific market. The x-axis shows the spillover index value, while the y-axis shows the quantiles that we use for each QVAR model. The first thing that stands out is that the quantile where the volatility spillover index between markets is lowest is q = 0.5. That is, the results obtained with standard VAR models underestimate the spillover index in very low and very high volatile market conditions. The shape of the risk spillover index between different quantiles generally resembles an inverted bell curve. The second important finding is that the pairwise spillover index between markets is greater at the higher quantile than at the lower quantile. This is not the case for *exchange* → *stock* and *oil* → *gold* volatility spillovers.

Fig. 4, in contrast, depicts the total transmission of volatility across several quantiles. Similar to prior analyses, the transmission of volatility across the whole market reaches its highest level at the extreme right end of the distribution. This indicates that the level of interaction between different financial markets reaches its peak during financial conditions where extreme volatility prevails. Consequently, risk-averse investors should be more careful in such markets than in low volatile times. We conclude that price volatility in any market has the most significant influence on other markets in the volatile times. While the total spillover index is 35% in moderate times, this value exceeds 60% in times of very low volatility and approaches 80% in very high volatility market conditions. This difference is quite substantial. Investors in Turkish financial assets should take note of this empirical finding.

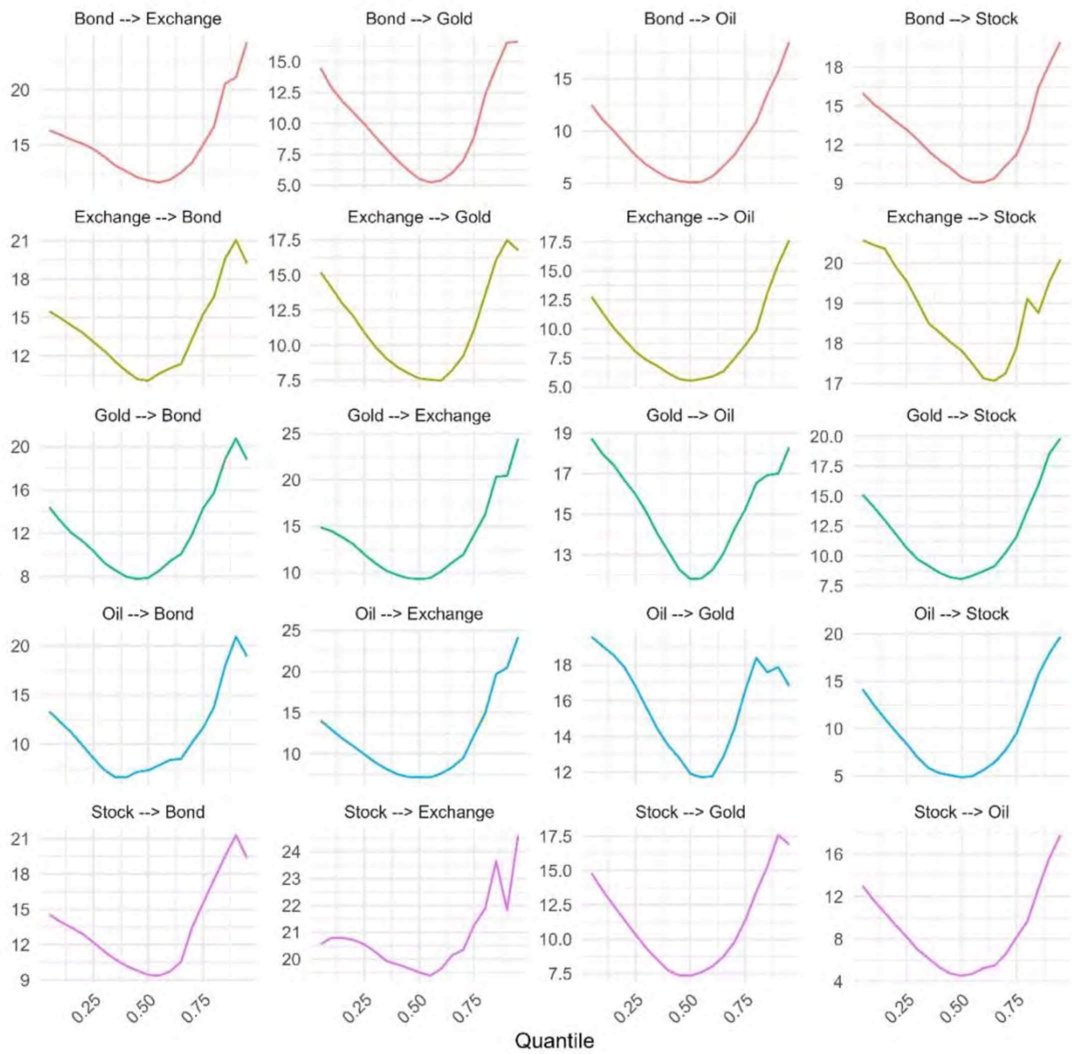

Figure 3. The volatility spillover effects from financial markets to other markets at different quantiles

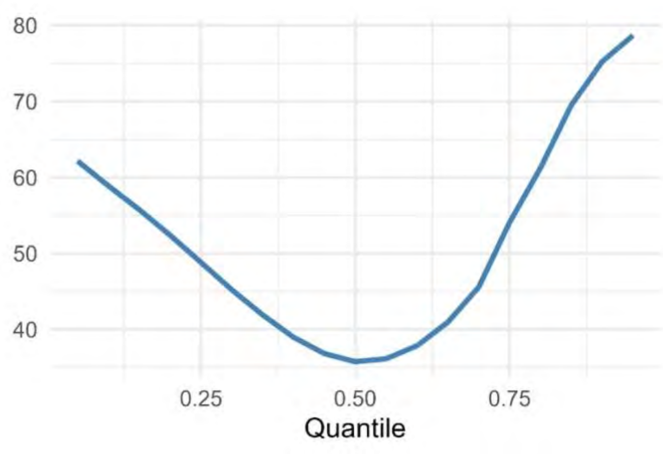

Figure 4. The total volatility spillover effects at different quantiles

4.3. Time-varying spillover results

The full sample results offer useful insights to researchers during periods of economic stability. Nevertheless, during periods of structural change in the economy, such as an economic downturn, war, earthquakes, and such events, it is anticipated that the relationship among variables will not stay stable. In order to address this issue, we employ a rolling estimator to get time-varying coefficients for each quantile. This allows us to generate time-varying volatility spillover effects throughout the observation period. We utilize our rolling estimator specifically for the calculation of spillover changes, focusing just on the 0.5 quantiles. The computation of time-varying quantile spillovers is based on a rolling window of 52 weeks and 12 step-ahead forecast horizons. The graphical evidence depicted in Figures 5 and 6 demonstrates that the magnitudes of pairwise and total volatility spillovers are not consistent over time. A key finding indicates that the Turkish stock market is the primary risk transmitter following the advent of the COVID-19 pandemic. The largest value of the spillover index appears during the COVID-19 health crisis, as seen in Figure 6. Subsequently, it steadily decreased during the observation period.

