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Research Article

**Dynamic Volatility Connectedness between the Sustainability Index and Stock
Market Main Sector Equity Indices**

Letife Özdemir^a

Abstract

Introduction: Assessing volatility spillovers provides guidance the decision-making processes of market participants and policymakers. In this context, identifying volatility transmitters and receivers between sustainability and traditional indices contributes to risk management.

Method: The dynamic volatility spillover among the Sustainability Index (XUSRD), the BIST-100 (XU100) and main sector indices in Turkey using the time-varying parameter vector autoregressive method. Daily data for the period 02 February 2020 to 31 July 2025 for the XUSRD, XU100, Financial (XUMAL), Industrial (XUSIN), Services (XUHIZ), and Technology (XUTEK) indices are used.

Results or Findings: The XUSRD, XU100, and XUSIN indices are volatility transmitters; while the XUMAL, XUTEK, and XUHIZ indices are volatility receivers. The high value of TCI indicates that volatility spillovers among the indices are quite strong. Volatility spillovers increases during periods of global events (the coronavirus outbreak and the Russia-Ukraine war), as well as domestic events (the February 6 earthquakes and political developments in 2025). Furthermore, volatility transfer occurs from the XUSRD to the Industrial, Services, and Technology indices at rates of 19.50%, 17.59%, 17.47%, and 14.97%, respectively.

Discussion or Conclusion: The findings indicate a high degree of dynamic volatility connectedness among the indices included in the analysis. Therefore, including these indices in the same portfolio may increase portfolio risk. Furthermore, changes in sustainability-focused expectations are seen to be rapidly transmitted to the production and service sectors, particularly the financial sector. Investors can make less risky investment decisions by paying attention to the volatility spillovers among these indices.

Keywords: sustainability index, stock market sector indices, dynamic connectedness, volatility spillover, TVP-VAR model

JEL Codes: C32, G11, G17

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Araştırma Makalesi

**Sürdürülebilirlik Endeksi İle Borsa ve Ana Sektör Pay Endeksleri Arasındaki
Dinamik Volatilité Bağlantısı**

Letife Özdemir^a

Öz

Giriş: Volatilité yayılımının değerlendirilmesi, piyasa katılımcılarının ve politika yapıcıların karar alma süreçlerine rehberlik eder. Bu bağlamda, sürdürülebilirlik ve geleneksel endeksler arasındaki volatilité aktarıcılarını ve alıcılarını belirlemek, risk yönetimine katkı sağlar.

Yöntem: Türkiye’de Sürdürülebilirlik Endeksi (XUSRD) ile BİST-100 (XU100) ve ana sektör endeksleri arasındaki dinamik volatilité yayılımı, zamana göre değişen parametrelili vektör otoregresif yöntemiyle incelenmektedir. XUSRD, XU100, Mali (XUMAL), Sınai (XUSIN), Hizmetler (XUHİZ) ve Teknoloji (XUTEK) endekslerine ait 02.02.2020–31.07.2025 dönemi günlük veriler kullanılmaktadır.

Sonuçlar ya da Bulgular: XUSRD, XU100 ve XUSIN endeksleri volatilité yayıcısı; XUMAL, XUTEK ve XUHİZ endeksleri ise volatilité alıcısı konumundadır. TCI katsayısının yüksek olması, endeksler arasında volatilité yayılımı oldukça güçlü olduğunu işaret etmektedir. Volatilité yayılımı koronavirüs salgını ve Rusya–Ukrayna savaşı gibi küresel olayların ve 6 Şubat depremleri ve 2025 yılı siyasi gelişmeleri gibi ülke içi olayların olduğu dönemlerde artmaktadır. Ayrıca, XUSRD endeksinden Mali, Sınai, Hizmetler ve Teknoloji endekslerine sırasıyla %19,50, %17,59, %17,47 ve %14,97 oranlarında volatilité aktarımı gerçekleşmektedir.

Tartışma ya da Yapılan Çıkarımlar: Bulgular, analize dâhil edilen endeksler arasında yüksek düzeyde dinamik volatilité bağlantılılığı olduğunu ifade etmektedir. Bundan dolayı, bu endeksler aynı portföy içerisinde yer alması portföy riskini artırabilir. Ayrıca, sürdürülebilirlik odaklı beklentilerdeki değişimlerin başta finans sektörü olmak üzere üretim ve hizmet sektörlerine hızlı biçimde yansıdığı görülmektedir. Yatırımcıların, bu endeksler arasındaki volatilité yayılımına dikkat ederek daha az riskli yatırım kararları alabilirler.

Anahtar Kelimeler: sürdürülebilirlik endeksi, borsa sektör endeksleri, dinamik bağlantılılık, volatilité yayılımı, TVP-VAR modeli

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Introduction

Sustainability is described in the Brundtland Report (1987) as “meeting the needs of the present without compromising the ability of future generations to meet their own needs”. Corporate sustainability represents the firm-level application of the sustainability concept and refers to the adaptation of environmental, social, and governance (ESG) principles into corporate activities in order to enable firms to maintain their existence and support their growth. ESG principles were conceptually, for the first time, provided with a systematic framework through the report “Who Cares Wins” published by the United Nations in 2004 (Mian et al., 2024). The global acceptance of ESG criteria and their incorporation into investment decision-making processes gained prominence following the establishment of the United Nations Principles for Responsible Investment in 2006 (Peillex & Comyns, 2020).

The integration of ESG principles into investment decision-making processes has facilitated the emergence of sustainability indices as a new category of equity market indices. Sustainability indices include firms that carry out activities in accordance with ESG principles (Bhue et al., 2025). In recent years, sustainability indices have gained increasing importance in financial markets and have emerged as an alternative investment option for investors in portfolio construction (Zhang et al., 2022; Aboluwodi et al., 2024). At the same time, sustainability indices are important financial indicators that guide investors within the framework of a responsible investment approach (Kurnoga et al., 2022). Unlike traditional stock market indices, these indices offer an evaluation opportunity based on sustainability principles, and their importance has been increasing day by day in both the academic literature and investment strategies. Existing studies indicate that sustainability indices exhibit strong bidirectional volatility spillovers with traditional stock market indices during periods of global crises and uncertainty (Arouri et al., 2025; Naeem et al., 2023; Nogueira & Madaleno, 2022; Malhotra, 2025; Zeng et al., 2025; Doğan et al., 2023; Erben Yavuz, 2023; Kavas, 2025; Toy, 2025).

Globalization, liberalization, and technological advancements have led financial markets to become more integrated with one another and have caused adverse developments arising in one market to be transmitted rapidly to other markets. In this context, volatility spillovers and dynamic connectedness among financial markets have become an extensively assessed subject in prior studies (Khan, 2025). Generally, during periods when economic uncertainty and volatilities specifically the coronavirus outbreak, market participants and policymakers tend to closely examine risk and return spillovers across markets in order to protect investments and ensure financial stability (Naeem et al., 2023). Existing empirical studies have been undertaken to enhance the understanding of volatility spillovers in financial markets, to assess their implications for diversification benefits, and to develop portfolio construction approaches aimed at mitigating the associated risks (Choi et al., 2021).

Volatility spillover refers to the process by which uncertainty or fluctuations occurring in a particular market are transmitted to other markets. In this context, the “volatility transmitter” refers to the market that transmits net volatility to other markets, while the “volatility receiver” refers to the market that absorbs net volatility in the system, meaning the market that is more affected by shocks in other markets. Volatility connectedness quantitatively reveals the extent and direction in which shocks arising in different markets or assets spread throughout the system (Baruník, Kočenda, & Vácha, 2017). Assessing volatility spillovers contributes significantly to the decision-making processes of market participants and policymakers. Identifying net volatility transmitters and net volatility receivers between sustainability and conventional indices enables the enhancement of effective portfolio

diversification and risk management strategies. Moreover, it provides important insights into understanding the role of sustainable finance markets within the financial system.

Although prior studies have investigated volatility spillovers between sustainability indices and financial market assets, notable gaps remain in the existing literature. The literature indicates that there is strong dynamic volatility connectedness among various sustainability indices (Bhue et al., 2025; Marin-Rodriguez et al., 2024; Umar et al., 2020; Wan et al., 2024; Shaik & Rehman, 2023); that volatility spillovers run from sustainability indices to capital market indices (Zhang et al., 2022; Maraqa & Bein, 2020; Arouri et al., 2025; Naeem et al., 2023); and that analyses of dynamic volatility spillovers between sustainability indices and sectoral indices reveal sustainability indices to act as net volatility transmitters (Malhotra, 2025; Zeng et al., 2025). In the context of Türkiye, empirical evidence on volatility spillovers involving sustainability indices remains rather limited. Empirical evidence indicates that the Sustainability Index functions as a net volatility receiver from the Dow Jones Sustainability Index (Başkaya & Özdemir, 2025; Erben Yavuz, 2023). This finding is also supported by the study of Doğan et al. (2023). Kaya (2023) and Kavas (2025) investigated volatility spillovers between the sustainability index and various commodity prices, showing that, in most cases, the sustainability index acts as a net volatility transmitter. However, only two studies focusing on the Indian and Chinese capital markets have been identified that incorporate sectoral indices into their analyses (Malhotra, 2025; Zeng et al., 2025). These studies have demonstrated that the sustainability index transmits volatility to sectoral indices. To our knowledge, no prior study has been identified for the case of Türkiye. The need for further research to identify volatility spillovers between the sustainability index and sectoral indices, and to understand how these dynamics are reflected in investor behavior, constitutes the main motivation of this study.

