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Research Article

Connectedness Analysis of Volatility Transmission: Evidence from Turkey

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Abstract

The study is conducted to accomplish the objective of connectedness among Turkey's exchange rate, interest rate, inflation, and stock returns. The results explore the highest value of the Total Connectedness Index (TCI), which coincides with the currency crisis and with COVID-19. The results of the dynamic from the total directional connectedness reveal that TCI has greater connectedness with the interest rate and exchange rate. Similarly, the TCI has a strong connection with the stock market and inflation during 2021-2022. The results of the dynamic to TCI show that all the indicators have contributed to the TCI during the crisis. The dynamic net total directional connectedness results explore that the interest rate, exchange rate, inflation and stock returns have both transmitter and net receiver roles. The transmitting role of exchange rates to inflation confirms the high dependency on imported inputs reflected in inflation. The stability of prices and other variables appears to be determined by the appropriate interest rate policy and the stabilization of interest rates.

Keywords: Dynamic Connectedness; Currency Crisis, Volatility; Debt Stock

1. Introduction

This paper aims to investigate the dynamic connectedness among volatility shocks in the Turkish exchange rate, interest rate, inflation, and stock returns using a volatility spillover index technique proposed by Diebold and Yilmaz (2012) and developed by Antonakakis and Gabauer (2017). The process of connectedness is important in the assessment and management of risk in the wake of the twin crisis, such as the currency crisis and pandemic. The Turkish economy had a tumultuous time in 2017 because of internal and external factors. There was an economic environment with a combination of high inflation, high unemployment, and high external debt. The Turkish Lira continued to depreciate and there were serious rises in the foreign exchange rates and external debt stock increased. According to the Central Bank of the Republic of Turkey (CBRT), the total external debt was $184 billion and the credit ratings of Moody and S&P downgraded

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the country rating mainly caused by the high external debt. The share of the private sector in gross external debt increased in 2017 which was denominated in foreign currencies, with 59 % in dollars and 32 % in euros (Republic of Turkiye Ministery of Treasury and Finance), implying that rising exchange rates drove up the cost of imported inputs and rose production expenses. This caused the general level of market prices to rise and translated into higher inflation. Furthermore, the spiral of rising currency rates, inflation, and interest rates increased the financing and production costs and created risks. The exchange rate was under more pressure as a result of the credit default swap (CDS) premiums rising from 166 at the beginning of the year to 582 in August 2021. This causes a vicious circle in import-dependent economies. The rising inflation and currency increased the need to hoard foreign currency which has contributed to the Lira's devaluation and resulted in the crisis.

The high inflation resulted in negative real interest rates is increased Turkey's currency substitution tendency. As inflation rises, the CBRT adjusts the interest rates through monetary policy and pushes banks' interest rates by raising lending rates. The CBRT made certain interest rate choices in response to rising exchange rates. The monetary policy committee boosted the late liquidity window facility on 14 December 2017, which it used instead of the policy rate in financing banks. Moreover, the committee did not change the benchmark repo rate which was 8%. During the period, the exchange rate shows an upward trend because of currency depreciation, foreign debt repayment, and costly financing alternatives. Furthermore, the closing of open positions in the private sector without further depreciation increased foreign currency demand and pushed depreciation. Meanwhile, the BIST 100 index has dropped with a loss of more than 21 % due to global and internal factors (Borsa Istanbul).

COVID-19, along with the ongoing economic crisis, caused Turkey to experience a second currency shock, and international capital and investments decreased. The exchange rate remained under pressure in 2021 in wake of the insufficient global economic recovery and global interest rate increase. Similarly, the domestic events that were thought to cause the exchange rate shocks in 2021 include opposition to orthodox economic views based on the interest-inflation relationship (Eğilmez, 2002). Furthermore, the significant reliance of the country on imports and rising foreign debt have made it more vulnerable to currency changes. Meanwhile, the issue of dollarization resurfaced and the rate which was 35.47 % in January 2021 rise to 58.52 % in May 2022 (BRSA, May 2022). Expectations that interest rate reduction would continue fueled investors' appetite for foreign currency. This situation was instantly reflected in the pricing of products and services, resulting in significant inflationary pressures. The Lira lost nearly 60% of its value in December 2021. The CBRT intervened in December 2021 to counter the increasing value loss. The government announced the foreign exchange-protected deposit scheme in December 2021, which lowered the growth rate in exchange rates but was not stopped. The rising foreign exchange rates translate into inflation and pull the country back into the vicious cycle of exchange rates, inflation, and interest rates. The CDS premiums continued to rise in 2022 in the country. The CBRT continued its monetary expansion since the beginning of the pandemic and the increase in liquidity created an inflationary environment. The Banking Regulation and Supervision Agency (BRSA) on 24 June 2022 decided to restrict foreign currency assets for private companies.

