The Effects of the Volatilities in Global Determinants on the Istanbul Stock Exchange

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Summary: This study investigates the impact of the VIX, volatility in the oil price, gold price, exchange rate, interest rate, and traded value on volatility in the Istanbul stock exchange. The structural vector autoregression (SVAR) model and pairwise and multivariate Granger causality tests were utilized for weekly data ranging from January 2002 to November 2020. According to causality tests, the volatility in global determinants were the primary factors that determined the volatility in the stock exchange. The variance decomposition analysis indicated that the VIX was the main contributor to stock exchange volatility, and its influence increased in successive time periods. The impact of the volatility in the gold price had the second highest influence, while the influence of the oil price remained more limited. The volatility in the stock exchange was significantly affected by volatility in the exchange rate, but the significance of its movements decreased over time. In the early stages, the gold price had no effect, but then it started to have a significant and continuous positive impact. The volatility in the oil price was initially positive and significant, but after a few weeks, its influence became insignificant. Interest rate volatility was insignificant, but exchange rate volatility remained positive and significant for a few of weeks. The volatility in traded value initially appeared insignificant, but it eventually became significant, had a positive influence, and had a long-lasting effect on stock exchange volatility. Hence, the VIX is the most important global driver of stock exchange volatility in both long and short terms.

Keywords: Granger causality tests, Istanbul stock exchange, SVAR model.
JEL: C32, C58, G12

This study applies Granger causality tests, and an SVAR model for variance decomposition, and the impulse response function to investigate the impact of volatilities in global and domestic determinants on the volatility in the Istanbul stock exchange. The Chicago Board Options Exchange's Volatility Index (VIX), oil price volatility, and gold price volatility are the global determinants. Exchange rate volatility, interest rate volatility, and traded value volatility are the domestic drivers. We anticipate that volatility would play a significant role in analyzing stock exchange volatility. Turkey is susceptible to global and domestic factors because of its status as a developing nation. It has the potential to expand to reach the financial frontier that developed nations have already filled, leading to improved economic stability in these countries. Thus, volatility is presumed to be a key factor in the Turkish economy. Investors who want safety to reduce losses, are looking for opportunities to hedge their risks, or are positioning themselves for diversification will avoid an environment with high volatility because it poses risks to their investments. By contrast, markets have the potential to attract risk-takers who seek opportunities to make substantial returns. The volatility approach has the potential to shed light on the state of the stock exchange, particularly on whether or not it is a safe haven or a risky investment market. Hence, some essential concerns that need to be addressed. First, what is the extent of the impact of volatilities in certain variables on stock exchange volatility? Second, is stock exchange volatility largely driven by volatility in global or domestic determinants? If these questions are clarified, then investors, portfolio managers, and policymakers may be better equipped to assume positions according to the levels of volatility of the determinants. The financial markets of emerging nations are known to be more prone to volatility and speculation than those of developed countries. Changes in investment positions in financial markets may be caused by a variety of factors, including global panics, increasing oil prices, unexpected depreciations in currencies, skyrocketing interest rates, spikes in the gold price, herding behavior, and volatile stock exchanges. The volatility of financial instruments may have significant economic consequences. Turkey has often been affected by this issue throughout history. It continues to be susceptible to high levels of volatility in its currency rate, as well as major movements in its stock exchange and interest rates, which are greater than those of many industrialized countries. Therefore, it is insightful to examine the impact of financial market volatility on stock exchange volatility by focusing on Turkey.

1. Previous research and the current work

There is insufficient research on the significance of market volatility in the Turkish stock exchange. Using the SVAR model, this study offers a novel perspective on volatility analysis. Developing nations are desperately in need of financial market investments. It is essential for these economies to succeed in attracting investments if they are to expand and become more stable. However, excessive levels of volatility in the market might provide the impression that there is risk, which, in turn, can encourage negative responses from investors. By considering both domestic and global drivers, investors can gain a better understanding of the Turkish financial market and help generate political opportunities for regulators to take steps. We anticipate that the findings of this study will pave the way for alternative solutions for other emerging nations whose financial markets are prone to high volatility. Stock exchange volatility can substantially impact investment decisions, hedging strategies, diversifications, and risk-management policies. This is critical in gaining investor attention. Both domestic and global determinants can affect stock exchange performance.

Variables that are generally agreed upon to have a substantial international impact on stock markets are referred to as global determinants. When investors experience a confidence crisis, they have the option to diversify their holdings into different types of financial assets. Fear is a significant global element. The VIX quantifies fears about the market and serves as a global indicator that may influence stock markets worldwide. This factor has been regarded as a measure of uncertainty in the US stock market, and is known as the investor fear gauge (Jeff Fleming et al. 1995; Robert E. Whaley 2000 and 2009). This index is derived from the forward pricing of 30-day volatility (Yueh-Neng Lin and Anchor Y. Lin 2016). It can be used to evaluate the anticipated levels of uncertainty and risk perception in the stock markets to identify potential hedging opportunities. Political news that escalates existing tensions on a global scale can impact the VIX, which may in turn detect rising risk signals in the market (Tobias Burggraf et al. 2020). The Turkish economy is open, and it is financially linked to the economies of other industrialized nations. Therefore, global issues centered on developed countries can easily be transferred to stock exchanges. Thus, the VIX was included into this study to provide an approximate the effect of fear has on the stock market. Oil is both a commodity and one of the most important sources of energy. It is an essential component of power that not only influences the expansion of the economy and also the dynamics of the financial markets. Oil price volatility (uncertainty) can have a significant effect on stock markets (Bhaskar Bagchi 2017; Shupei Huang et al. 2017; Xingguo Luo and Shihua Qin 2017). Changes in the oil

price have the potential to create a direct or indirect impact on every sector of the economy (Paulo Ferreira et al. 2020; Reem Khamis Hamdan and Allam Mohammed Hamdan 2020; Besma Hamdi et al. 2019). High oil price volatility can alter investors' expectations of a stock exchange's future performance (Peng Li and Yaofu Ouyang 2022; Yensen Ni et al. 2020). A higher oil price is often considered an indication of increased economic activity, which, in turn, may lead to better stock returns. As prices of commodities in the economy continues to rise, it may also give rise to feelings of dissatisfaction. It is possible to invest in it as a commodity to reduce risk or utilize it as a safe haven. The gold price was taken into consideration because it is generally seen as one of the most significant investment opportunities worldwide. It is a tool that can be a safe haven (Juha Junttila et al. 2018). Hence, gold price volatility may affect market instability. Elie Bouri et al. (2017) found a substantial correlation between the implied volatility of gold and that of the Indian stock market. Gold is widely used in Turkey due to its reputation as a risk-free investment option. It is a global investment tool that can provide protection against items with higher levels of risk.

The exchange rate is one of the domestic factors that determines the state of a financial market. Stock markets can be affected by it depending on the prevailing conditions in a certain nation (Hock Tsen Wong 2017). In some countries, appreciation can positively influence stock exchanges, whereas depreciation can do this in others (Paresh Kumar Narayan et al. 2020). If a nation is undergoing dollarization, this variable is essential. Thus, the exchange rate is an important determinant that must be considered, as it can be accepted as a diversifier against the stock exchange. The function of global foreign currencies in combating persistent inflation is crucial. Hence, it is reasonable to anticipate that this may be a viable choice for investors seeking to remove their money from stock exchanges. When a currency experiences a significant decline in value, citizens also have the option of investing in the stock exchange. If the central bank changes its monetary policy, it may affect the stock market (Natthinee Thampanya et al. 2020). The interest rate offered on savings deposits is one factor that might influence decisions. When the interest rate increases, it is reasonable to anticipate that it has the potential to affect the preferences of investors. In other words, investors can deposit in banks rather than purchase equities in the financial market. Finally, the traded value demonstrates how the financial markets operate. Significant shifts in stock exchange volatility can result from high levels of volatility in the traded value. Thus, it is possible that this was an indication of herding behavior.