This paper aims to evaluate the dynamic volatility spillovers among Türkiye's the Sustainability Index, the benchmark stock market index, and the main sectoral indices by employing a time-varying parameter vector autoregressive (TVP-VAR) methodology. Volatility spillovers among the XUSR index, the XU100 index, representing the largest equity market benchmark, and the main sectoral indices, namely Financial, Industrial, Services, and Technology, are examined in detail using daily data covering the period from 02.02.2020 to 31.07.2025. From an investor perspective, evaluating sectoral indices alongside the XU100 Index, rather than focusing solely on the XU100 Index, is of considerable importance. While the XU100 Index reflects the overall market trend, sectoral indices allow for a more detailed assessment of sector-specific behaviors and structural characteristics. Within this framework, the study focuses on the following research questions: (i) Does the Sustainability Index act as a volatility transmitter or a volatility receiver in the equity market? (ii) Which of the main sectoral indices acts as the largest net volatility receiver? (iii) To which sector does the Sustainability Index transmit volatility most strongly?

While aiming to answer these research questions, this paper is considered to add to the literature in three notable respects. First, the inclusion of firms with high ESG performance in sustainability indices within a given sector influences the return and volatility dynamics of those sectors. Therefore, price movements and volatility shocks occurring in sustainability indices can spillover into sectoral indices. Therefore, price movements and volatility shocks occurring in sustainability indices can spillover into sectoral indices. Similarly, sector-specific developments may also influence the performance of sustainability indices. For these reasons, this study provides empirical evidence to the existing literature by examining how volatility spillovers and shocks are transmitted between sustainability and sectoral indices. Second, instead of methods based on the assumption of constant parameters, this study employs the TVP-VAR approach, which allows parameters to vary over time and enables an analysis of the

temporal evolution of connectedness. In this manner, the temporal sensitivity of Türkiye's capital markets to periods of uncertainty is identified, and market reactions are assessed in a comparative framework. Thus, identifying volatility-transmitting and volatility-receiving markets between sustainability and sectoral indices will contribute to investors' portfolio diversification and risk management decisions. Third, this paper addresses an existing gap in the literature by analyzing volatility spillovers between the XUSR Index, the XU100 Index, and the equity indices of main sectors in the Turkish economy, namely the industrial, financial, technology, and services sectors.

The remainder of the study is structured as follows. In the second section, studies investigating dynamic volatility spillovers between the sustainability index and financial indicators are reviewed. In the third section, the data set and methodology are presented, while the findings are reported in the fourth section. In the final section, the findings are discussed and evaluated.

Literature Review

Previous studies on volatility spillovers and dynamic interconnectedness across financial markets plays a critical role in shaping investment decision-making processes. In recent years, the incorporation of ESG considerations into investment strategies has enhanced the role of sustainability indices by offering various advantages in portfolio diversification. Consequently, the number of studies examining volatility spillovers between sustainability indices and different financial markets has increased substantially.

Maraqa and Bein (2020) examine the dynamic interrelationships and volatility spillovers among sustainability equity indices and the major stock market returns of oil-importing and oil-exporting European countries, using a DCC-MGARCH framework. Their findings reveal that the dynamic relationships among sustainability equity indices, stock returns of European oil-importing/exporting countries, and oil markets differ across market conditions. Arouri et al. (2025) investigate the mutual connectedness among the S&P Green Bond Index, the S&P500 Index, and the S&P500ESG Index by employing TVP-VAR and DCC-GARCH models. The results indicate the presence of significant volatility spillovers regardless of market conditions, with green bonds acting as the primary volatility receivers, while the S&P500 and S&P500ESG indices serve as net volatility transmitters. Using the Diebold–Yilmaz and Baruník–Křehlík connectedness frameworks, Naeem et al. (2023) analyze the country-level connectedness among sustainable and Islamic equity investments across nineteen countries representing developed and emerging financial markets. Their results document moderate to strong short-term connectedness, and time-varying connectedness analyses reveal that major market-wide shocks, such as the European sovereign debt crisis, the Chinese financial crisis, and the coronavirus outbreak, significantly intensify interconnectedness among the indices. Nogueira and Madaleno (2022), employing an MGARCH model, find that the EURO STOXX Sustainability Index is highly dependent on movements in conventional stock market indices, indicating that sustainability indices function predominantly as net volatility receivers.

Studies examining the dynamic volatility connectedness between sustainability indices belonging to different markets are also included in the literature. Bhue et al. (2025) investigate information asymmetry, dynamic connectedness, and volatility spillovers between ESG equity indices in emerging markets using GARCH, FIGARCH, and TVP-VAR models. Their findings reveal the presence of leverage effects in ESG equity indices and indicate a moderate level of connectedness among the indices. In particular, ESG equity indices from the Philippines, Indonesia, Korea, Singapore, and India are found to be more sensitive to sustainability-related

innovation shocks originating from the ESG indices of Brazil, South Africa, and Mexico. Marin-Rodriguez et al. (2024) analyze the connectedness of sustainable investment indices using a quantile VAR (QVAR) framework. The results show persistent dynamic connectedness among the Sustainable Impact Index, the Paris-aligned equity index, and the green bond index. Moreover, the green bond index generally acts as a net volatility receiver, whereas the other sustainability indices function as volatility transmitters. Zhang et al. (2022) employ a DCC-GARCH-based dynamic connectedness approach to examine volatility spillovers among the MSCI World ESG equity index, the renewable energy equity index, the S&P Green Bond Index, the Dow Jones Sustainability equity index, and carbon emission futures. Their findings identify carbon emission futures as the primary volatility transmitter, followed by the ESG and the sustainability equity index.

Using a DCC-GARCH framework, Shaik and Rehman (2023) assess dynamic volatility connectedness among ESG equity indices and show that ESG indices in the Middle East and Africa as well as Latin America act as net shock transmitters, while those in the United States and the Asia-Pacific region are net volatility receivers. Umar et al. (2020) document significant and persistent volatility spillovers among ten ESG equity indices from developed and emerging markets. The connectedness among these indices exhibits a pronounced dynamic structure, particularly during periods associated with the European sovereign debt crisis, Greece-originated systemic disturbances, and the coronavirus pandemic. Wan et al. (2024), employing a TVP-VAR framework, reveal strong connectedness among ESG equity indices in both returns and volatility. While ESG indices in Europe and North America predominantly display outward spillovers, those in the Asia-Pacific region and India are characterized by inward spillovers. In addition, the coronavirus outbreak is found to have a positive effect on volatility connectedness among ESG equity indices.

Focusing on volatility spillovers between sustainability indices and sectoral indices, Malhotra (2025) finds that India's ESG and clean energy indices consistently act as net volatility transmitters, whereas sectoral indices serve as diversification assets with relatively low connectedness, based on a TVP-VAR approach. Similarly, Zeng et al. (2025) examine risk connectedness between China's sustainability index, the Chinese stock market, and seven sectoral indices using a TVP-VAR-CAViaR connectedness framework. The evolution of total risk connectedness exhibits dynamic fluctuations in both the Chinese stock market and the sustainability index, particularly during extreme events specifically the coronavirus outbreak. Their results indicate that sustainability indices play a central role in risk transmission.

A limited number of studies focusing on the Turkish context examine volatility spillovers among the XUSR Index and stock market indices or other financial indicators, generally concluding that the XUSR Index functions as a net volatility receiver. Doğan et al. (2023) investigate the dynamic connectedness between the XUSR Index, the XU100 Index, the S&pGCEI, and S&P GSCI using a TVP-VAR framework. Their findings indicate that volatility originating from S&P GSCI is transmitted to the S&PGCEI, the XU100 Index, and the XUSR Index. Erben Yavuz (2023) analyze dynamic connectedness among the XUSR Index, the S&PGSCI, and the Dow Jones Sustainability World Index using a TVP-VAR approach, documenting that the XUSR Index acts as a net volatility receiver. In a related study, Başkaya and Özdemir (2025) employ a DCC-GARCH model and show that volatility shocks in the S&P Dow Jones Sustainability Index reduce the volatility of the XUSR Index.