A short-term decrease in dollar rates is observed but it again reached 17.000 levels in July. Even though the existing conditions are not very attractive for stock investments, the stock market entered an upward trend in 2022 (Borsa Istanbul).

The main contributions of this study are highlighted as follows. The study examines the connectedness among the financial indicators during the twin crisis. The Turkish economy is passing through a difficult period characterized by high inflation, unbridled exchange rates, interest rates, foreign debts, and a volatile stock market. The process of connectedness is important in the assessment and management of risk in the aftermath of the pandemic crisis. This study evaluates the phenomenon of volatility spillover transmission and detects the receiving and transmission role of the variables. Similarly, connectedness is a quantitative indicator that measures the connectivity of market elements which is influenced by changes in fiscal and monetary policies, wars, and regime transitions (Balcilar *et al.,* 2021). The link between these indicators driven by numerous political and economic factors has pulled the country back into the crisis. Thus, the transmission mechanism confirms that volatility spillover exists among these variables. In terms of methodology, the study enriches the literature by employing Time-Varying Parameter Vector Autoregression (TVP-VAR) to generate the spillover effects. The method has the key advantages of not requiring to select the window size, not losing data, not having an outlier issue, and not having too volatile or too flattened-out parameters. The results explore the highest value of the Total Connectedness Index (TCI) during 2018 and 2021 which coincides with the currency crisis and COVID-19. Similarly, the TCI has a strong connection with the stock market and inflation during 2021-2022. The dynamic net total directional connectedness results explore that the interest rate, exchange rate, inflation, and stock returns have both transmitter and net receiver roles over the sample period. The transmitting role of exchange rates to inflation confirms the high dependency on imported inputs reflected in inflation. Moreover, the interest rate has a transmitting role to the exchange rate while observing both the transmitting and receiving role of the stock market and inflation. The stability of prices and other variables appears to be determined by the appropriate interest rate policy and the stabilization of interest rates.

The remaining of the study is organized as follows. The previous studies are analyzed in the literature review section. The method of the TVP-VAR is outlined in the methodology section. The data is explained in the data section which is followed by the analysis of the results in the empirical section. The study is concluded and policy recommendations are highlighted in the conclusion section.

2. Literature review

The preceding literature shows some of the studies which have examined the nexus between exchange rate, stock market, and interest rate. Mouna and Anis (2017) examine the stock returns responses to exchange rate and interest rate risk in the U.S. China and European economies. The results explore the connection among exchange rates, stock returns, and interestratese in most countries. Moreover, regarding volatility spillovers, an association between the series is observed. Yacouba and Altintas (2019) find asymmetric cointegration relationships between the exchange rate, stock price, and interest rate in Turkey. Similarly, stock prices