1.1 Previous research

Works have investigated the influence that both domestic and global variables have on stock markets. This section presents an overview of these studies. Using monthly data from January 2003 to December 2019, David G. McMillan et al. (2021) employed an asymmetric dynamic conditional correlation model to examine the effect of oil on the interdependence of the US-GCC stock markets. It was discovered that fluctuations in the US-GCC correlation could be explained by the returns and volatility of the oil market. The VIX was another important element in the analysis of this correlation. Using the traditional dynamic conditional correlation generalized autoregressive conditional heteroscedasticity (DCC-GARCH) model, and other advanced models, such as the corrected conditional correlation GARCH and the generalized orthogonal GARCH, Zhenhua Liu et al. (2020) analyzed the relationship between the oil market and the US stock market based on the VIX. The study considered the daily period between 10 May 2007 and 11 June 2018. According to estimates, there is a considerably positive time-varying link between the oil price and the returns on implied stock volatility. Additionally, the financial crisis strengthened the significance of the link between oil and the stock markets. Chin Chia Liang et al. (2020) applied a NARDL model to analyze the impacts of US uncertainty on eleven Asian stock markets, utilizing monthly data between August 2000 and February 2017. This study provides substantial support for the hypothesis that rising uncertainty levels are directly correlated with falling stock values. Ghulam Sarwar (2020) analyzed the interdependency between the VIX and five European markets by using a VARMAX-GARCH model for daily periods spanning from 2 January 2004 to 30 June 2019. The variance-covariance of the VIX and European volatilities was shown to have a substantial interaction. Two different factors were shown to have predictive impacts on one another when the Granger causality tests were performed. Lu Yang et al. (2018) investigated the link between six Chinese stock markets, global variables, and safe haven assets by using a quantile regression in conjunction with a wavelet decomposition analysis. Daily data were collected from five different stock exchanges between 10 October 2006 and 14 September 2016, with the exception of the growth enterprise market, which had its beginning date set to 2 June 2010. The determinants were the three-month repurchase rate, the VIX, the gold price, the oil price, and the US dollar index. It was discovered that in the medium and long-run periods, there was an asymmetric dependency between the oil price and the index of the US dollar on each of the six stock markets. Gold was evaluated as a potential safe haven during times of economic crisis, and the VIX was shown to be an effective risk-management

tool. Juan Andres Rodriguez-Nieto and Andre V. Mollick (2021) used a multivariate DCC-GARCH model to investigate the relationship between the US stock markets and various Latin American equities during the financial crisis. Daily data were collected between 1 January 2002 and 31 December 2015. It was hypothesized that a negative intertemporal link could be established between rises in the VIX and the majority of stock returns. Ghulam Sarwar and Walayet Khan (2017) employed multivariate regression and pairwise Granger causality tests to assess the impacts of the VIX on stock returns in Latin America and developing equity markets for the daily period covering 1 June 2003 and 30 September 2014. The investigation considered the consequences before, during, and after, the 2008 financial crisis. It was discovered that a spike in the VIX leads to substantial decreases in emerging market returns, both immediately and in the longer term. Moreover, it was discovered that the VIX could explain a larger proportion of changes in emerging market returns during the financial crisis. The VIX Granger caused post-crisis emerging market returns. Fear of the VIX can increase the volatility of emerging market returns through GARCH type volatility processes. Other works have also strongly connected the VIX and stock market returns (Jalaj Pathak and Soumya G. Deb 2020; Ghulam Sarwar, 2019; Lee A. Smales, 2016; Ghulam Sarwar, 2012).

The oil price and its impact on stock markets are popular topics among scholars. Taking the examples of the GCC and the BRICS nations, Zaghum Umar et al. (2021) studied the relationship between oil price shocks and the stock markets between 6 January 2005 and 17 July 2020. Methodologically, oil price shocks were divided into demand, supply, and risk shocks. A network connectedness technique was developed to investigate the static and time-varying connectivity of oil price shocks in equity markets. During the COVID-19 pandemic, it was believed that there was a medium connectivity between the stock markets and oil price shocks. It was noted that oil price shocks can be used as a predictor of equity markets, and that the volatility of oil-exporting nations largely accounted for this connectedness. Walid Mensi et al. (2021) analyzed volatility spillovers between certain developed countries and BRICS stock markets, as well as commodity futures markets such as oil and gold, by employing a spectral representation of the variance decomposition method based on frequency responses to shocks. The daily period between the dates of 3 January 2000 and 28 February 2018 was considered. It was determined that the most successful method of hedging for both industrialized nations and developing countries was to have a diversified portfolio comprising both commodities and stocks. In the short term, it was discovered that the effectiveness of hedging gold was greater than that of hedging oil. The dynamic link between the oil price and returns on stock markets in seven different nations was investigated by Jose E. Gomez-Gonzalez et al. (2021). The oil price was

divided into its component parts, which are supply, demand, and risk. Weekly average daily data were collected between July 2002 and April 2018. The total and directional spillover indicators were computed using VAR, and Granger causality tests were implemented. There was a stronger bidirectional relationship from the stock to oil markets, suggesting that the oil markets were net volatility receptors. Kris Ivanovski and Abebe Hailemariam (2021) assessed the dynamic relationship between Standard and Poor's (S&P500) stock returns and the oil price based on the WTI for monthly periods between January 1871 and October 2020. A generalized autoregressive score (GAS) model was employed for the analysis. It was estimated that there was a time-varying relationship between the two determinants, and that the dynamic correlation increased during turbulent events. There are also additional studies that investigated the connection between the two determinants and arrived at various conclusions (Anand B. and Sunil Paul 2021; Jinxin Cui et al. 2021; Precious Adaku Enwereuzoh et al. 2021; Shabir Mohsin Hashmi et al. 2021; Fatima M. Abdulkarim et al. 2020; Zhuhua Jiang and Seong-Min Yoon 2020; Khaled Mokni 2020; Parnia Shahrestani and Meysam Rafei, 2020; Suleman Sarwar et al. 2020).

Recent studies have evaluated the gold price, interest rates, exchange rates, and traded value. Mohamed Bilel Triki and Abderrazek Ben Maatoug (2021) conducted research to determine whether or not gold acts as a safe haven compared with the US stock market when geopolitical tensions are high. An MV-GARCH model and a dynamic copula were applied to monthly data that was collected between January 1985 and December 2018. The findings demonstrated that gold was a safe haven during times of extreme stress. Lei Ming et al. (2020) used weekly data for the time period between 5 April 1991 and 8 April 2016 and utilized a wavelet technique to determine whether or not gold served as a hedge for the stock market in China. It was found that gold could not be used as a hedging tool in the short term, but could be used as a hedge in the long term after 2005. Using daily data ranging from 1 November 2014 to 20 April 2018, Yu-Sheng Kao et al. (2020) employed threshold models within a GJR-GARCH framework for the S&P 500 VIX Future Index. This study investigated the nature of the connection between returns and trading volumes. It was pointed out that raising trading volume is a technique for investors to increase their returns, but this results in higher volatility. Shelly Singhal et al. (2019) applied daily data between January 2006 and April 2018 to conduct an ARDL bound testing cointegration analysis to investigate the relationship between the oil price, the gold price, the exchange rate, and the stock exchange in Mexico. It was reported that the gold price had a positive effect on the stock exchange, whereas the oil price had a negative impact. Ke Chen and Meng Wang (2019) explored the hedging and safe-haven features of gold in relation to the Dow Jones stock industries by using a quantile-GARCH approach on

daily data spanning from 2 January 1980 to 23 March 2017. Gold was found to be a safe haven for almost all sectors except technology. Md Gyasuddin Ansari and Rudra Sensarma (2019) used a VAR model to evaluate monthly data from January 1996 to December 2018 to examine how the Federal Fund Rate, the gold price, and the oil price affect the stock exchanges in the BRICS. It was mentioned that the monetary policies of the US had an effect on the Bombay Sensex. The oil price shocks negatively affected on the South African stock index. Russia and Brazil responded positively to fluctuations in the gold price. Ekhlas Al-hajj et al. (2018) implemented a nonlinear ARDL model for monthly periods from January 1990 to November 2016 to determine whether changes in the oil price, interest rate, exchange rate, industrial production, and inflation have similar effects on stock market returns in Malaysia. It was stated that the Malaysian financial market was highly sensitive to fluctuations in the oil price. Both an increase in interest rates and an increase or decrease in the exchange rate negatively impact on the stock market. Using a VAR model, Nancy Areli Bermudez Delgado et al. (2018) evaluated the connection between the oil price, the stock market, and the exchange rate in Mexico throughout the monthly period spanning from January 1992 to June 2017. It was shown that the exchange rate had a negative and statistically significant effect on the stock market. In other words, an increase in the stock market index was a result of the appreciation of the exchange rate. Pu Gong and Jun Dai (2017) investigated the effects of the interest rate and exchange rate on the stock exchange using a panel regression analysis for daily periods from 21 July 2005 to 30 June 2016. The findings demonstrated that an increase in the interest rate as well as a depreciation in the exchange rate contributed to the herding behavior in the stock exchange. There are further studies that investigated these factors to determine their relationships (Gazi Salah Uddin et al. 2020; Muhammad Akbar et al. 2019).