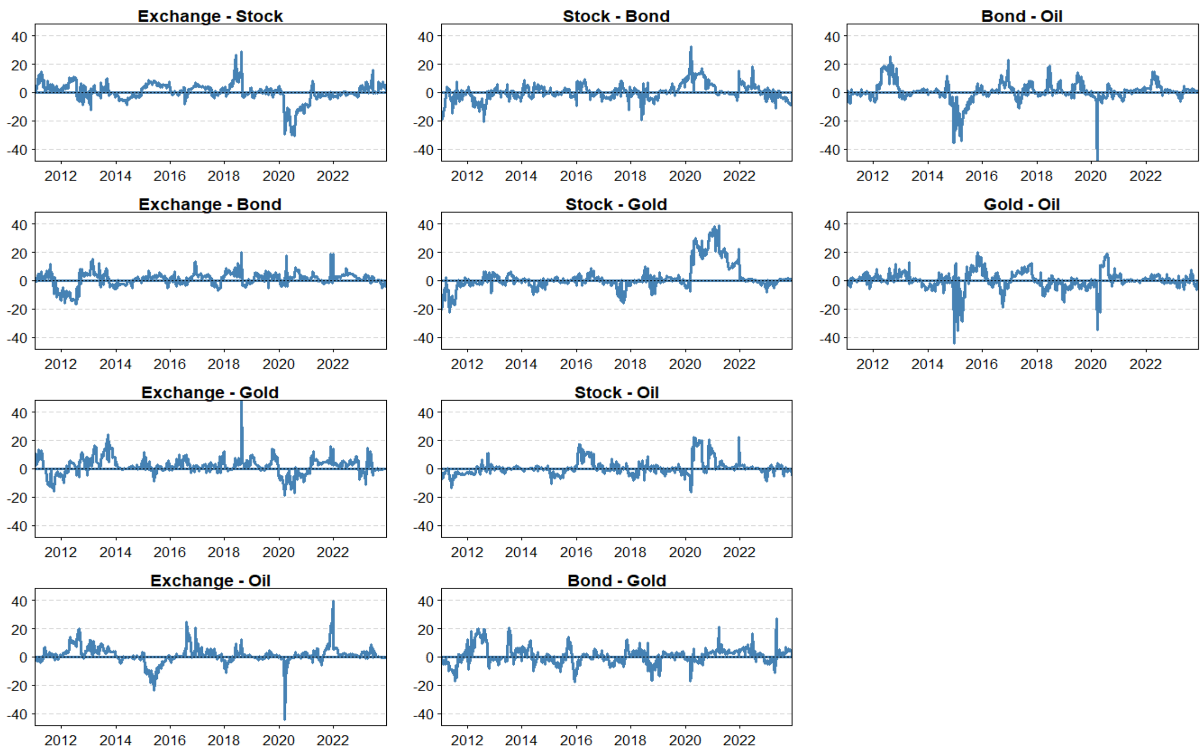

Figure 5. Time-varying pairwise volatility spillover results (q=0.5)

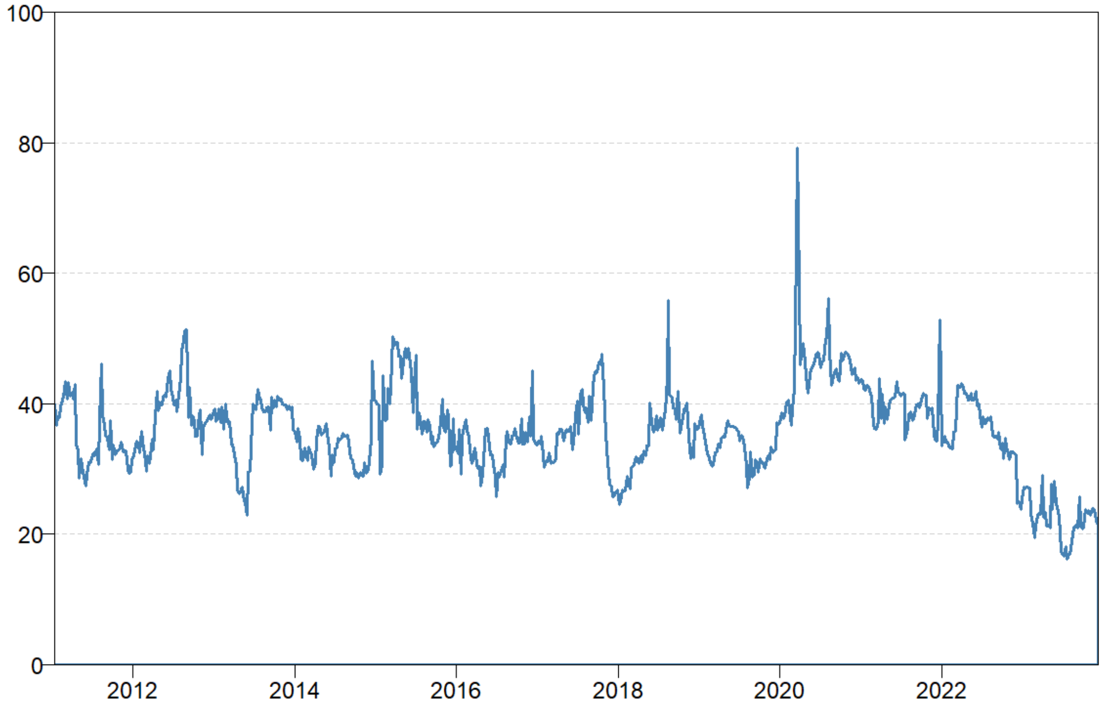

Figure 6. Total time-varying volatility spillover index (q=0.5)