react asymmetrically to effective exchange rate changes in the long run. While stock returns response is asymmetric to interest rate variation in the short term. Tiryaki *et al.* (2019) show that the impact of changes in the money supply and exchange rate on stock returns in Turkey is asymmetric. Furthermore, the empirical findings imply that restrictive monetary policies tend to stifle stock returns more than loose monetary policies do. Fernández-Rodríguez and Sosvilla-Rivero (2020) consider volatility transmission between stock and foreign exchange rates in developed economies. The outcomes recommend that more than half of the total variance of the forecast errors is described by shocks across markets. Similarly, the volatility connectivity changes throughout time, peaking during times of rising economic and financial instability. Moussa and Delhoumi (2021) analyze the exchange rate and interest rate impact on the stock market in the Middle East and Northern Africa (MENA) regions. The empirical analysis reveals the cointegration between interest rate, exchange rate, and stock returns. Moreover, the stock market is sensitive to exchange rate and interest rate changes in the short run. Zhao *et al*. (2021) evaluate the returns and volatility connectedness between the Chinese exchange rate markets. They conclude connectedness with volatility coincides with internal reforms and external shocks periods. Aharon *et al*. (2021) investigate the relationship between the U.S. yield curve exchange rate and Bitcoin. The results explore that the yield curve is a net transmitter of shocks to the exchange rate and its volatility. However, the Euro and the Canadian exchange rates are net shock transmitters. The Japanese Yen, Swiss Franc, and British Pound, on the other hand, serve primarily as net receivers.

Some of the studies undertake the relationship between exchange rate and interest rate. Capasso *et al.* (2019) show that the exchange rate causes interest rate asymmetrically while positive variations in the exchange rate have a lower impact on the interest rate. Moreover, the variables are cointegrated in the long run. Chatziantoniou *et al*. (2021) investigate the impact of 1-year interest rates on different exchange rates. The results reveal that interest rate changes have an impact on financial market connections, and currency drives developments based on interest rate variations' direction. Mohammed *et al*. (2021) detect that interest rate volatility affects the exchange rate in the long run. According to Karamelikli and Karimi (2022), increasing the interest rate has a stronger influence on the exchange rate than decreasing the interest rate. Furthermore, the findings show that the short-run impact of interest rate differs from the long-run. Kassouri and Altıntaş (2020) conclude that exchange rate and interest rates have large predictive power for stock price fluctuations at various frequencies. Ahmed and Mazlan (2021) observe that changes in interest rates have short-run symmetric effects on the exchange rate in the long run. Similarly, changes in interest rates have asymmetric (negative) effects on the exchange rate. The existing literature comprises studies about the exchange rate and stock prices. Wong (2022) shows that the exchange rate has a significant impact on the stock price. Moreover, the interest rate is found to have a significant impact on the stock price. Effiong and Bassey (2019) show a significant impact of exchange rate changes on stock prices while these prices have a different response to appreciation and depreciation. In this regard, currency depreciation has a strong pass-through effect on stock prices than appreciation in the long

run. Nusair and Al-Khasawneh (2022) show the relationship between the exchange rate and stock prices in the short term.

Fazlollahi and Ebrahimijam (2022) prove that the interest rate has a long-run association with other macroeconomic factors. Furthermore, the outcomes explore mutual causality between interest rates and inflation. Dogan *et al*. (2020) examine the relationship between interest rates and inflation and the results confirm that inflation cause interest rate. The preceding literature covers the relationship between Concerning the above, the Vector Autoregression technique, is a common tool for investigating the interaction of a group of variables with specific economic shocks. Consequently, one of this approach's most helpful characteristics (the prediction error variance decomposition feature) served as the foundation for studying the connectivity of a system of variables (Diebold and Yilmaz, 2014; Antonakakis and Gabauer, 2017). The connectedness technique has several benefits, one of which is that it enables the classification of the variables under study by distinguishing between net shock transmitters and net shock receivers. In this regard, it appears to be a highly pertinent scientific activity to examine the interconnectedness of the various geographically divided areas within a nation in light of any economic shock.

3. Time-Varying Parameter Vector Autoregressions (TVP-VAR)

Diebold and Yilmaz (2009) introduce a volatility spillover measure based on forecast error variance decompositions from vector autoregressions (VAR). It can be used to measure the spillovers in returns or return volatilities across assets, asset portfolios, asset markets, etc. However, the Diebold and Yilmaz's (2009) framework has several limitations. First, it relies on the Cholesky factor identification of VAR and thus, the resulting variance decompositions can be dependent on variable ordering. One would prefer a spillover measure that was invariant to ordering. Second, the most crucial, Diebold and Yilmaz (2009) only address the total spillovers. However, one would also like to examine directional spillovers (from/to a particular market). Diebold and Yilmaz (2012) use a generalized vector autoregressive framework in which forecast-error variance decompositions are invariant to the variable ordering, and they explicitly include directional volatility spillovers. Moreover, Diebold and Yilmaz (2014) further use the rolling window method to investigate the time-varying nature of the connectedness, and they also show that variance decompositions define weighted, directed networks so that our connectedness measures are intimately related to key measures of connectedness used in the network literature.