In addition, Nezir Köse and Emre Ünal (2020) applied the SVAR model to the monthly data between March 2005 and June 2018 to analyze the impact of oil price shocks on stock exchanges in nations that are part of the Caspian Basin. It was estimated that stock exchanges were affected more by negative oil shocks than by positive ones. Saleha Ashfaq et al. (2019) examined the volatility spillover effects of oil prices on stock returns in leading exporting and importing countries in Asia using GARCH models for the daily period from 1 September 2009 to 31 August 2018. It was explored that the impact of oil price shocks on exporting countries was stronger than that on importing countries. Barbara Będowska-Sójka and Agata Kliber (2019) analyzed the causality between liquidity and volatility in the Polish stock market for the daily period from January 2006 to December 2016. A bidirectional relationship was estimated using Toda-Yamamoto and Granger causality tests. Nevertheless, this

relationship was found to be asymmetric. Employing the generalized auto-regressive conditional heteroskedasticity (GARCH) model for daily data between January 2019 and June 2021, Muntazir Hussain et al. (2023) investigated the relationship between exchange rate volatility and stock exchange volatilities in BRICS countries during the pandemic. It was found that there was a significant connectedness between exchange rate volatility and stock exchange volatilities.

1.2 The current work

There are various works that have centered their attention on the Istanbul stock exchange. Xingxing He et al. (2021) analyzed the causal relationship between exchange rates and the Istanbul stock exchange by employing a wavelet coherence approach for monthly periods spanning from April 2000 to March 2019. For the analysis, USD/TRY and EUR/TRY were utilized. It was pointed out that there was a negative correlation between the exchange rates and the stock exchange. The correlation was stronger between the USD/TRY and the stock exchange. Moreover, volatility in the exchange rates during crisis periods was also observed in the stock exchange. Abdurrahman Nazif Çatık et al. (2020) investigated time-varying effects of the oil price and the exchange rate on the Istanbul stock exchange, using daily data between 3 January 1997 and 9 August 2018. The results show that the impact of the oil price on the stock exchange was lower than that of the exchange rate. However, the impacts varied depending on the chosen industries, although the majority of these industries were much more affected by the exchange rate. Using monthly data spanning January 2003 to December 2018, Yacouba Kassouri and Halil Altıntaş (2020) examined the complex dynamic co-movement connection between the exchange rate and the stock exchange. It was discovered that stock exchange volatility can be predicted by the exchange rate, money supply, and interest rate. Ugur Akkoc and Irfan Civcir (2019) employed the SVAR-DCC-GARCH model using daily data from 1 January 2009 to 31 December 2017, to examine the correlation between oil prices, gold prices, and the stock exchange. According to the findings, there was a time-varying co-movement and volatility spillover from gold and oil to the stock exchange. Gold demonstrated a more significant influence, and it was noticed that gold did not behave in the form of a safe haven. Elif Akay Toparlı et al. (2019) applied a time-varying parameter vector autoregression model (TVP-VAR) for monthly periods from February 1988 to March 2017. The impact of oil price shocks was estimated to be less than that of the interest rate and the exchange rate. It was thus noted that the interest rate and the exchange rate were major factors affecting the stock exchange. In addition, Nuket Kirci Cevik et al. (2020) and Onur Polat (2020) found a significant connection between the oil price and the stock exchange. Guglielmo Maria Caporale

et al. (2022) used daily data spanning the period from 2 January 2 2001 to 22 March 2021, and employed a time-varying methodology to analyze the impact of exchange rates and oil prices on sectoral stock returns. It was noted that oil prices and the exchange rates suggested different findings across sectors in terms of their impact on the stock market in Turkey. Using FAVAR models for the monthly data between January 1992 and December 2015, Coşkun Akdeniz and Abdurrahman Nazif Çatık (2017) stated that global factors have the potential to create a considerable impact on the financial circumstances in Turkey, but the role that the interest rate and exchange rate play in explaining the phenomenon is more limited. Using the flexible least squares approach, Ali İlhan and Coşkun Akdeniz (2020) studied the influence of the macroeconomic factors on the Istanbul stock market during COVID-19. This analysis was completed for daily period between 13 September 2019 and 11 September 2020. The exchange rate was reported to have the greatest influence on the stock market. Although not linked to the stock exchange, Nezir Köse and Emre Ünal (2021) evaluated the influence of oil price and oil price volatility on inflation in Turkey by using the SVAR model for the monthly period between March 1988 and August 2019. It was stated that the oil price volatility accounts for a stronger explanatory influence on inflation over the long term.

Studies on the effects of volatility in developing economies are limited. Our research addresses this gap in the previous works by focusing on volatility analyses. Volatilities are examined in great depth in this study, with a particular emphasis placed on the Istanbul stock exchange. Furthermore, the Turkish economy is still in its early stages of development; therefore, its stock exchange is likely to be volatile owing to both global and domestic factors. It is generally accepted that as volatilities increase, the stocks can become extremely risky, because rising volatilities can lead to significant price fluctuations in the stock exchange. This indicates that investors who are looking for a safe haven or a chance to mitigate their risk may find the stock market to be an unfavorable option for portfolio managers. Nevertheless, increasing volatility may provide investors with greater possibilities to take risks and profits. Throughout this study, all information and restrictions required to test the SVAR model are provided. Volatility-based SVAR models have received little attention in developing nations. Volatilities for the variables –the Istanbul stock exchange, oil price, gold price, interest rate, exchange rate, and traded value, excluding the VIX– were computed by employing appropriate conditional variance models. Granger causality tests and the SVAR model analysis were performed on the weekly time series obtained for the computed volatilities. This work utilized weekly analysis as an alternative frequency technique, which was different from the approach adopted in prior research. To the best of our knowledge, this study is among the first to examine the role of volatilities as determinants of stock exchange volatility. Most studies are restricted to analyzing

either financial or commodity factors. To quantify the effects of various determinants, this paper considers both financial and commodity factors and estimates their volatilities. This study expands the scope of research to include the VIX and, for the first time, traded value in addition to the oil price, gold price, exchange rate, and interest rate. Estimations should also be made regarding the impact of investors' feelings on the stock exchange. The volatility of traded value can shed light on herding behavior in the stock market. This is an innovative approach to addressing an issue that has been lacking in existing works. Furthermore, it is possible to explore the ways in which both domestic and global drivers affect the stock exchange. Volatilities can be taken into consideration by investors, portfolio managers, and policymakers so that action can be taken to establish positions for diversification, hedging, or safe havens. In addition, the SVAR model has not been extensively used in previous studies. Compared to the single equation and the VAR models, this approach offers a number of significant advantages. As a result, the purpose of this study is to investigate the influence of many factors from a wide perspective to develop a model that would not only facilitate future research but also assist policymakers, investors, and portfolio managers in better comprehending the dynamics of the stock market.