Kaya (2023) analyze dynamic connectedness among the XUSR Index and fossil fuel prices, including crude oil, Brent oil, heating oil, natural gas, and coal, using a TVP-VAR methodology. The evidence confirm that Brent oil, crude oil, and heating oil serve as net

volatility transmitters, whereas the XUSRD Index, natural gas, and coal predominantly act as volatility receivers. Kavas (2025) apply a TVP-VAR model to examine dynamic connectedness and volatility spillovers among the XUSRD Index, the US dollar exchange rate, Bitcoin, oil prices, and gold prices. Their findings identify Bitcoin as the largest volatility transmitter, followed by the XUSRD Index, while oil and gold emerge as the largest volatility receivers.

The existing literature also includes studies analyzing volatility spillovers between the XU100 Index and various market indicators. Specifically, Aydoğdu (2025) examine volatility spillovers among the XU100 Index, Brent crude oil, the US dollar, gold, Bitcoin, and the Volatility Index; Çilek (2025) focus on the XU100 Index, interest rates, gold, and the US dollar; Erdoğan (2023) analyze volatility spillovers among interest rates, the XU100 Index, bond yields, the US dollar, gold, and CDS premiums; and Gülcemal (2025) investigate volatility spillovers among the XU100 Index, the Housing Price Index, gold, and the US dollar exchange rate. These studies generally suggest that the XU100 Index acts as a net volatility transmitter in the domestic market. In contrast, Polat (2021), examining volatility spillovers between BRICS markets and Türkiye, and Erdoğan (2024), analyzing volatility spillovers between the XU100 Index and stock market indices of eight different countries, find that the XU100 Index functions as a net volatility receiver in the global market context. Collectively, these findings suggest that while the XU100 Index acts as a volatility transmitter within the domestic market, it tends to assume the role of a volatility receiver in international market settings.

Only a limited number of studies examine volatility spillovers among sectoral indices in Türkiye. Kocaarslan (2020) analyze volatility interactions among the Technology, Industrial, Services, and Financial indices using a causality-in-variance framework, revealing substantial volatility transmission from the Technology Index to other major sectoral indices. Additionally, significant volatility spillovers are identified from the Industrial Index to the Services and Financial indices. Toy (2025), employing a TVP-VAR approach, document the presence of dynamic connectedness among the Financial, Services, Industrial, and Technology indices. Their results indicate that the Industrial and Services indices act as net volatility transmitters, whereas the Financial and Technology indices serve as net volatility receivers.

Overall, when evaluated in general terms, the number of studies examining volatility spillovers between sustainability indices and financial indicators in the existing literature is still limited. To our knowledge, no prior research has addressed volatility spillovers between the XUSRD Index, the XU100 Index, and equity indices representing key sectors of the Turkish economy, namely industrial, financial, technology, and services, within a unified framework. Moreover, few studies have jointly analyzed sustainability indices and sectoral indices, focusing exclusively on the Indian and Chinese markets. To address these gaps, the present study evaluates the dynamic connectedness structure and volatility spillovers between the XUSRD Index and major sectoral indices using a time-varying parameter vector autoregressive methodology.

Method

This paper examines volatility spillovers among the XUSRD Index, the XU100 Index, and equity indices representing key sectors of the Turkish economy, namely industrial, financial, technology, and services, using the TVP-VAR methodology developed by Antonakakis and Gabauer (2017). Daily closing price data for the selected indices were obtained from the Investing database and cover the period from 2 January 2020 to 31 July 2025. Prior to the analysis, logarithmic daily returns were derived using $100 \times \ln(P_t/P_{t-1})$. Detailed information regarding the variables and their definitions is presented in Table 1.

Table 1*Variable Description*

Variable	Description	Data Source	Period
XUSRD	BIST Sustainability Index	Investing.com	02/01/2020-31/07/2025
XU100	BİST-100 Index	Investing.com	02/01/2020-31/07/2025
XUSIN	BİST Industrial Index	Investing.com	02/01/2020-31/07/2025
XUMAL	BİST Financial Index	Investing.com	02/01/2020-31/07/2025
XUTEK	BİST Technology Index	Investing.com	02/01/2020-31/07/2025
XUHIZ	BİST Services Index	Investing.com	02/01/2020-31/07/2025

Notes. Prepared by the author.

In this paper, volatility spillovers among the XUSRD Index, the XU100 Index, and sectoral equity indices are examined using the TVP-VAR methodology. The TVP-VAR framework, which allows for the analysis of volatility spillovers and time-varying volatility dynamics, was originally developed within the connectedness framework pioneered by Diebold and Yılmaz (2009, 2012, 2014) and subsequently extended by Antonakakis and Gabauer (2017). The TVP-VAR model in light of the BIC is presented in Equations (1), (2), and (3) (Antonakakis, Gabauer, Gupta ve Plakandaras, 2018):

$$Y_t = \beta_t Y_{t-1} + \varepsilon_t \quad \varepsilon_t \sim N(0, S_t) \quad (1)$$

$$\beta_t = \beta_{t-1} + u_t \quad u_t \sim N(0, R_t) \quad (2)$$

$$Y_t = A_t \varepsilon_{t-1} + \varepsilon_t \quad (3)$$

In Equations (1), (2), and (3), Y_t , ε_t , and u_t are $N \times 1$ vectors, while A_t , S_t , β_t , and R_t are $N \times N$ matrices. Equation (3) represents the Wold decomposition of the system. The time-varying coefficients in the vector moving average representation constitute the theoretical foundation of the connectedness index developed by Diebold and Yılmaz (2012). This index is computed using generalized impulse response functions and generalized forecast error variance decompositions (GFEVD), drawing on the frameworks proposed by Koop et al. (1996) and Pesaran and Shin (1998).

In this study, the primary focus is on the proportion of the h -step-ahead forecast error variance of variable i that is attributable to shocks originating from variable j . This can be expressed mathematically as follows:

$$\phi_{ij,t}^{\sim g}(h) = \frac{\sum_{t=1}^{h-1} \delta_{ij,t}^{2,g}}{\sum_{i=1}^N \sum_{t=1}^{h-1} \delta_{ij,t}^{2,g}} \quad (4)$$

In Model (4), $\phi_{ij,t}^{\tilde{g}}(h)$ denotes the h -step-ahead GFEVD. Building on the GFEVD, the Total Connectedness Index (TCI), which measures the overall degree of interdependence within the network, is constructed and formulated as follows:

$$C_t^g(h) = \frac{\sum_{i,j=1, i \neq j}^N \varphi_{ij,t}^{\sim g}(h)}{\sum_{j=1}^N \varphi_{ij,t}^{\sim g}(h)} \times 100 \quad (5)$$

The TCI consists of three main components: total directional connectedness (TDC) to others, TDC from others, and net TDC. These components capture both the direction and the magnitude of interactions among variables.

First, attention is focused on spillovers transmitted from variable i to all other variables j . This measure is referred to as TDC to others and is presented in Equation (6):

$$C_{i \rightarrow j,t}^g(h) = \frac{\sum_{j=1, i \neq j}^N \varphi_{ji,t}^{\sim g}(h)}{\sum_{j=1}^N \varphi_{ji,t}^{\sim g}(h)} \times 100 \quad (6)$$

Second, spillovers transmitted from all variables j to variable i are computed. This concept is referred to as TDC from others and is presented in Equation (7).

$$C_{i \leftarrow j,t}^g(h) = \frac{\sum_{j=1, i \neq j}^N \varphi_{ij,t}^{\sim g}(h)}{\sum_{i=1}^N \varphi_{ij,t}^{\sim g}(h)} \times 100 \quad (7)$$

Third, net TDC, denoted as $C_{i,t}^{\tilde{g}}$, is obtained by computing the difference between TDC to others and TDC from others.

$$C_{i,t}^g(h) = C_{i \rightarrow j,t}^g(h) - C_{i \leftarrow j,t}^g(h) \quad (8)$$

The sign of net TDC provides information on the role of each variable in the volatility transmission mechanism. If net TDC is positive ($C_{i,t}^{\tilde{g}}(h) > 0$), variable i acts as a net volatility transmitter; conversely, if it is negative ($C_{i,t}^{\tilde{g}}(h) < 0$), variable i functions as a net volatility receiver. Finally, to examine bilateral interactions, net TDC is decomposed, and net pairwise directional connectedness (NPDC) is computed and expressed as follows:

$$NPDC_{ij}(h) = \frac{\varphi_{ji,t}^{\sim g}(h) - \varphi_{ij,t}^{\sim g}(h)}{N} \times 100 \quad (9)$$