Antonakakis *et al*. (2020) enhance the dynamic connectedness measures originally introduced by Diebold and Yılmaz (2012, 2014) with a time-varying TVP-VAR which predicates upon a time-varying variance-covariance structure. This framework allows capturing possible changes in the underlying structure of the data more flexibly and robustly. Specifically, there is neither a need to arbitrarily set the rolling-window size nor a loss of observations in the calculation of the dynamic measures of connectedness, as no rolling-window analysis is involved. Given that the proposed framework rests on multivariate Kalman filters, it is less sensitive to outliers. Furthermore, they emphasize the merits of this approach by conducting Monte Carlo simulations. The framework is put into practice by investigating dynamic connectedness measures of the four most

traded foreign exchange rates, comparing the TVP-VAR results with those obtained from three different rolling-window settings. Finally, they propose uncertainty measures for both TVP-VAR-based and rolling-window VAR-based dynamic connectedness measures. Lastrapes and Wiesen (2021) propose an alternative measure of system-wide connectedness to the popular generalized spillover index, based on the generalized forecast error variance decompositions of Diebold and Yılmaz (2012, 2014). Their measure relies on joint conditional forecasts to decompose variance, as opposed to the popular method's reliance on single-variable conditioning sets and is a more precise measure of aggregate spillovers.

The quantile connectedness begins with the calculation of connectedness matrices through Bayesian Information Criteria as follows:

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

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

x_t and x_{t-j} are k × 1 dimensional vector and B_t and S_t are k×k dimensional matrix. *vec* (B_t) and v_t are k^2 × 1 dimensional conditional, R_t is k^2 × k^2 dimensional matrix.

Koop *et al*. (1996) and Pesaran and Shin (1998) suggested for the estimation of the H-step ahead Generalized Forecast Error Variance Decomposition (GFEVD). The proposed equation is employed to detect the shock impact in variable *q* on the variable *r* and is described as follows;

$$\omega_{ab}^{g}(H) = \frac{\sum(\tau)_{aa}^{-1}\sum_{h=0}^{H-1}(e_a'\omega_h(\tau)\sum(\tau)e_b)^2}{\sum_{h=0}^{H-1}(e_a'\omega_h(\tau)\sum(\tau)e_b)} \quad (3)$$

$$\omega_{ab}^{g}(H) = \frac{\omega_{ab}^{g}(H)}{\sum_{b=1}^{k}\omega_{ab}^{g}(H)}$$

e_i represents a zero vector with unity on the *rht* position. This normalization results in the following two equalities:

$\sum_{b=1}^{k}\omega_{ab}^{g}(H) = 1$ and $\sum_{b=1}^{k}\omega_{ab}^{g}(H) = k$.

The following estimate represents the total directional connectedness TO others that variable *a* has on the other variables in *b*.

$$C_{a\to b}^{g}(H) = \sum_{b=1, b\neq 1}^{k}\omega_{ab}^{g}(H) \quad (4)$$

Similarly, total directional connectedness FROM others is used to determine the shock impact of all other variables *b* on variable *a*;

$$C_{b\to a}^{g}(H) = \sum_{b=1, b\neq 1}^{k}\omega_{ab}^{g}(H) \quad (5)$$

"The differences between the total directional connectedness TO others and the total directional connectedness FROM others produce the net total directional connectedness that can be viewed as the net effect variable *a* has on the evaluated network."