2. Assumptions and data collection

There are assumptions regarding the drivers of stock exchange volatility. Financial market risk perceptions can change with the VIX. At times of high volatility, this might affect stock exchange volatility. This is expected to affect investors' trading and portfolios. In other words, it may be regarded as a signal to avoid risks (Mahmoud Qadan et al. 2019). Studies have shown that the VIX may accurately predict global stock markets, particularly during panics like the COVID-19 pandemic (Jiqian Wang et al. 2020; Chao Liang et al. 2020). Hui-Chu Shu and Jung-Hsien Chang (2019) found that the VIX significantly impacted both US and non-US equities. Hui Wang (2019) studied the relationship between VIX and stock market volatility. This study examines 13 G20 equity markets. It was estimated that the VIX was statistically significant in most nations in terms of its role in producing high levels of stock exchange volatility. The VIX and stock exchanges should be negatively correlated (Ghulam Sarwar 2014). Unexpected VIX spikes encourage investors to hedge against stock losses. Financial managers and investors can hedge against stock market volatility using the VIX. A high VIX boosts stock exchange volatility. Therefore, this factor was included into the research because it is a global variable that can potentially influence the choices made on the Istanbul stock exchange.

Oil is a significant commodity that provides developing countries with a vital source of energy to meet their demands. Trading this variable as a security influences the investment strategy. Oil prices can also influence stock markets. Oil price volatility can negatively impact stock exchanges in developing nations (Naveed Raza et al. 2016). Oil price volatility in the GCC nations was expected to have a negative effect on stock markets (Abdullah Alqahtani et al. 2019). Market volatility or shocks can be detrimental, necessitating the search for strategies to reduce their impact (Victor S.H. Wong and Suzanna El Massah 2018). Stock market volatility may increase with oil price volatility (Lu Wang et al. 2020). Oil can be a favorable commodity for hedging stock prices in developing markets (Syed Abul Basher and Perry Sadorsky, 2016). It can forecast movements in stock markets (Coşkun Akdeniz et al. 2021). Zhifeng Dai et al. (2021) found that oil price predictions were more effective during recessions. Research indicates that oil price returns positively impacted US stock returns during the recovery after the 2008 financial crisis (André Varella Mollick and Tibebe Abebe Assefa 2013). Hence, it is reasonable to assume that the oil price can affect the Istanbul stock exchange.

Gold is recognized as a commodity that can be held as a safe haven investment in many different economies. This hedges against excessive inflation and financial market risks. In portfolio management, it can serve as a safe haven and diversifier (Oluwasegun B. Adekoya et al. 2021; Walid Mensi et al. 2018). Gold was determined to be a stable investment in Turkey, offering protection from both inflation and exchange rate fluctuations (Meng Sui et al., 2021). Thus, it might be an investment platform for stock market turbulence. High gold price volatility may also affect stock exchange volatility. Hence, gold may be a risk-free investment during stock market crises. Rising gold volatility may warn financial managers and investors of market risks and assist them in choosing between stock exchanges and gold. In moments of risk, gold price volatility, and investments targeting gold would indicate financial market instability, which may affect stock exchange volatility. Walid Mensi et al. (2016) analyzed Gulf stock markets, investigating four factors: the VIX, three-month US Treasury bill rate, the oil price, and the gold price. It was stated that gold was a powerful hedge and a safe haven for all Gulf markets.

Exchange rates are key drivers of macroeconomic dynamics within a nation and can be seen as a domestic factor in that context. The exchange rate, and stock exchange are assumed to have a high correlation (Mourad Mroua and Lotfi Trabelsi 2020; Xiyong Dong and Seong-Min Yoon 2019; Shuming Bai and Kai S. Koong 2018). It can deliver vital signals to developing economies vulnerable to currency fluctuations. There was evidence, as Smita Mahapatra and Saumitra N. Bhaduri (2019) showed that

the Indian stock market responded considerably to changes in the exchange rate. Economic instability can be demonstrated by high exchange rate volatility. This was expected to increase stock market volatility. Currency depreciation can negatively affect stock markets (Muhammad Kamran Khan et al. 2021). Rising exchange rate volatility may force investors toward safer spots. Stock markets in emerging economies were expected to suffer from exchange rate volatility. In Turkey, exchange rate volatility was assumed to increase stock exchange volatility.

Monetary policy is assumed to significantly affect the stock market (Aeimit Lakdawala and Matthew Schaffer 2019). The interest rate is a major investment factor. Rania Jammazi et al. (2017) found that there was a substantial bidirectional causal relationship between the interest rate and the stock exchange in the US. An increase in this variable may encourage investors to save in banks. Volatile interest rates may negatively impact the stock market. High interest rates may shift stock exchange investments toward banks. Stock exchange volatility may result from interest rate volatility. Turkey has historically utilized interest rates to show investors that the economy is under control in a high inflation environment (Ali İlhan et al. 2022). Thus, this dynamic must be addressed in Turkey and its stock exchange effects.

Traded value refers to stock market terminology. It indicates that investor attention is closely connected to trade volumes (Amal Aouadi et al. 2013). In addition, it may demonstrate herd behavior in the stock market (Shamila A. Jayasuriya 2011). This variable significantly affects stock exchange volatility. Investors may detect stock exchange stress via stock turnover. Increasing traded value volatility increases stock exchange volatility. This is particularly true when the risk perception or speculation is high. On the other hand, a low level of volatility in the value that is exchanged would send the message that the stock market is not being impacted by speculators, and that it is more stable.

The data collected for this analysis covered weekly periods starting from the first week of January 2002 to the last week of November 2020. The research starts from 2002 because the Turkish economy experienced a structural economic crisis in the period of 2000-2001. Following the financial crisis, the country implemented institutional reforms, which led to a more liberal economic policy stance. These reforms were expected to allow the financial sector to act in an environment consistent with a much freer economy. The period following the economic crisis serves as the starting point for this study. The reduced impact of the crisis on the economy facilitated this investigation.

An international database was used to evaluate factors that are global in scope. The Federal Reserve Bank of St. Louis provided the data that was used to derive the

VIX. This index approximates the effects of fear, and speculation on stock exchanges. The CBOE volatility index is one such category. Two primary data sources were considered when analyzing oil prices. These are Brent crude oil and West Texas Intermediate (WTI). Brent was considered for this study because Turkey is geographically located in close proximity to European nations and because it has established substantial levels of engagement with this area. Despite this, it can be assumed that all international oil prices have exhibited a certain degree of correlation. The prices of Brent (European) crude oil were derived from the Federal Reserve Bank of St. Louis. These prices are based on US dollars per barrel. The gold price is another factor that has a global impact and has an effect on investors. Using the same data source, the gold price was determined based on US dollars per Troy Ounce in the London Bullion Market (3:00 PM).

Turkish data sources were used to collect information on domestic factors. The economy is profoundly impacted by the exchange rate. As Turkey is still considered to be a developing nation, it is reasonable to assume that the country may be greatly impacted by the volatility of its currency. Following the economic crisis of 2000-2001, the government began adopting more liberal economic policies. The mechanism that sets the exchange rate has evolved into a flexible one that was driven by market conditions. The system was established to prevent unexpected depreciations of the currency value. However, the exchange rate continued to be highly volatile and prone to consistent depreciation. In addition, the country was dominated by dollarization, and this trend helped prepare the way for a structural crisis in the years 2000-2001. It was discovered that the exchange rate had a major impact on the stock market, since the nation was exposed to enormous impact due to the high volatility in its currency. Information on the exchange rate between the Turkish lira and the US dollar was collected from the Central Bank of the Republic of Turkey (CBRT). The interest rate was used as a significant instrument for regulating both the financial system and controlling inflation. Following the economic crisis, the interest rate became more flexible, based on market conditions. Fluctuations in interest rates may indicate that the economy is under stress, which can impact investors' decisions in stock markets. When the interest rate rises to the point at which saving money in a bank becomes more appealing, it might provide an opportunity for investment. Thus, the deposit interest rate was considered in this study. The CBRT was the source of these particular statistics.