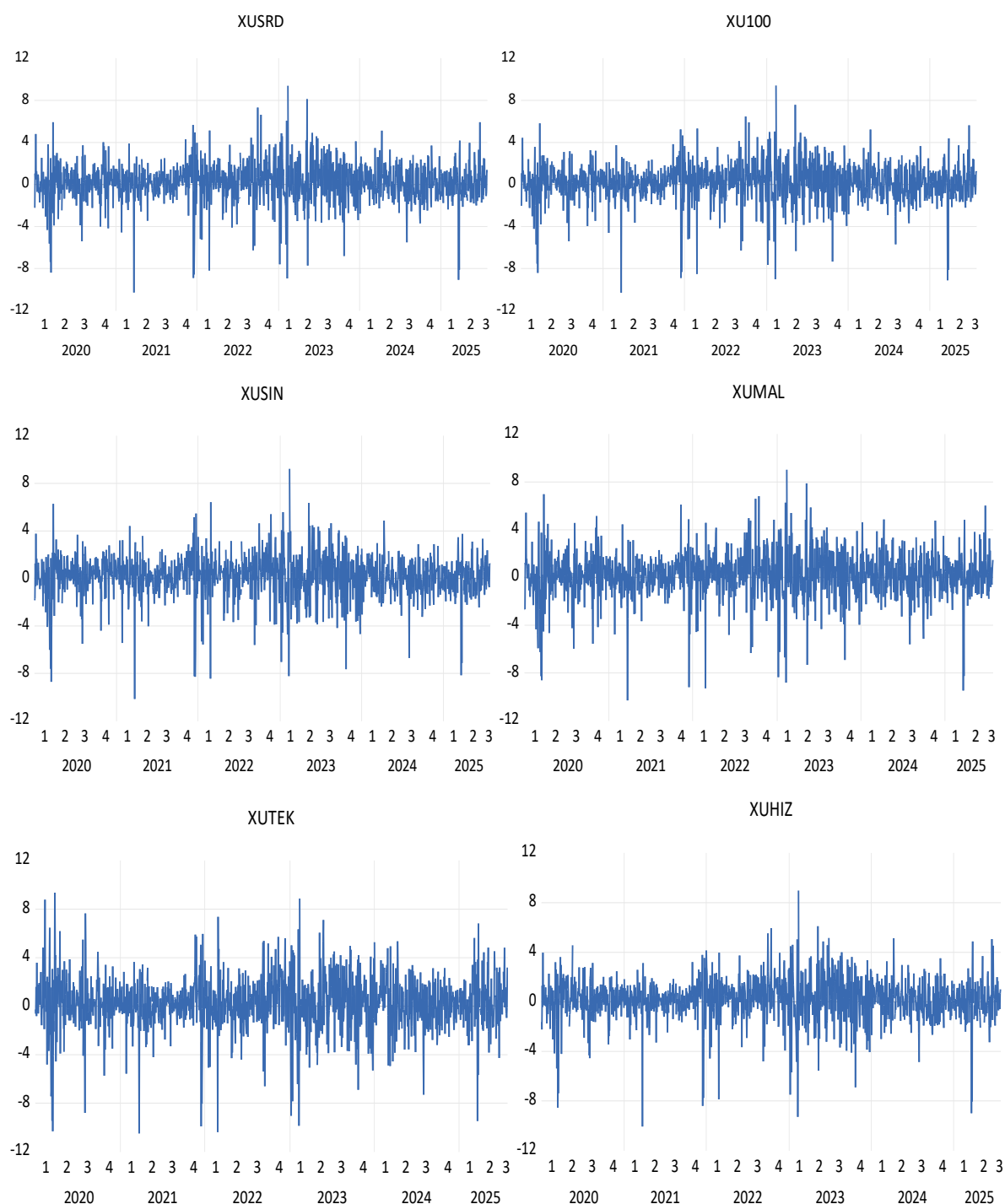
If $NPDC_{ij}(h) > 0$, variable i exerts an influence on variable j ; conversely, if $NPDC_{ij}(h) < 0$, variable j exerts an influence on variable i .

Empirical Findings

The study first presents the return series of the XUSRD Index, the XU100 Index, and the sectoral equity indices in Figure 1. An examination of the graphs shows that the indices exhibit similar volatility patterns. The effects of the coronavirus outbreak in 2020, the Russia–Ukraine war in 2022, the February 6 earthquakes in 2023, and the political events in 2025, which caused volatility in the markets, can be observed in the graphs.

Figure 1.

Plots of the Return Series



Note. Created by the author in EViews 12; Arial font customization is not supported.

Summary statistics for the index returns included in the paper are reported in Table 2. The Technology equity index exhibits the highest average return among the indices considered. Variance, as a fundamental statistical measure, captures the dispersion of observations around the mean and reflects the degree of variability in the series. Among the indices, the Technology equity index displays the greatest deviation from its mean. The negative skewness values indicate that the distributions are left-skewed, while kurtosis values exceeding three suggest that the return distributions exhibit leptokurtic characteristics. The Jarque–Bera test results, based on skewness and kurtosis measures, indicate that none of the variables follow a normal distribution (Jarque ve Bera, 1987). The test statistics confirm the rejection of normality for all indices at the 1% significance level. The stationarity properties of the variables are examined using the ERS unit root test developed by Elliott, Rothenberg, and Stock (1996), and the results reveal that all variables are stationary. Finally, the Ljung–Box Q and Q² test confirm the presence of autocorrelation in the return series.

Table 2

Descriptive Statistics

	XUSRD	XU100	XUSIN	XUMAL	XUTEK	XUHIZ
Mean	0.166	0.16	0.163	0.167	0.228	0.178
Variance	3.415	3.27	3.151	3.826	4.848	2.926
Skewness	-0.646 (0.000)	-0.768 (0.000)	-0.854 (0.000)	-0.591 (0.000)	-0.516 (0.000)	-0.850 (0.000)
Kurtosis	4.616 (0.000)	4.856 (0.000)	4.583 (0.000)	3.892 (0.000)	3.406 (0.000)	5.173 (0.000)
Jarque-Bera	1334.824 (0.000)	1506.743 (0.000)	1389.345 (0.000)	960.882 (0.000)	735.627 (0.000)	1721.831 (0.000)
ERS	-5.093 (0.000)	-5.547 (0.000)	-5.739 (0.000)	-4.604 (0.000)	-13.407 (0.000)	-6.066 (0.000)
Q(10)	7.159 (0.238)	6.928 (0.261)	8.052 (0.166)	11.206 (0.039)	8.789 (0.121)	3.284 (0.778)
Q ² (10)	139.645 (0.000)	130.264 (0.000)	150.412 (0.000)	113.443 (0.000)	171.256 (0.000)	167.766 (0.000)

Note. Created by the author using a web-based R-Shiny interface.

To examine the dynamic volatility connectedness between the variables, the TVP-VAR model is employed. The TDC relationships between the XUSRD Index, the XU100 Index, and the sectoral equity indices obtained from the model are summarized in Table 3. Dynamic connectedness reflects the transmission of volatility spillovers across the variables.

Table 3

Dynamic Correlation Relationships for Variables

	XUSRD	XU100	XUSIN	XUMAL	XUTEK	XUHIZ	From
XUSRD	19.68	19.29	16.32	17.60	11.34	17.60	80.32
XU100	18.86	19.23	16.96	16.98	11.68	16.29	80.77
XUSIN	17.59	18.69	21.14	14.16	12.78	15.63	78.86
XUMAL	19.50	19.24	14.52	21.83	10.74	14.18	78.17
XUTEK	14.97	15.79	15.81	12.76	26.40	14.26	73.60
XUHIZ	17.47	18.48	16.09	14.17	11.94	21.86	78.14
To	88.39	91.49	79.70	75.67	58.48	76.12	469.86
Inc.Own	108.07	110.71	100.85	97.50	84.88	97.98	cTCI/TCI
NET	8.07	10.71	0.85	-2.50	-15.12	-2.02	93.97/78.31

Note. Created by the author using a web-based R-Shiny interface.

Table 3 reports the extent to which volatility in each index is driven by its own shocks and by shocks originating from other indices, as well as the direction and magnitude of spillover effects across indices. The “NET” measure presented in the table captures the difference between the volatility transmitted to other variables and the volatility received from them. A positive NET value indicates that the variable acts as a net volatility transmitter, whereas a negative value implies that it functions as a net volatility receiver. According to Table 3, the XUSRD Index, the XU100 Index, and the Industrial Index are identified as net volatility transmitters, while the Financial, Technology, and Services sector indices emerge as net volatility receivers. The XU100 Index is the largest volatility transmitter (10.71%), followed by the XUSRD Index (8.07%), whereas the Technology sector index is the largest volatility receiver (15.12%).