$$C_{a}^{g}(H) = C_{a\to b}^{g}(H) - C_{a\leftarrow b}^{g}(H) \quad (6)$$

It provides information on whether a variable is a net transmitter or a net receiver of shocks. Furthermore, the net directional connectedness reveals whether a series is the transmitter (receiver) of shocks and driving (driven) by the network. The TCI, which is suggested by Chatziantoniou and Gabauer (2021) and Gabauer (2021), leads to the estimation of the final connectedness metric and lies between [0, 1]:

$$TCI(H) = \frac{\sum_{a,b=1, a\neq b}^{k}\omega_{ab}^{g}(H)}{k-1} \quad (6)$$

Since the higher the TCI, the higher the degree of network interconnection, so this

indicator is usually used as a substitute indicator of market risk. The TCI represents the average impact one variable has on all others. It implies that higher TCI means high interconnectedness of the network and shock in one variable will influence others. However, the low TCI value suggests that most variables are rather independent of each other and shock in one variable will not cause other variables.

$$NPDC_{ab,t} = C^{g}_{a\rightarrow b}(H) - C^{g}_{a\leftarrow b}(H) \qquad (7)$$

Equation (7) is related to the bilateral relationship between variables. The net pairwise directional connectedness (NPDC) shows whether variable *a* is the driving variable *b* or vice versa. The connectedness method is most appropriate to measure the net transmitter/receiver role. It measures the extent of connectedness and detects whether the influence of shock is negative or positive. Similarly, this approach is useful for detecting systematic connectedness or vice versa (Khan *et al*., 2022). The findings recommend that volatility spillover is higher around the currency crisis and pandemic. Moreover, the connectedness confirms that variables have receiving/transmitting roles.

4. Data

The study undertakes the daily data returns of the interest rate, exchange rate, inflation and stock market for Turkey from 2018:01 to 2022:06. The period is of special importance in terms of national and global events. On the global front, the trade conflicts between the two major economies of the world, the Organization of the Petroleum Exporting Countries (OPEC) price war, the pandemic and the Russia-Ukraine war occurred. Similarly, the currency crisis, political reasons and effects of the coup attempt at the country level have fraught the exchange rate, interest rate and inflation. The country has seen the highest level of inflation and unbridled exchange rate, which has serious repercussions for the country. The transmission channel of the volatility is critical to effectively identify the transmitter and receiver roles of these variables. The exchange rate is the lira to U.S. dollar spot exchange rate. Similarly, the overnight reference rate has been created to meet the need for a short-term interest rate which can be used as a variable interest indicator, underlying asset or benchmark in financial derivative products, debt instruments and various financial contracts. The stock market is represented by the BIST-100 index which contains 100 common stocks and shows the general market condition. The consumer price index is used for inflation in the country. Table 1 is the explanation of the variables. It shows positive returns for all series. The inflation and stock are the most unstable series through the sample period evident from the variances. The skewness values indicate that interest rate and inflation is positively skewed while exchange rate and stock returns are negatively skewed. Similarly, it is observed that series are platykurtic distributed throughout the sample period. The Jarque-Bera test confirms the non-normality distribution of the series. As per the ERS, series are stationary and auto-correlated. Thus, the modeling of the interconnectedness of the series employs a TVP-VAR approach with a time-varying variance-covariance structure.

Table 1. Summary statistics.

	INT	EXR	STR	CPI
Mean	0.002	0.001***	0.001	0.001***
Variance	0.001***	0.000***	0.000***	0.000***
Skewness	0.506***	-0.682***	-1.220***	2.535***
Kurtosis	10.097***	42.326***	6.346***	17.209***
JB	4745.141***	82645.341***	2130.418***	14831.713***
ERS	-17.812***	-15.019***	-6.682***	-6.202***
Q(20)	64.822***	42.996***	19.251**	4479.598***
Q2(20)	29.566***	212.509***	99.137***	1753.454***
Kendall	INT	EXR	STR	CPI
INT	1.000***	-0.008	-0.002	0.019
EXR	-0.008	1.000***	-0.195***	0.076***
STR	-0.002	-0.195***	1.000***	0.034
CPI	0.019	0.076***	0.034	1.000***

Data Source: Inflation data is taken from TSI (Turkish Statistical Institute), exchange rate and interest rates data are taken from CBRT, and stock returns data is taken from investing.com

Note: INT denotes interest rate; EXR is the exchange rate; STR represents stock returns and CPI denotes inflation.