The final determinant is the traded value. When investors make significant changes in their holdings in a short period, this sends a signal to the financial market, indicating that the stock exchange is experiencing risk and speculation stress. A

significant shift in stock exchange volatility can encourage risk-appetizing investors while prompting other with a more consistent investment strategy to seek new opportunities that can provide a safe haven. Hence, the CBRT was used to collect traded values based on the lira. The conditional heteroskedastic models for measuring volatilities are given in Tables 1A and Table 2A in Appendix. In the end, the volatilities of all the determinants were calculated and notated as follows:

VIX: The Chicago Board Options Exchange's Volatility Index
VOIL: Oil price volatility (US dollars)
VGOLD: Gold price volatility (US dollars per ounce)
VER: Exchange rate volatility (lira per US dollar)
VIR: Interest rate (deposit rate) volatility (nominal)
VTV: Traded value volatility (based on the lira)
VBIST: Stock exchange volatility (Istanbul Stock Exchange, BIST-100)
All weekly determinants were defined as percentage changes from the equation below:

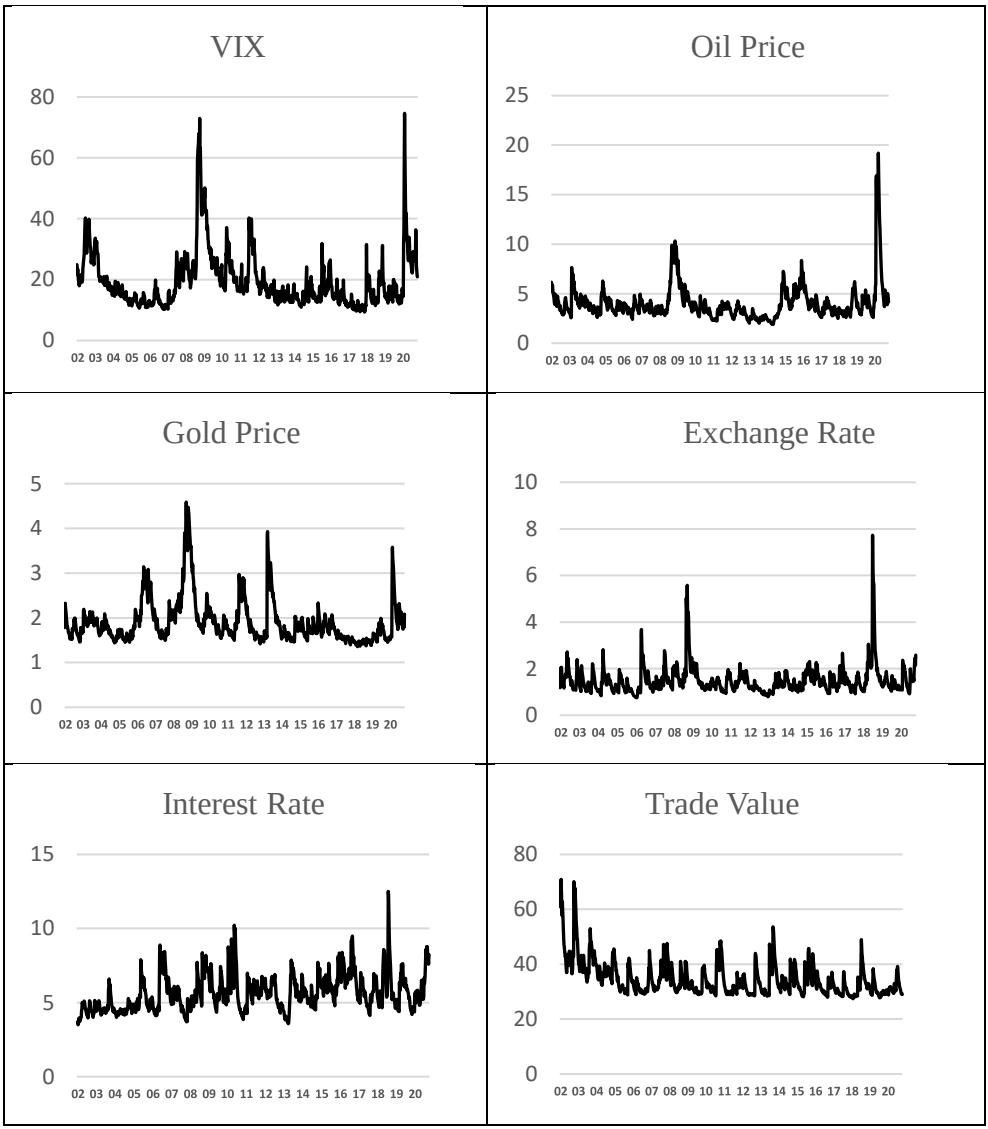
$$Ln\left(\frac{X_t}{X_{t-1}}\right)100$$

3. Empirical analysis

3.1 Unit root test and the nature of data

To robustly check the stationarity of the variables, two alternative unit root tests, the Augmented Dickey-Fuller (ADF, David A. Dickey and Wayne A. Fuller 1981) and Phillips-Perron (PP) tests, were employed. The results of the unit root tests are presented in Table 1. The results show that the integrated orders of all volatility indicators are zero, and all series are stationary at the 5% significance level, according to both the ADF and PP test results.

Table 1: ADF and PP unit root tests results					
Variable	**Optimal lag**	**ADF**	**p-value**	**PP**	**p-value**
VIX	11	−3.6058	0.0058	−4.9103	0.0000
VOIL	9	−6.0064	0.0000	−5.5190	0.0000
VGOLD	2	−4.6484	0.0001	−4.6855	0.0001
VER	0	−7.8693	0.0000	−8.0269	0.0000
VIR	1	−7.0929	0.0000	−6.8818	0.0000
VTV	10	−6.1924	0.0000	−7.2645	0.0000
VBIST	1	−3.8257	0.0028	−4.9103	0.0000
The ADF includes only a constant term from the deterministic components. The optimum lag length is selected with AIC with a maximum lag of 12.					


VIX
80
60
40
20
0
02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20
Oil Price
25
20
15
10
5
0
02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20
Gold Price
5
4
3
2
1
0
02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20
Exchange Rate
10
8
6
4
2
0
02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20
Interest Rate
15
10
5
0
02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20
Trade Value
80
60
40
20
0
02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20

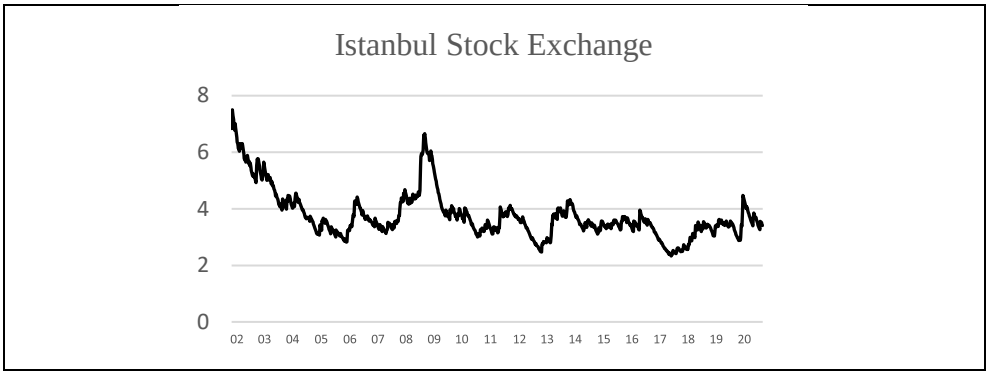


Figure 1: Representation of volatilities

Figure 1 shows the general characteristics of all the data. Each sub-figure indicates the volatility in the determinants over the analyzed period. Because of the 2008 global financial crisis, the VIX experienced a significant degree of volatility. During the COVID-19 pandemic, its volatility reached a new all-time high. This information demonstrates the widespread fear that had spread across the financial sector. These volatilities were also caused by the other global drivers. In 2008, the global crisis affected oil price volatility. By mid-2020, the increased volatility became apparent. During the 2008 financial crisis and the pandemic, the gold price was very volatile. This finding demonstrates that financial market turmoil reflects the volatility of global factors.