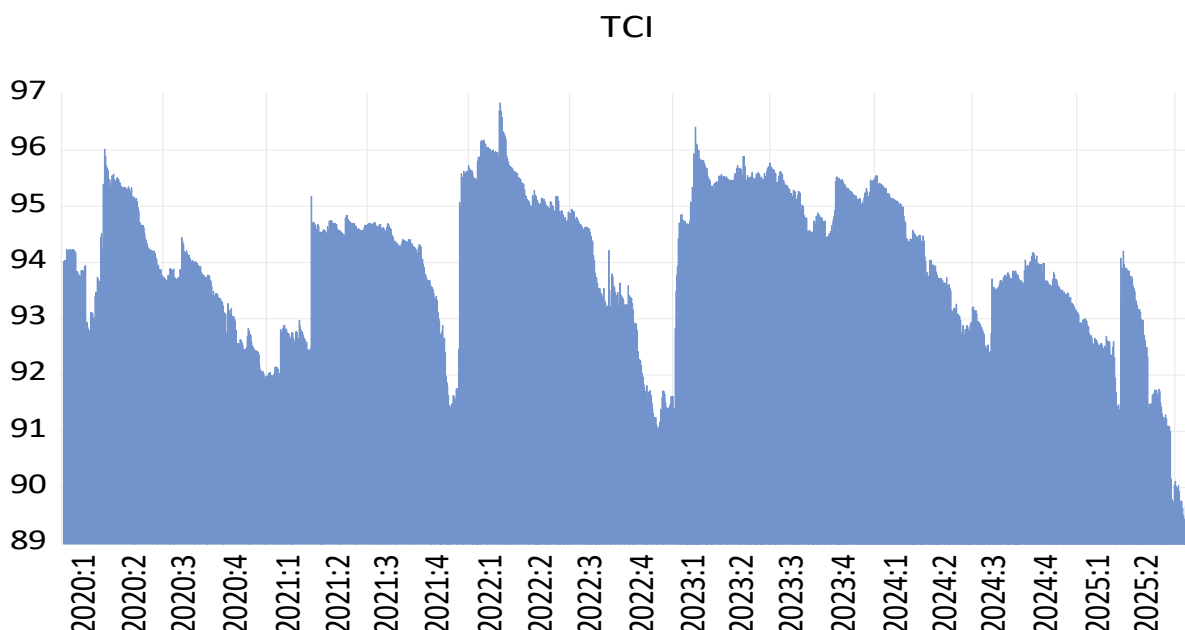
The findings reported in Table 3 also allow for an assessment of the sources of volatility fluctuations across the variables. In this context, volatility fluctuations observed in the XUSRD Index are largely driven by its own innovations (19.68%), followed by shocks originating from the XU100 Index (19.29%). The Technology sector index exerts the weakest influence on the XUSRD Index, accounting for only 11.34% of its volatility. For the XU100 Index, 19.23% of volatility fluctuations stem from its own shocks, while 18.86% originate from the XUSRD Index, 16.98% from the Financial Index, 16.96% from the Industrial Index, 16.29% from the Services Index, and 11.68% from the Technology Index. Volatility fluctuations in the Industrial Index are primarily driven by its own shocks (21.14%), followed by shocks from the XU100 Index (18.69%) and the XUSRD Index (17.59%). Similarly, volatility fluctuations in the Financial Index are mainly explained by its own shocks (21.83%), while shocks from the XU100 Index (19.24%) and the XUSRD Index (19.50%) also play a substantial role. For the Technology Index, 26.40% of volatility fluctuations are attributed to its own innovations, whereas 15.79% and 14.97% are driven by shocks from the XU100 and XUSRD indices, respectively. Finally, volatility fluctuations in the Services Index are largely explained by its own shocks (21.86%), followed by shocks from the XU100 Index (18.48%) and the XUSRD Index (17.47%).

Over the entire sample period, the XUSRD Index transmits volatility most strongly to the Financial, XU100, Industrial, Services, and Technology indices, respectively. Conversely, it receives volatility primarily from the XU100 Index, followed by the Financial, Services, Industrial, and Technology indices.

Finally, the TCI between the variables is estimated at 78.31% over the sample period, indicating a high degree of interconnectedness across the indices. Figure 2 illustrates the evolution of the TDC among the XUSRD Index, the XU100 Index, and the sectoral equity indices.

Figure 2

Total Dynamic Connectedness

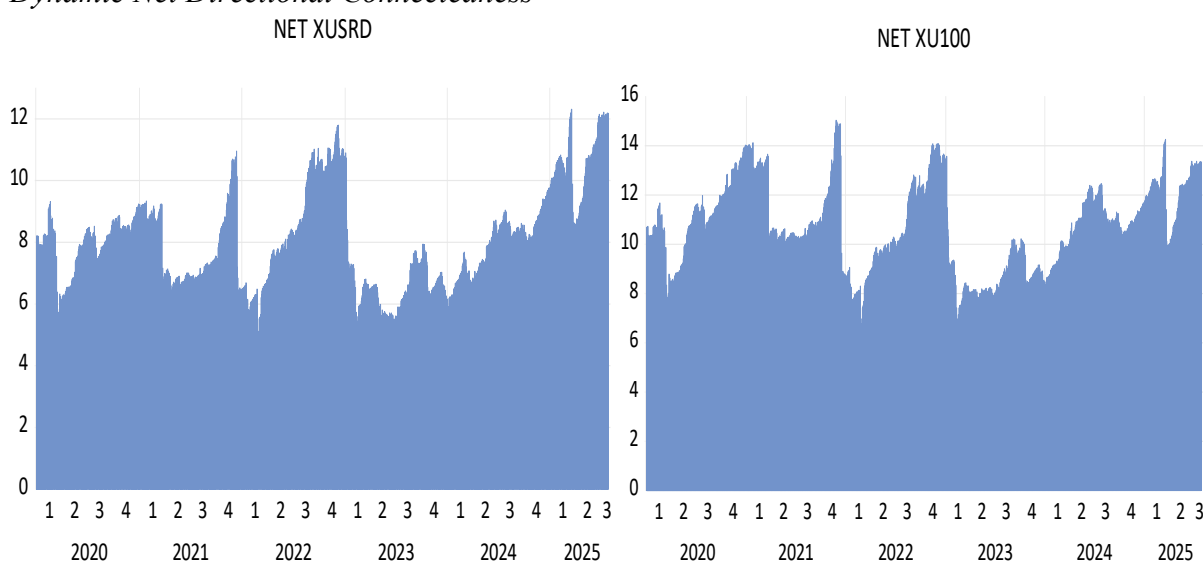


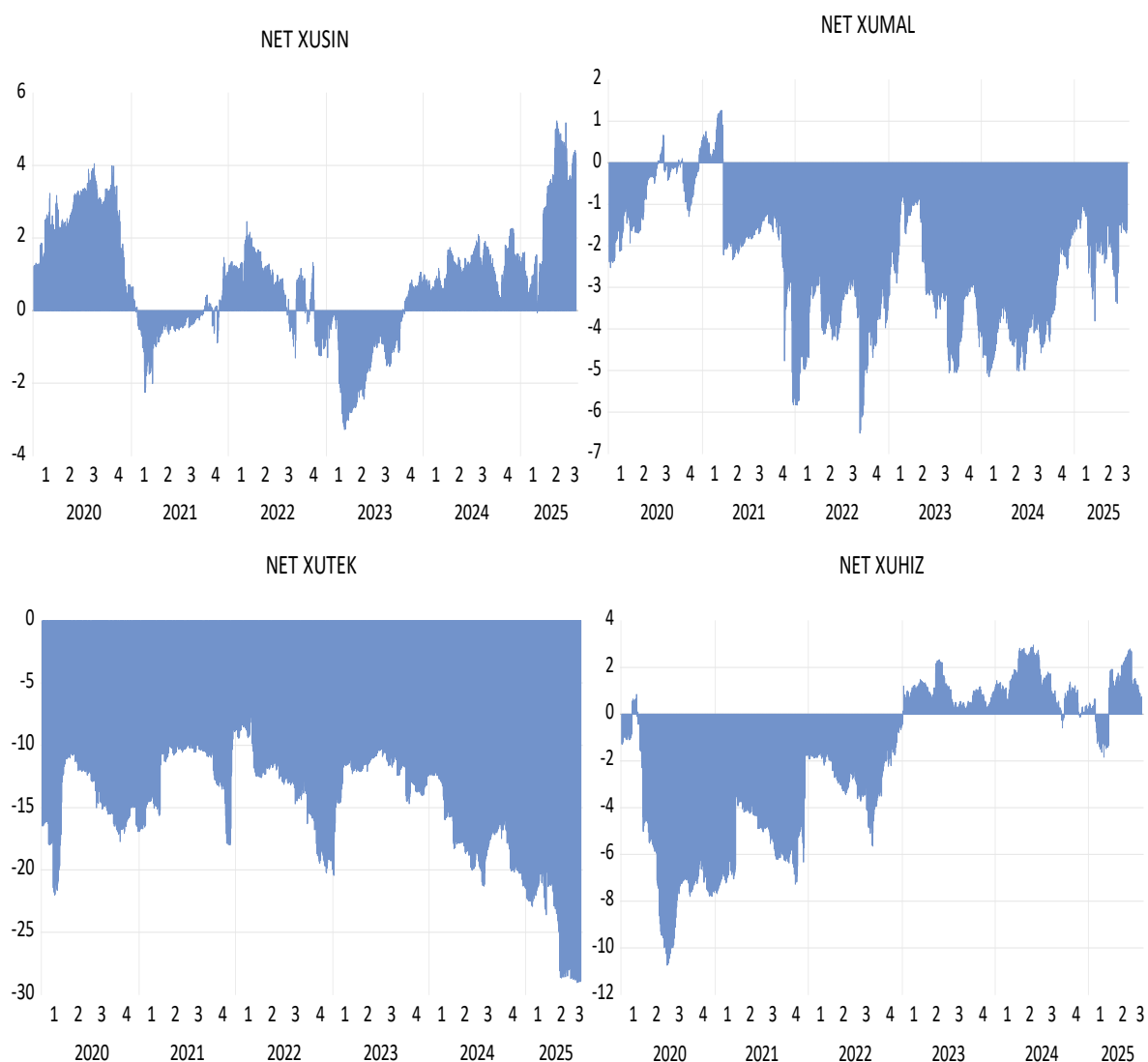
Note. Created by the author in EViews 12; Arial font customization is not supported.