5. DISCUSSION

This study represents a significant extension of existing academic literature concerning spillover effects, particularly through the utilization of conventional mean-based models. For instance, seminal research by Diebold and Yilmaz (2009) illustrates that the intensify of economic crises corresponds with heightened volatility spillover effects. Our empirical findings substantiate this observation. Nonetheless, we posit that during periods of crisis, the magnitude of spillover effects surpasses the estimations presented by Diebold and Yilmaz. This assertion holds true not only for total spillover effects but also for the pairwise spillover effects among variables. Noteworthy studies, including those by Balcilar et al. (2019), Balcilar et al. (2020a), and Zhou et al. (2022), provide further evidence indicating a marked increase in spillover effects during economic events. Recent investigations (e.g., Abuzayed and Al-Fayoumi, 2021; Tiwari, Aikins Abakah, et al., 2022; H. Zhang et al., 2021) emphasize the significant impact of the COVID-19 pandemic on the dynamic spillovers among diverse macro and financial markets, findings that align with the outcomes of this study. Furthermore, our primary finding that spillover effects are more pronounced in extreme market conditions finds corroboration in the literature, as evidenced by works such as those by Balcilar et al. (2022), Jiang et al. (2023), Liu et al. (2021), Mensi et al. (2022, 2023), and Yousaf et al. (2023).

Our empirical findings emphasize the dynamic nature of spillover effects, revealing their temporal variability rather than a fixed pattern over time. This finding coincides with the results of previous studies in a similar field. For instance, Nekhili et al., (2021) examine spillovers among copper, gold, oil, wheat, and major currency markets, concluding that spillover effects exhibit time-varying dynamics and sensitivity to crises. Indeed, presuming a static relationship among financial markets amidst economic and financial upheavals would be overly simplistic, a notion consistently refuted by studies employing time-varying models.

Furthermore, a significant contribution made by this research is the identification of differential spillover effects across different quantiles. This is a finding that has been confirmed in previous research conducted in the field. According to Chen et al. (2022), for instance, the dynamic spillover structure is found to be distinct between the upper and lower tails in comparison to the conditional mean and median. Furthermore, our own findings are consistent with the asymmetrical impact that spillover effects have on the right and left tails of the distribution. An important finding from our study is that total volatility spillovers are more pronounced in the right tail compared to the left tail. This finding is consistent with the findings that were discovered by Tiwari, Abakah, et al. (2022).

6. CONCLUSION

This study examines the volatility spillover amid BIST-100, TR 10-year bonds, USD-TL, gold futures, and Brent petroleum at different quantiles. To analyze the spillover index of Turkish financial markets, we used the quantile connectedness technique that Ando et al. (2022) proposed. Internationally traded commodities like gold and oil are subject to changes on other financial markets like the stock and bond markets. The weekly frequency data used in this study spans from January 28, 2010, to December 8, 2023.

Our overall findings indicate that during extremely low and moderately volatile times, stock, bond, and currency markets are net risk spillovers, but gold and oil are net risk receivers. However, in times of excessive volatility, the only risk-transmitter market in Turkish financial markets is the currency market. Furthermore, as the economy moves from low to high volatility regimes, the network topology entirely changes. The primary goal of the study is to determine if the volatility spillover index varies among quantiles, namely extremely low (0.05), moderate (0.50), and very high (0.95) volatile periods. The pairwise spillover index between markets is larger at the higher quantile than at the lower quantile. This is not the case for volatility spillovers from the currency market to the stock and commodity markets. Furthermore, the time-varying analysis demonstrates that the total volatility spillover index hits record levels following the COVID-19 outbreaks and then gradually declines. In addition to this result, there is evidence suggesting the currency market is the main source of risk in the Turkish financial market. Surprisingly, we found little evidence that external shocks (gold and oil) cause risk spillovers in the Turkish financial system.

In addition, our research provides specific suggestions for policymakers, speculators, and traders in Turkey. Amidst periods of higher volatility, such as the COVID-19 pandemic, the primary source of risk in the Turkish financial system is inside the currency market. During such circumstances, bond and stock investors should focus on monitoring the movement of the US dollar/Turkish lira currency exchange rate rather than the international commodities market. It is important to understand that they also consider the financial conditions (low, moderate, and high volatility regimes) when making investment decisions. Turkish authorities must recognize that the Turkish financial market's danger stems from domestic shocks rather than external shocks. Furthermore, it is important for them to recognize that the risk structure undergoes a complete transformation during periods of high volatility, in contrast to periods of low and moderate volatility. Consequently, they should adopt appropriate precautionary measures. when they come across such unexpected economic turmoil.

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