The pattern that was shown by the domestic determinants was quite close to the one that was shown by the global determinants, particularly for the global crises. Exchange rate volatility reached a record high during the global financial crisis. The highest level of volatility was observed in 2018, marked by a significant depreciation in the value of the currency after intense speculative pressure in the market. In response to the crisis, the central bank of Turkey introduced new monetary policies to resolve this issue. The characteristics of the interest rate reflect how this policy was implemented. Volatility rose during both the global financial crisis and in 2018, when the central bank raised interest rates in an effort to exert more control over the exchange rate. During the global financial crisis in the mid-2010s, and again in 2018, there was a spike in the traded value volatility level. The behavior of the stock exchange was comparable to that of traded value when volatility was high at the beginning of the 2000s, when it skyrocketed in 2008, and when it exhibited only a modest degree of volatility in the mid-2010s and in 2018. Both the stock exchange and traded value both reacted with a slight rise in volatility when the COVID-19 outbreak

reached the nation. In addition, the degree of volatility in both exchange rate and interest rate increased in the 2020s.

3.2 Granger causality test

G. S. Maddala and In-Moo Kim (1998) argue that a better term for Granger causality would be the precedence. Johann Burgstaller (2002) also suggests that if x_t Granger causes y, it is a predictor or signal for y_t as the concept of Granger causality only deals with short-run forecasting ability. Hence, the Granger causality test results can be used to determine the leading volatility indicators of Istanbul stock exchange uncertainty.

Table 2: Granger causality test results

pairwise Granger causality			
Null hypothesis: X does not Granger cause of Istanbul stock exchange uncertainty	Lag	F-Statistic	p-value
VIX	5	36.5269	0.0000
VOIL	7	2.2372	0.0293
VGOLD	2	5.0744	0.0064
VER	2	0.4274	0.6524
VIR	2	1.8702	0.1546
VTV	2	1.8998	0.1502
multivariate Granger causality			
	Lag	Chi-square Statistic	p-value
VIX	2	164.16	0.0000
VOIL	2	8.78	0.0124
VGOLD	2	16.14	0.0003
VER	2	0.89	0.6400
VIR	2	3.85	0.1456
VTV	2	9.78	0.0075
All	2	215.31	0.0000

AIC determine the optimal lag length, whereas the maximum lag length is 24. It is well known that the Granger causality test is sensitive to the choice of lag length. To avoid this problem, three alternative lag selection criteria (AIC, Hannan-Quinn (HQ), and Final Prediction Error (FPE)) were used for optimum lag length selection. In cases where the lag lengths selected according to these criteria differed, the Granger causality test results have not changed.

For more robust results, the outcomes of both the pairwise and multivariate Granger causality tests are presented in Table 2. According to the results of both Granger causality tests, the table indicates that volatilities in certain global determinants – the VIX, the oil price, and the gold price – are causes of Istanbul stock exchange volatility at the 5% significance level in the Granger sense. However, there is no Granger causality for stock exchange volatility from exchange rate volatility or interest rate volatility at the conventional level of significance for the pairwise and multivariate Granger causality test results. Nevertheless, the opposite results were obtained for causality from trade value volatility to Istanbul stock exchange volatility. Specifically, traded value volatility is not the cause of stock exchange volatility at the 5% significance level in the Granger sense for the pairwise Granger causality test result. According to the multivariate causality test, it is the cause of stock exchange volatility.

In general, these results indicate that volatilities in the global determinants are leading indicators of stock exchange volatility, in contrast to those in the domestic determinants. The global financial crisis and the COVID-19 pandemic were endogenous factors. In other words, these phenomena did not arise because of inherent issues within the Turkish economy. However, these actions significantly affected stock exchange movements. The evidence points to the existence of a contagion effect in the global financial sector. Stock exchanges react to shocks that occur on a global scale.

3.3 SVAR model

Empirical investigations can determine the VAR model by the Cholesky decomposition of orthogonalized reduced-form disturbances, which is a widely utilized technique. There is a possibility that the results of the Cholesky decomposition may change depending on the ordering of the variables. Because the VAR model is not founded on any theory, it is impossible to use it to derive only a set of impulse-response functions (IRFs). On the other hand, to derive the sole set of IRFs necessary for processing the contemporaneous issues of random shocks, the SVAR model must place restrictions on the time-ordering relationship, in accordance with economic theory. Hence, the ordering of the variables does not affect the performance of a particular SVAR model.

The short-run SVAR(p) specification for the A-B model can be written as the following:

$$\boldsymbol{A}\left(\mathbf{I}_{\boldsymbol{k}} - \boldsymbol{A_1 L} - \boldsymbol{A_2 L^2} - \ldots\ldots\ldots \boldsymbol{A_p L^p}\right)\boldsymbol{y_t} = \boldsymbol{A e_t} = \boldsymbol{B u_t}$$

where, $\boldsymbol{L}$ is lag operator, the vector $\boldsymbol{e_t}$ is the error terms of standard VAR model with covariance matrix $\boldsymbol{\Sigma_e}$, the vector $\boldsymbol{u_t}$ is error terms of the structural VAR model with covariance matrix $\mathbf{I_k}$, k is the number of variables in the model, and $\boldsymbol{A}$ and $\boldsymbol{B}$ are restriction matrices. The order condition requires $k^2 + k(k-1)/2$ restrictions for identification in the short-run A-B model. The identifying restrictions in this study are given as follows:

- ✓ The VIX is an exogenous variable. The shocks to other volatility indicators, except the interest rate, are contemporaneously affected by the VIX. On the other hand, shocks of the VIX are not contemporaneously affected by the shocks of other volatility indicators in the system.
- ✓ Oil price volatility shocks are only contemporaneously affected only by VIX shocks. Moreover, interest rate volatility shocks are not affected contemporaneously by oil price volatility shocks. Thus, oil price volatility shocks contemporaneously influence the gold price, exchange rate, traded value, and stock exchange shocks.
- ✓ Gold price volatility shocks have a contemporaneous effect on the exchange rate, traded value, and stock exchange shocks. Moreover, gold price volatility shocks are contemporaneously influenced by VIX and oil price volatility shocks.
- ✓ Exchange rate shocks are affected contemporaneously by VIX, oil price, and gold price volatility shocks. Moreover, exchange rate shocks have a contemporaneous effect on the interest rate, traded value, and stock exchange volatility shocks.
- ✓ Interest rate volatility shocks are contemporaneously affected only by exchange rate volatility shocks. Otherwise, interest rate volatility shocks have contemporaneous effects on both traded value and stock exchange volatility shocks. The interest rate is an important tool used by the central bank to stabilize the exchange rate. Hence, it is assumed that this determinant is under the control of the monetary authority; thus, it is not directly influenced by the other variables. This determinant is applied when there is an unexpected depreciation in the exchange rate. In other words, this is a monetary tool that is directly affected by currency changes.
- ✓ Traded value volatility shocks are affected by other volatility indicator shocks other than stock exchange volatility shocks. On the other hand, they have a contemporaneous effect only on stock exchange volatility shocks
- ✓ Stock exchange volatility is assumed to be the most endogenous variable. Thus, its shocks are contemporaneously affected by all of the shocks of other

volatility indicators, but its shocks do not have a contemporaneous effect on the shocks of other volatility indicators.

Under these restrictions, the SVAR model with matrices *A* and *B* can be specified as follows:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & a_{54} & 1 & 0 & 1 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{bmatrix} \begin{bmatrix} e_t^{VIX} \\ e_t^{VOIL} \\ e_t^{VGOLD} \\ e_t^{VER} \\ e_t^{VIR} \\ e_t^{VTV} \\ e_t^{VBIST} \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_{77} \end{bmatrix} \begin{bmatrix} u_t^{VIX} \\ u_t^{VOIL} \\ u_t^{VGOLD} \\ u_t^{VER} \\ u_t^{VIR} \\ u_t^{VTV} \\ u_t^{VBIST} \end{bmatrix}$$

The optimum lag length for the VAR model was selected as 2, using AIC, HQ, and FPE, with a maximum lag of 24. Due to the over-identified SVAR model, the Likelihood Ratio (LR) test for over-identification was performed. The p-value for the LR statistic was found to be 0.3256, greater than 0.05, the null hypothesis, which indicates that over-identification is valid, and is not rejected at the 5% significance level.