An examination of the figure reveals that dynamic connectedness among the variables exhibits periods of increase and decrease over time. Periods characterized by heightened total connectedness and intensified volatility spillovers across variables coincide with the onset of the coronavirus outbreak in early 2020, the outbreak of the Russia–Ukraine war in early 2022, the earthquakes of 6 February 2023, and the period of political events in the second quarter of 2025. Notably, volatility spillovers across the indices reached their highest level following the earthquakes that occurred on 6 February 2023. To provide a clearer depiction of volatility transmission among the variables, the net total directional connectedness plots are presented in Figure 3.

Figure 3

Dynamic Net Directional Connectedness



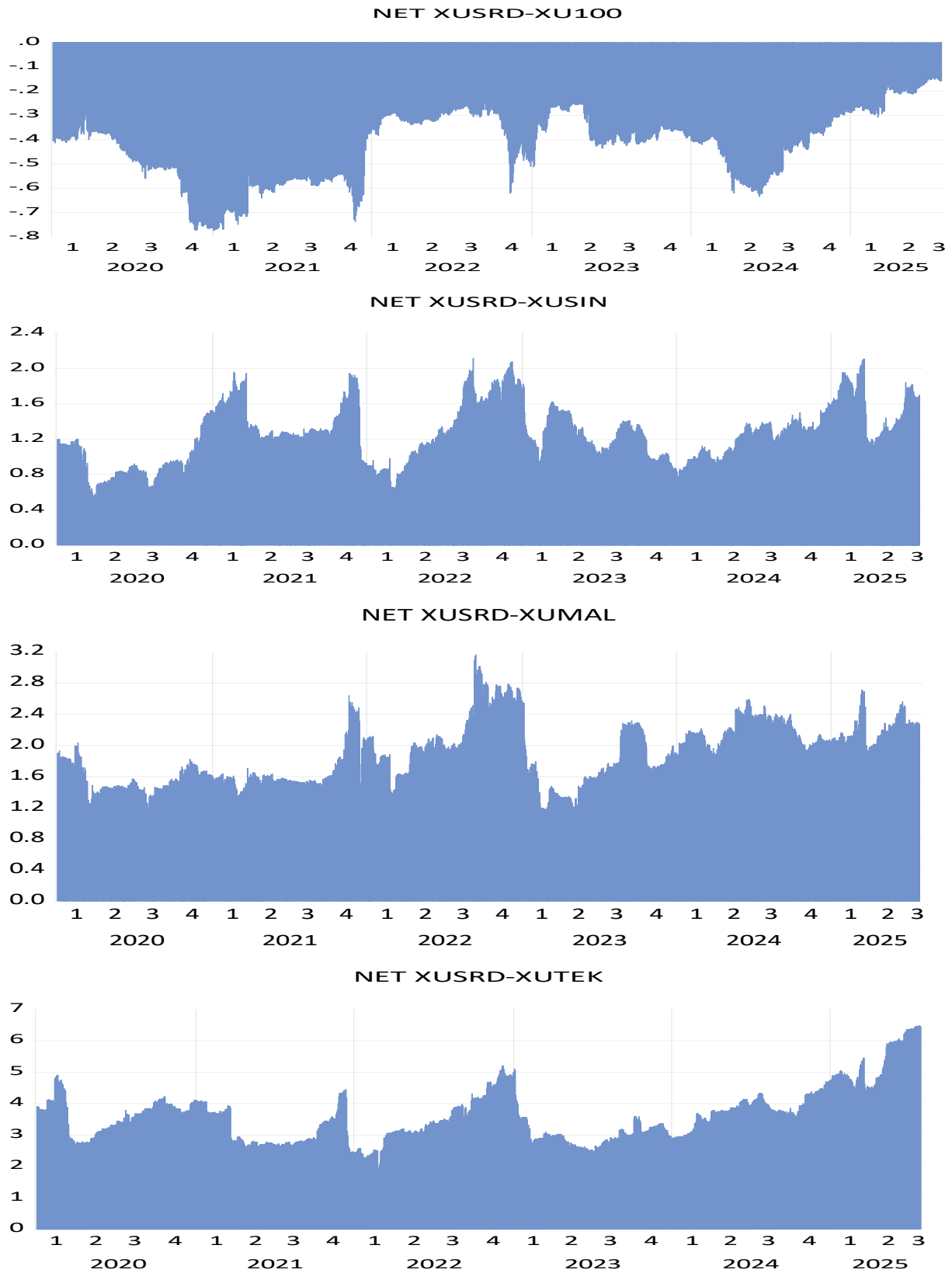


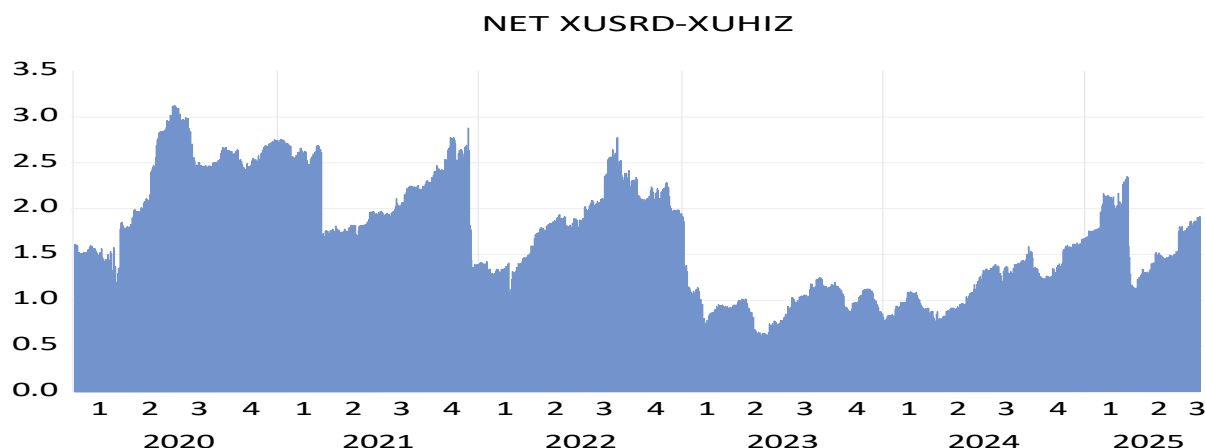
Note. Note. Created by the author in EViews 12; Arial font customization is not supported.

According to the directional connectedness analysis, the dark-shaded area in Figure 3 remaining above the horizontal axis indicates that the corresponding variable acts as a net volatility transmitter during the sample period, whereas values below the horizontal axis imply a net volatility receiver. The graphical evidence suggests that both the XUSRD Index and the XU100 Index function as net volatility transmitters. The Industrial equity index acts as a volatility receiver in 2021 and 2023, while serving as a volatility transmitter during the remaining periods. An examination of the Financial equity index indicates that it behaves as a volatility transmitter only at the beginning of 2021, whereas it assumes the role of a volatility receiver throughout the rest of the sample period. The Services equity index functions as a volatility receiver between 2020 and 2022, but shifts to a volatility-transmitting role after 2023. In contrast, the Technology equity index consistently remains a net volatility receiver throughout the entire period. The net pairwise dynamic connectedness relationships illustrating bilateral volatility spillovers between the XUSRD Index and the other indices are presented in Figure 4.