5. Empirical Analysis

It is presented the average connectedness results in Table 2. It examines how the average connectedness of these variables in Turkey changes after the onset of the currency crisis. The results illustrated in Table 2 show evidence of increased connectedness between these variables. The value of TCI indicates that co-movements of the indicators are greater as they constitute 62.56% of the total forecast error variance of the network. In other words, on average, 62.56% of the forecast error variance in one financial indicator can be attributed to the innovations in all others. It implies a large interdependence among the volatility returns. Moreover, the interest rate and exchange rate are the primary receivers of the shocks, while stock and inflation are the transmitters within the network during the crisis.

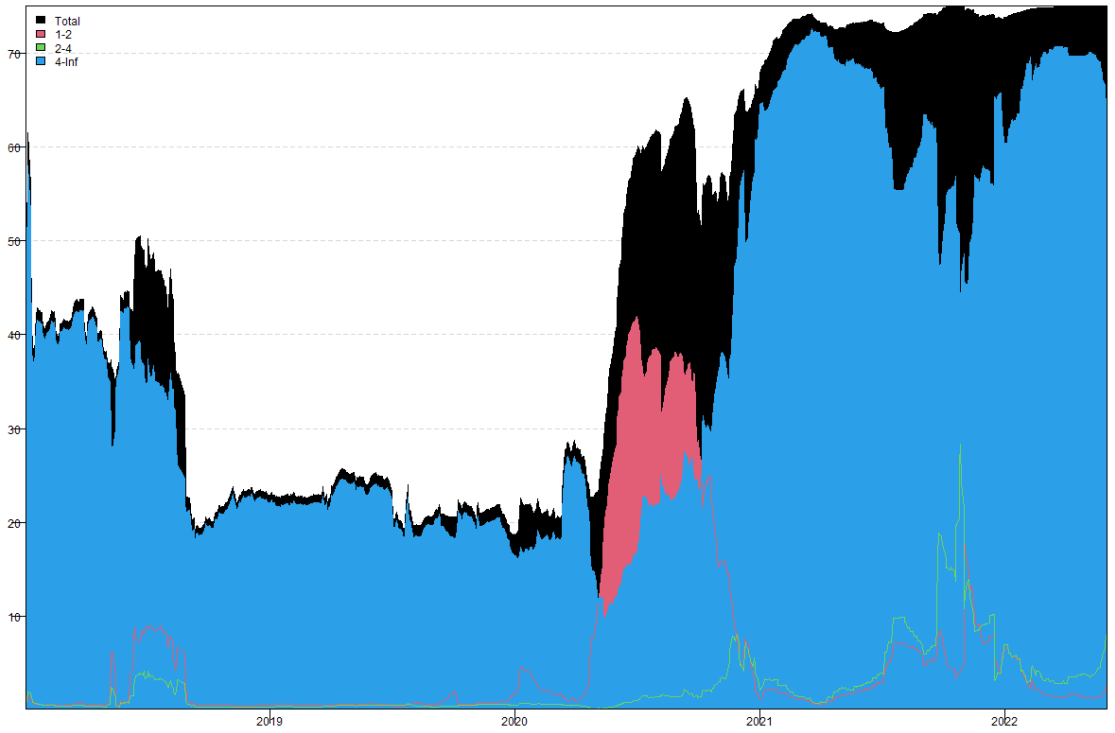
Table 2: Total Connectedness Index (TCI)

	INT	EXR	STR	CPI	FROM
INT	55.70	11.67	12.23	20.41	44.30
EXR	12.49	47.02	12.55	27.95	52.98
Stock	11.71	8.83	63.98	15.47	36.02
CPI	15.40	24.51	14.48	45.61	54.39
TO	39.60	45.01	39.26	63.83	187.69
Inc. Own	95.29	92.03	103.24	109.44	cTCI/TCI
Net	-4.71	-7.97	3.24	9.44	62.56/46.92
NPDC	1.00	0.00	2.00	3.00	

Note: (TCI) measures the average effect that all variables have on one variable's forecast error variance throughout time