3.4 Variance decomposition

Table 3 shows the results of the forecast error variance decomposition analysis for Istanbul stock exchange volatility. These results were obtained after 24 weeks of treatment. In the first week, the impact of exchange rate volatility on stock exchange volatility was the highest among all variables. The explanatory effect was 5.4%. Although the exchange rate remained significant for the stock exchange, its influence gradually decreased over the weeks. Its average impact was approximately 3.7%. In the first week, the VIX did not significantly affect stock exchange volatility. In the second week, its impact increased from 0.25% to 9.72%, and reached 14.99% in the third week. In the 24th week, the impact sharply increased to approximately 32.91%. Its influence reached its highest point compared with the other determinants. The VIX constituted the largest source of the impact on stock exchange volatility. Oil price volatility did not exert a strong influence in the first week. Its effect was 0.70%. The explanatory power of this determinant was 0.59% in the 12th week, but slightly increased to 2.17% in the 24th week. The effect of gold price volatility was almost zero in the first week. Its impact increased to 4.42% in the 12th week and moved to 9.07% in the 24th week. This determinant became the second largest source of change in stock exchange volatility. The effect of interest rate volatility on the stock exchange did not show any strong significance in the first week. Its impact was almost zero. In

the 12th week, the impact became 1.46%. Its importance then increased slightly to 3.03% in the 24th week. Similarly, the impact of traded value volatility was not apparent in the first week. The effect increased to 2.41% in the 12th week and 4.51% in the 24th week. The impact of stock exchange volatility by itself started at 93.6% in the first week and then gradually decreased over the weeks. The impact was 59.63% in the 12th week, and 45.57% at week 24th. This shows that the stock exchange also has a significant impact on itself. High volatility in the stock exchange further stimulates its own volatility.

Table 3: Variance decomposition for Istanbul stock exchange volatility

Period	VIX	VOIL	VGOLD	VER	VIR	VTV	VBIST
1	0.25	0.70	0.01	5.40	0.02	0.02	93.60
2	9.72	1.13	0.06	4.83	0.02	0.07	84.18
3	14.99	0.84	0.18	4.39	0.04	0.06	79.51
4	17.86	0.64	0.43	4.31	0.11	0.15	76.50
5	19.84	0.52	0.79	4.32	0.22	0.32	73.98
6	21.44	0.44	1.23	4.34	0.37	0.57	71.62
7	22.79	0.39	1.73	4.33	0.54	0.85	69.37
8	23.97	0.38	2.26	4.30	0.72	1.16	67.21
9	25.00	0.40	2.80	4.24	0.90	1.49	65.16
10	25.93	0.45	3.35	4.17	1.09	1.80	63.21
11	26.76	0.51	3.89	4.08	1.28	2.12	61.36
12	27.51	0.59	4.42	3.98	1.46	2.41	59.63
13	28.19	0.68	4.93	3.87	1.64	2.69	57.99
14	28.82	0.79	5.42	3.75	1.81	2.95	56.46
15	29.39	0.91	5.89	3.64	1.97	3.19	55.02
16	29.91	1.03	6.34	3.52	2.12	3.40	53.67
17	30.40	1.17	6.76	3.41	2.27	3.60	52.40
18	30.84	1.30	7.15	3.30	2.40	3.78	51.22
19	31.26	1.44	7.53	3.20	2.52	3.94	50.11
20	31.64	1.59	7.88	3.10	2.64	4.08	49.08
21	31.99	1.73	8.20	3.00	2.75	4.21	48.11
22	32.32	1.88	8.51	2.91	2.85	4.32	47.21
23	32.63	2.02	8.80	2.83	2.94	4.42	46.36
24	32.91	2.17	9.07	2.75	3.03	4.51	45.57

Factorization: Structural

3.5 Impulse response function

Figure 2 illustrates the response of Istanbul stock exchange volatility to structural one standard deviation positive innovations for the determinants.

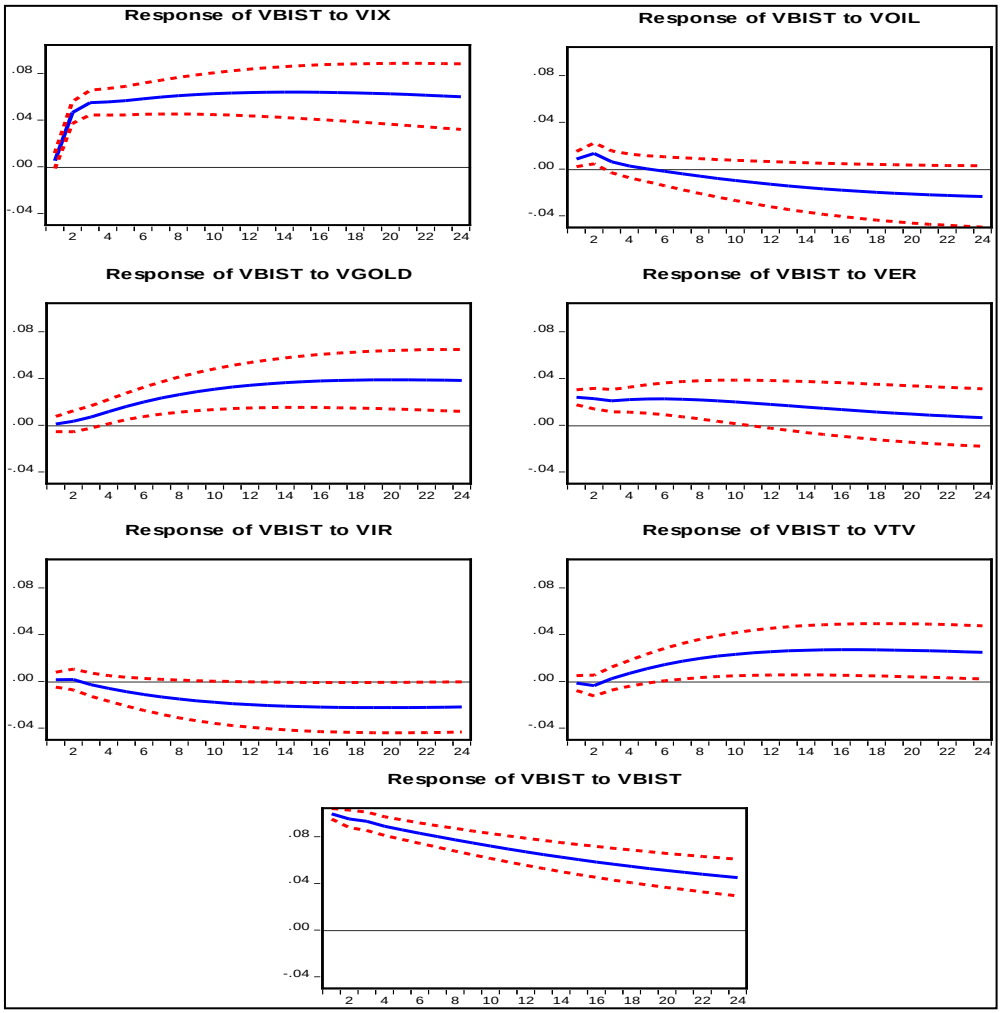


Figure 2: Response of BIST to structural one standard deviation positive innovations

Note: *Y-axis shows responses and X-axis shows weeks.*

The impulses are the VIX, oil price volatility, gold price volatility, exchange rate volatility, interest rate volatility, and traded value volatility. The response is stock exchange volatility. Using the impulse response function, the significance of the responses over weekly periods can be estimated. Global determinants had different impacts on the stock exchange. The results show the response of stock exchange volatility to the VIX was statistically significant and positive over the entire period. This indicates that the VIX is very important for stock exchange volatility in both the short and the long term. The response of stock exchange volatility to oil price volatility was positive and statistically significant until the third week. The response then became negative but was statistically insignificant. The oil price influences the stock exchange in the short run, but this effect does not continue for long. The response of stock exchange volatility to gold price volatility was statistically insignificant for three weeks. After that, the response became positive and statistically significant. Furthermore, the response remained significant throughout the study period. This shows that gold price volatility does not positively influence stock exchange volatility in the short run but does so in the long run.