Figure 4.

Net Pairwise Dynamic Connectedness



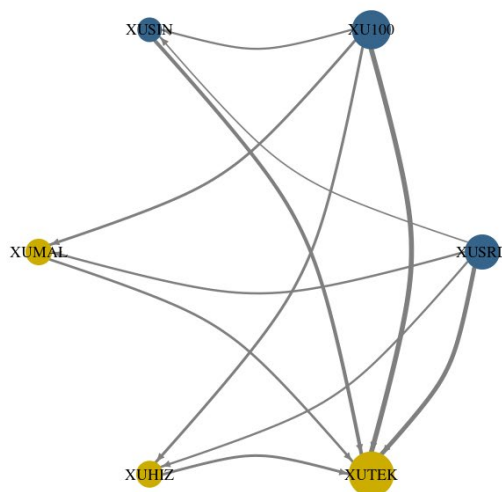


Note. Created by the author in EViews 12; Arial font customization is not supported.

In the net pairwise dynamic connectedness plots, the dark-shaded area lying above the horizontal axis indicates that volatility is transmitted from the first index to the second, whereas an area below the horizontal axis implies that volatility is transmitted from the second index to the first. An examination of the plots reveals a volatility spillover from the XU100 index to the XUSRD Index, while volatility is transmitted from the XUSRD Index to the Industrial, Financial, Services, and Technology stock indices. To further illustrate the direction and strength of volatility spillovers among the XUSRD Index, the XU100 index, and the sectoral indices, the net connectedness network across variables is presented in Figure 5.

Figure 5

Connectedness Network among Variables



Note. Created by the author using a web-based R-Shiny interface. Arial font customization is not supported.

In Figure 5, the indices shown in blue act as net volatility transmitters, whereas those shown in yellow are net volatility receivers over the sample period. The varying sizes of the circles representing the indices are proportional to the magnitude of volatility transmitted and received by each variable. The arrows depicting volatility spillovers indicate the direction of transmission, while their thickness reflects the strength of the spillover effects. An examination of the network reveals that the XU100, XUSRD, and Industrial sector indices function as net

volatility transmitters, whereas the Financial, Services, and Technology sector indices are positioned as net volatility receivers. The XU100 index emerges as the largest volatility transmitter, followed by the XUSRD Index as the second most influential transmitter. These indices transmit the highest level of volatility to the Technology sector index, which is also identified as the sector index receiving the greatest amount of volatility. The values of the net connectedness indicator presented in Table 3 for the dynamic connectedness relationships among the variables are consistent with the network outputs shown in Figure 5.

Conclusion

Dynamic connectedness and volatility spillovers across markets constitute one of the core research areas that has attracted considerable attention in the finance literature. This study examines in detail the volatility spillovers between Türkiye's sustainability index, the stock market benchmark index, and the main sector indices. In this study, the volatility spillovers among Türkiye's sustainability index (XUSRD Index), the largest equity market index (XU100 Index), and the main sectoral equity indices, Financial, Industrial, Services, and Technology are analyzed using daily data for the period from 02 February 2020 to 31 July 2025. In the empirical analyses, a TVP-VAR model with a dynamic parameter structure is adopted, and volatility spillovers are evaluated within this framework. The TVP-VAR model reveals the dynamic structure of volatility spillovers among variables and provides the opportunity to examine their evolution over time.

The net connectedness indicator, a key outputs of the TVP-VAR model, identifies whether variables act as net volatility transmitters or net volatility receivers over time. According to the net connectedness outcomes, the XUSRD, XU100, and Industrial indices function as net volatility transmitters, whereas the Financial, Technology, and Services indices are net volatility receivers. The XU100 Index is identified as the strongest volatility transmitter, with a value of 10.71%, while the XUSRD Index ranks second with 8.07%. The index receiving the highest level of volatility is the Technology equity index, with a value of 15.12%. Findings show that the sustainability index acts as a volatility transmitter is consistent with the results reported by Malhotra (2025), Zeng et al. (2025), Kavas (2025), and Arouri et al. (2025). In contrast to these studies, Doğan et al. (2023), Erben Yavuz (2023), and Başkaya and Özdemir (2025) found that the XUSRD Index acts as a volatility receiver. These studies analyzed the interactions between the XUSRD Index and global indices, including the S&P and Dow Jones Sustainability indices, indicating that the XUSRD Index, as an emerging market index, is affected by international financial markets. Another implication of the net connectedness index, namely the role of the Technology equity index as a volatility receiver, corroborates the results of Toy (2025).

The estimated TCI of 78.31% indicates a very strong level of interaction among the indices. This indicates a high degree of dynamic volatility connectedness among the indices included in the analysis and suggests that holding these indices together in the same portfolio may increase portfolio risk.

According to the total dynamic connectedness plot, volatility spillovers among the indices exhibit periods of increase and decrease over time. The dynamic net directional connectedness evidence show that the XUSRD and XU100 indices generally act as volatility transmitters, while the Technology Index functions as a volatility receiver. The Industrial, Financial, and Services indices assume alternating roles as volatility transmitters and receivers across different subperiods. Periods of elevated total connectedness and stronger volatility

interactions among the indices are observed to coincide with episodes of major economic, geopolitical, and political shocks. Within this context, particularly notable are the onset of the coronavirus outbreak in early 2020, the outbreak of the Russia-Ukraine war in early 2022, the February 6, 2023 earthquakes, and political developments in the second half of 2025. The highest level of volatility spillovers is observed during the February 2023 earthquake period. Findings reveal that major global and domestic shocks amplify volatility spillovers across markets is in line with the empirical evidence reported by Arouri et al. (2025), Naeem et al. (2023), Nogueira and Madaleno (2022), Bhue et al. (2025), Marin-Rodriguez et al. (2024), Zhang et al. (2022), Shaik and Rehman (2023), Wan et al. (2024), Malhotra (2025), Zeng et al. (2025), Doğan et al. (2023), Erben Yavuz (2023), Kaya (2023), Kavas (2025), and Toy (2025). The results suggest that, during adverse periods, the connectedness among indices does not remain constant but rather exhibits a dynamic structure characterized by fluctuations over time. This implies that investors should account for the changing connectedness structure among indices during crisis periods.

Finally, the TVP-VAR outcomes show that volatility originating from the XUSRD Index is transmitted by 19.50% to the Financial Index, 17.59% to the Industrial Index, 17.47% to the Services Index, and 14.97% to the Technology Index. These findings indicate that changes in sustainability policies and ESG-focused expectations have a significant impact on the real sector, and that fluctuations in the sustainability index are rapidly transmitted to the production and services sectors, particularly the financial sector. In particular, the Financial index exhibits a higher sensitivity to such sustainability-driven uncertainties.

By shedding light on the volatility spillover structure between Türkiye's sustainability index and the main sectoral indices, this study provides valuable insights for portfolio diversification and risk management strategies. Future research could examine the volatility structure between sustainability indices and equity market indices in both developed and emerging markets within a broader framework. Moreover, including alternative investment instruments beyond equity indices in the analysis would provide valuable information for risk management strategies.