The TCI results are illustrated in Figure 1. The values show consistent variation in the sample period. It exhibits three types of values, i.e., average values (lies around 50%) moderate values (lies around 20%) and peak values (lies above 70%). The result implies that average values coincide with 2018 when the country is passing through the first phase of the currency crisis, which suggests that the series have an average rate of the co-movement between these variables. Next, the moderate co-movement between the indicators coincide with 2019 and some parts of 2020. The reason might be the moderate recovery of the country from the crisis and the beginning of the pandemic. However, the higher co-movement between the series is observed onward from the last quarter of 2020 which mainly coincides with the COVID-19 period. The connectedness oscillates around the highest level during 2021-2022, largely caused by the ongoing twin crisis, such as the currency crisis and COVID-19. It demonstrates that TCI is responsive to large economic events and that connectedness increases as uncertainty increases. The findings show several spikes and declines in overall connectedness, validating the return connectedness network's time-varying character.

Figure 1: Total dynamic connectedness



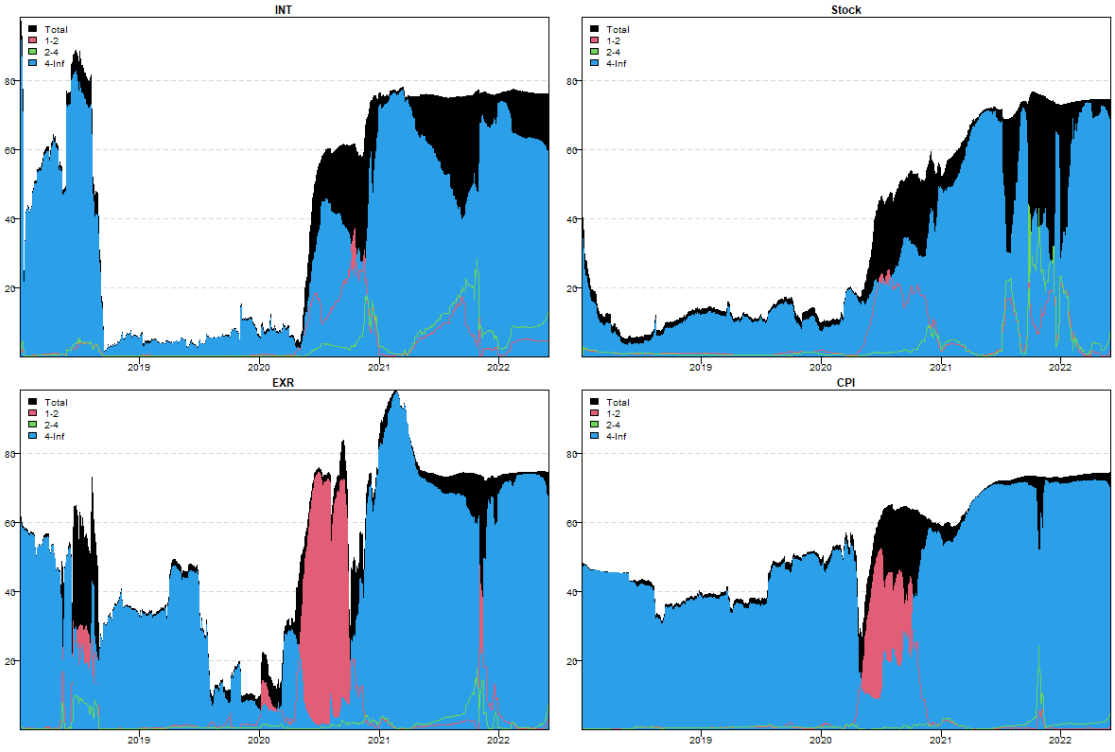
Note: Results are based on a TVP-VAR model with a 20-step-ahead generalized forecast error variance decomposition. Average values (lies around 50%), moderate values (lies around 20%), and peak values (lies above 70%).

Investigating the net connectedness results which identify commodities into net transmitting and net receiving roles. In other words, the underlying macroeconomic indicators within the network can assume either a net transmitter or a net receiver of shocks over time, depending on the period. The net total connectedness is a measure that looks at how a series has changed throughout the course of the investigation concerning all other series. The pairwise net connectedness is a method for examining commodity pairs to see how their relationships have changed over time in these two possible roles. Moreover, the positive values of each macroeconomic variable correspond to the net transmitting role and negative values to the net receiving role.