When the domestic determinants are considered, the exchange and traded value are essential for defining stock exchange volatility. The response of stock exchange volatility to exchange rate volatility was positive and statistically significant until approximately the tenth week. Then, the determinant lost its significance. The response to traded value volatility was statistically insignificant. After the fifth week, the determinant became positive and statistically significant. Its influence continued throughout the study period. The response to interest rate volatility was negative and remained insignificant for all periods. Finally, the response of stock exchange volatility to itself was initially very high. The response was statistically significant and positive. The influence persisted at significant levels throughout the weeks. This indicates that the stock exchange is an important determinant of its volatility. In other words, high volatility can create expectations of future volatility.

4. Conclusion

This work investigated the influence of volatilities in global and domestic determinants on stock exchange volatility using pairwise and multivariate Granger causality tests, and an SVAR model, with weekly data between January 2002 and November 2020. This investigation incorporated both global and domestic drivers,

such as oil price volatility, gold price volatility, exchange rate volatility, interest rate volatility, and traded value volatility, to explain stock exchange volatility.

Volatilities in global determinants were shown to be Granger causes of stock exchange volatility, according to the pairwise Granger causality test. These are external factors that have a substantial impact on the stock exchange. On the other hand, it was discovered that volatilities in domestic determinants do not serve as Granger causes of stock exchange volatility. The results of the multivariate Granger causality test showed a similar pattern, with the exception of traded value volatility, which revealed a substantial causality toward stock exchange volatility. The leading indicators of Istanbul stock exchange volatility are, in general, volatilities in global variables rather than in domestic ones. Stock exchange volatility was also explained using variance decomposition and impulse response functions. The variance decomposition revealed that the stock market was highly sensitive to changes in the VIX. Although the influence of the VIX was not immediately noticeable, over the course of the first week, its effect progressively increased and eventually became a major contributor to stock exchange volatility. The impulse response function indicated that the influence of the VIX was consistently positive and significant for the entire sample period. This shows that the VIX is crucial for assessing stock exchange volatility. In other words, stock exchange volatility is susceptible to the global turmoil. According to the variance decomposition, oil price volatility and gold price volatility had a limited impact on the stock exchange during the first week, but their effects steadily increased over the following weeks. The impact of gold price volatility on the stock exchange was larger than that of oil price volatility. Oil price volatility had a positive and significant impact on stock market volatility, as measured by the impulse response function, but this effect faded within a few weeks. The response of stock exchange volatility to gold price volatility was statistically insignificant in the early periods, but eventually became statistically significant after several weeks. This effect persisted for the remainder of the period. In comparison to oil price volatility and gold price volatility, the effect of the VIX was more noticeable and sustained and was the major cause of the change in stock exchange volatility.

Exchange rate volatility had a greater impact in the first week than any of the other domestic factors. However, its influence steadily decreased over time. Approximately ten weeks later, the positive and statistically significant response of the stock exchange to exchange rate volatility continued. The interest rate and traded value had relatively little impact on the stock exchange. Over time, these factors began to have an increasingly significant impact on the market. The response of stock exchange volatility to interest rate volatility did not indicate a significant change. Nevertheless, traded value volatility became significant and positive after a few weeks and remained significant over the time. According to the variance decomposition, stock exchange

volatility had a significant effect on itself, despite the fact that its impact steadily decreased over the course of the weeks. When impulsive responses were taken into account, the response of stock exchange volatility to itself was consistently positive and statistically significant. Overall, the outcomes of these analyses suggest that the VIX is the most significant factor affecting the stock exchange. In other words, fear has a significant impact on the stock exchange.

The findings of the present study have important implications. If investors, portfolio managers, and policymakers can get an understanding of how these drivers impact stock exchange volatility, they will be more prepared to take steps to diversify their holdings, hedge their risks, and discover safe havens. When there is a level of high uncertainty in the financial markets, it is quite difficult to make investment decisions. Investors who are uncomfortable taking risks may be discouraged from engaging in the stock exchange if the trading environment has high levels of volatility. They may seek for safe havens, search for opportunities to hedge their risks, or diversify their assets. The results show that investors and other interested parties can interpret signals from global determinants, particularly from the VIX. This factor may be used to reduce the exposure to potential risks in the stock exchange. The movements of the VIX may be interpreted as risk prediction and can be used as a strategy for getting out of or entering the stock exchange to minimize losses. Those who are willing to take risks might utilize the indications provided by the VIX to guide their decision-making and help them find opportunities for significant rewards. The findings also have implications for monetary policies. The exchange rate can have an effect on the stock exchange. A stable financial market requires policymakers to contribute to stock exchange stability by considering the interest rate and exchange rate. In conclusion, when all the factors are considered, the VIX is by far the most important factor driving stock exchange volatility.

Appendix

Conditional heteroskedastic models for measuring volatility

The mean equations for the weekly percentage changes in all series were selected using a correlogram[1]. The ARCH effects for lags from 1 to 6 were tested via the ARCH- LM test, and the null hypotheses of the absence of ARCH effects were rejected at the 1% significance level. These results indicate that conditional variance models can be used to predict volatility.

[1] ADF unit root test results indicate that all series which are defined as weekly percentage changes have no unit root.

Table 1A: EGARCH(1,1) model results						
	Istanbul stock exchange		Oil price		Interest rate	
	Mean equation					
Variable	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Constant	0.1899	0.1549	−0.1228	0.4316	−0.1536	0.2254
AR(1)	-	-	0.2597	0.0000	−0.3948	0.0000
AR(2)	0.0709	0.0285	-	-	-	-
	Variance equation					
Constant	−0.0138	0.2981	−0.0240	0.5066	0.1597	0.0040
$\log(h_{t-1})$	0.0560	0.0000	0.1877	0.0000	0.1981	0.0000
$\left\|e_{t-1}/\sqrt{h_{t-1}}\right\|$	−0.0398	0.0000	−0.1479	0.0000	0.0805	0.0002
$e_{t-1}/\sqrt{h_{t-1}}$	0.9885	0.0000	0.9554	0.0000	0.9102	0.0000
EGARCH model residuals do not have ARCH effects according to ARCH-LM F-statistic for lags from 1 to 6.						

The appropriate variance equation was selected from alternative conditional variance models such as ARCH, GARCH, and EGARCH using the Akaike information criterion (AIC). Volatility values for the weekly percentage changes in the Istanbul stock exchange, the oil price, and the interest rate were estimated using EGARCH(1,1) specification. In addition, volatility values were estimated using a GARCH(1,1) model for the weekly percentage changes in the gold price, the exchange rate, and the traded value. The results of the EGARCH(1,1) and GARCH(1,1) models are given in Table 1A and Table 2A, respectively.

Table 2A: GARCH(1,1) model results						
	Gold price		Exchange rate		Traded value	
	Mean equation					
Variable	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Constant	0.1559	0.0319	0.1142	0.0674	0.0555	0.9096
AR(1)	0.2123	0.0000	0.2902	0.0000	−0.5791	0.0000
AR(2)	-	-	-	-	−0.3991	0.0000
AR(3)	-	-	-	-	−0.2388	0.0000
AR(4)	-	-	-	-	−0.1350	0.0002

	Variance equation					
Constant	0.2275	0.0002	0.2466	0.0000	118.1773	0.0001
e_{t-1}^2	0.0906	0.0000	0.2065	0.0000	0.0686	0.0000
h_{t-1}	0.8491	0.0000	0.7057	0.0000	0.8322	0.0000
GARCH model residuals do not have ARCH effects according to ARCH-LM F-statistic for lags from 1 to 6.						

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