References

- Aboluwodi, D., Muzindutsi, P. F., & Nomlala, B. (2024). Investor sentiments and performance of selected ESG indices in BRICS markets during bull and bear conditions. *Investment Analysts Journal*, 53(3), 231–248. <https://doi.org/10.1080/10293523.2024.2397889>
- Antonakakis, N., & Gabauer, D. (2017). Refined measures of dynamic connectedness based on TVP-VAR (MPRA Paper No. 78282). Munich Personal RePEc Archive.
- Antonakakis, N., Gabauer, D., Gupta, R., & Plakandaras, V. (2018). Dynamic connectedness of uncertainty across developed economies: A time-varying approach. *Economics Letters*, 166, 63–75. <https://doi.org/10.1016/j.econlet.2018.02.011>
- Arouri, M., Mhadhbi, M., & Shahrour, M. H. (2025). Dynamic connectedness and hedging effectiveness between green bonds, ESG indices, and traditional assets. *European Financial Management*, 31, 1704–1719. <https://doi.org/10.1111/eufm.12561>
- Aydoğdu, A. (2025). Risk şokları ve Türkiye'deki finansal varlıklar arasındaki yayılım etkisinin TVP-VAR dayalı wavelet uyum analizi ile incelenmesi. *Ekonomi Politika ve Finans Araştırmaları Dergisi*, 10(1), 303–331. <https://doi.org/10.30784/epfad.1595233>
- Baruník, J., Kočenda, E., & Vácha, L. (2017). Asymmetric volatility connectedness on the forex market. *Journal of International Money and Finance*, 77, 39–56. <https://doi.org/10.1016/j.jimonfin.2017.06.003>
- Başkaya, H., & Özdemir, A. (2025). Bazı sürdürülebilirlik endekslerinin volatilité modelleriyle incelenmesi. *Selçuk Üniversitesi Sosyal Bilimler Meslek Yüksekokulu Dergisi*, 28(1), 60–77. <https://doi.org/10.29249/selcuksbmyd.1619942>
- Bhue, R., Gartia, U., Panda, A. K., & Nanda, S. (2025). Sustainable equity index dynamic: Connectedness and information asymmetry in emerging markets. *Business Strategy & Development*, 8(1), e70072. <https://doi.org/10.1002/bsd2.70072>
- Choi, K. H., McIver, R. P., & Ferraro, S. (2021). Dynamic volatility spillover and network connectedness across ASX sector markets. *Journal of Economics and Finance*, 45, 677–691. <https://doi.org/10.1007/s12197-021-09544-w>
- Çilek, A. (2025). Interaction and volatility spillover among selected financial assets in Türkiye. *Akademik İzdüşüm Dergisi*, 10(1), 101–131.
- Diebold, F. X., & Yılmaz, K. (2009). Measuring financial asset return and volatility spillovers, with application to global equity markets. *The Economic Journal*, 119(534), 158–171.
- Diebold, F. X., & Yılmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting*, 28(1), 57–66.
- Diebold, F. X., & Yılmaz, K. (2014). On the network topology of variance decompositions: Measuring the connectedness of financial firms. *Journal of Econometrics*, 182(1), 119–134.
- Doğan, M., Raikhan, S., Zhanar, N., & Gulbagda, B. (2023). Analysis of dynamic connectedness relationships among clean energy, carbon emission allowance, and BIST indexes. *Sustainability*, 15(7), Article 6025. <https://doi.org/10.3390/su15076025>

- Elliott, G., Rothenberg, T. J., & Stock, J. H. (1996). Efficient tests for an autoregressive unit root. *Econometrica*, 64, 813–836. <https://doi.org/10.2307/2171846>
- Erben Yavuz, A. (2023). Temiz enerji, sürdürülebilir ve BIST endeksleri arasındaki ilişkilerin analizi: TVP-VAR yaklaşımı. *İşletme Akademisi Dergisi*, 4(3), 339–354.
- Erdoğan, B. (2023). The volatility relationship among financial assets: TVP-VAR model. *International Journal of Business and Economic Studies*, 5(4), 225–237. <https://doi.org/10.54821/uiecd.1392184>
- Erdoğan, B. (2024). Bitcoin, petrol ile borsalar arasındaki volatilité analizi. *İstatistik Araştırma Dergisi*, 14(1), 19–35.
- Gülcemal, T. (2025). Hisse senedi, konut piyasası, altın ve döviz kuru arasındaki dinamik bağlantılılık ilişkisinin analizi: Türkiye örneği. *Üçüncü Sektör Sosyal Ekonomi Dergisi*, 60(3), 2729–2742. <https://doi.org/10.63556/tisej.2025.1575>
- Jarque, C. M., & Bera, A. K. (1987). A test for normality of observations and regression residuals. *International Statistical Review*, 55, 163–172. <https://doi.org/10.2307/1403192>
- Kavas, Ü. Y. B. (2025). Finansal enstrümanların BIST sürdürülebilirlik endeksi üzerindeki dinamik etkilerinin TVP-VAR modeliyle araştırılması. *Mali Çözüm Dergisi*, 35, 1201–1225.
- Kaya, M. (2023). BIST sürdürülebilirlik endeksi ile fosil yakıt fiyatları arasındaki ilişkinin analizi. *Abant Sosyal Bilimler Dergisi*, 23(3), 1475–1495. <https://doi.org/10.11616/asbi.1327883>
- Khan, I. (2025). An analysis of stock markets integration and dynamics of volatility spillover in emerging nations. *Journal of Economic and Administrative Sciences*, 41(3), 861–878. <https://doi.org/10.1108/JEAS-10-2022-0236>
- Koop, G., Pesaran, M. H., & Potter, S. M. (1996). Impulse response analysis in nonlinear multivariate models. *Journal of Econometrics*, 74(1), 119–147.
- Kurnoga N., Šimurina, N., & Fučkan, F. (2022). Performance differences between ESG indices and conventional market indices: A multivariate analysis of indices. *Zagreb International Review of Economics and Business*, 25(s1), 85–103. <https://doi.org/10.2478/zireb-2022-0026>
- Malhotra, P. (2025). Environmental, social and governance (ESG) investing and Indian capital market indices: Dynamic connectedness and risk management strategies. *Journal of Capital Markets Studies*, 9(2), 191–213. <https://doi.org/10.1108/JCMS-12-2024-0096>
- Maraqa, B., & Bein, M. (2020). Dynamic interrelationship and volatility spillover among sustainability stock markets, major European conventional indices, and international crude oil. *Sustainability*, 12(9), 3908. <https://doi.org/10.3390/su12093908>
- Marin-Rodriguez, N. J., Gonzalez-Ruiz, J. D., & Botero, S. (2024). Connectedness between sustainable investment indexes: The QVAR approach. *Economies*, 12(7), 170. <https://doi.org/10.3390/economies12070170>
- Mian, H. R., Hewage, K., & Sadiq, R. (2024). Responsible financing and investment: Identification, development, and assessment of environmental, social, and governance

- (ESG) metrics. *Sustainable Futures*, 8, Article 100246. <https://doi.org/10.1016/j.sftr.2024.100246>
- Naeem, M. A., Farid, S., Arif, M., Paltrinieri, A., & Alharthi, M. (2023). COVID-19 and connectedness between sustainable and Islamic equity markets. *Borsa Istanbul Review*, 23(1), 1–21. <https://doi.org/10.1016/j.bir.2022.06.001>
- Nogueira, M. C., & Madaleno, M. (2022). Are sustainability indices infected by the volatility of stock indices? Analysis before and after the COVID-19 pandemic. *Sustainability*, 14, 15434. <https://doi.org/10.3390/su142215434>
- Pesaran, H. H., & Shin, Y. (1998). Generalized impulse response analysis in linear multivariate models. *Economics Letters*, 58(1), 17–29.
- Peillex, J., & Comyns, B. (2020). Why do financial companies adopt the United Nations principles for responsible investment? *Comptabilité Contrôle Audit*, 26(1), 79–117. <https://doi.org/10.3917/cca.261.0079>
- Polat, O. (2021). Dynamic network connectedness of BRICS equity markets during the COVID-19 era. *Ömer Halisdemir Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 14(4), 1486–1498. <https://doi.org/10.25287/ohuiibf.936124>
- Shaik, M., & Rehman, M. Z. (2023). The dynamic volatility connectedness of major environmental, social, and governance (ESG) stock indices: Evidence based on DCC-GARCH model. *Asia-Pacific Financial Markets*, 30, 231–246. <https://doi.org/10.1007/s10690-022-09393-5>
- Toy, A. (2025). BIST ana sektör endeksleri arasındaki bağlantılılık ilişkileri: TVP-VAR yaklaşımı. *Uluslararası Akademik Birikim Dergisi*, 8(2), 160–170.
- Umar, Z., Kenourgios, D., & Papathanasiou, S. (2020). The static and dynamic connectedness of environmental, social, and governance investments: International evidence. *Economic Modelling*, 93, 112–124. <https://doi.org/10.1016/j.econmod.2020.08.007>
- Wan, J., Yin, L., & Wu, Y. (2024). Return and volatility connectedness across global ESG stock indexes: Evidence from the time-frequency domain analysis. *International Review of Economics & Finance*, 89, 397–428. <https://doi.org/10.1016/j.iref.2023.10.038>
- Brundtland, G. (1987). Report of the world commission on environment and development: our common future. *United Nations General Assembly document A/42/427*. https://cdn.iuc.edu.tr/FileHandler2.ashx?f=rapor_638035862645304306.pdf
- Zeng, H., Benkraiem, R., Abedin, M. Z., & Hajek, P. (2025). Transitioning to sustainability: Dynamic spillovers between sustainability indices and Chinese stock market. *European Financial Management*, 31(5), 1742–1770. <https://doi.org/10.1111/eufm.12560>
- Zhang, W., He, X., & Hamori, S. (2022). Volatility spillover and investment strategies among sustainability-related financial indexes. *International Review of Financial Analysis*, 83, Article 102223. <https://doi.org/10.1016/j.irfa.2022.102223>

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