Figure 2 illustrates the results of the dynamic from the total directional connectedness. It reveals that dynamic connectedness has greater connectedness with interest rate during 2018 and 2021-2022. This might be caused by the currency crisis in 2018, while the currency and pandemic crisis has resulted in 2021-2022. This can explain that higher interest rates put pressure on the exchange rate driven by the orthodox views about the interest rate policy. However, there is the lowest connection from dynamic connectedness to the interest rate during 2019 because the currency crisis has been managed. Similarly, the dynamic connectedness has a strong connection with the stock market during 2021-2022; the lira lost value as a result of the decreasing

interest rates to control inflation. It further explores that the exchange rate has strong co-movement with dynamic connectedness during 2018 and 2021-2022. While inflation has consistent connectedness with dynamic connectedness which becomes more robust in 2022.

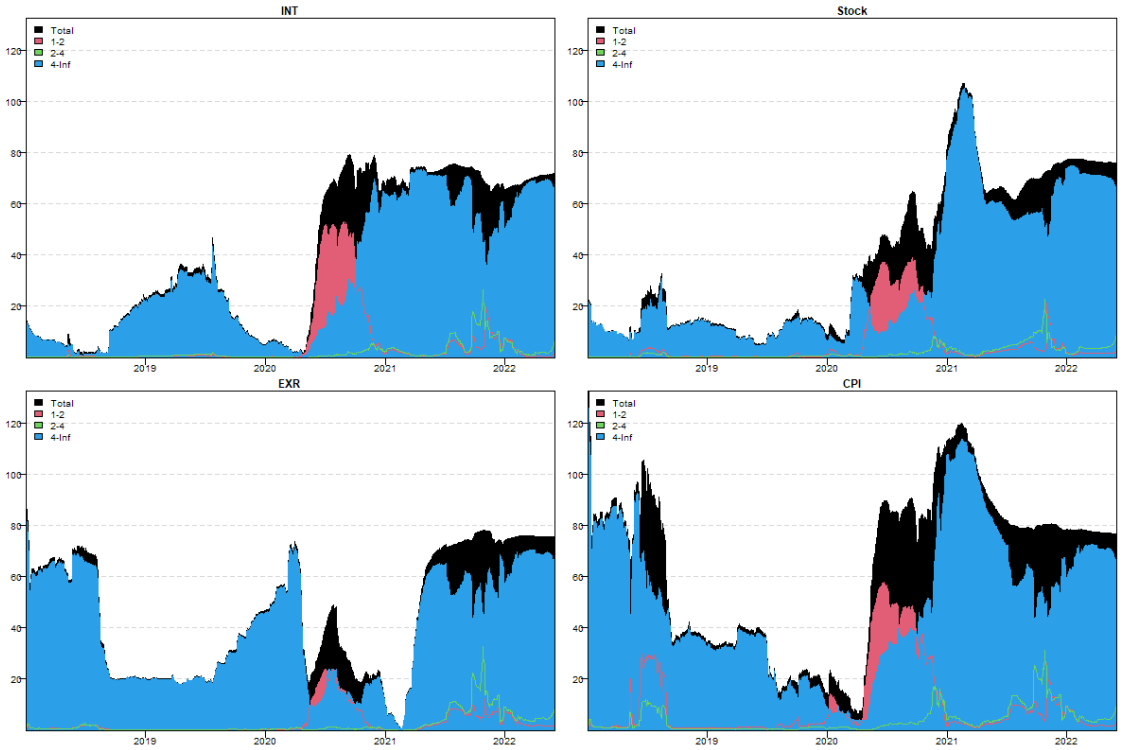
Figure 2. Dynamic from total directional connectedness



Note: Denotes net transmitting and receiving roles. Results are based on a TVP-VAR model with a 20-step-ahead generalized forecast error variance decomposition.

Figure 3 exhibits the results of the dynamic to TCI. It shows that all the indicators have contributed to the TCI during 2021-2022. It implies that currency is caused and reflected by interest rates and has much to do with stock prices. Consequently, the exchange rate affects stock returns and can be used to forecast market behavior.

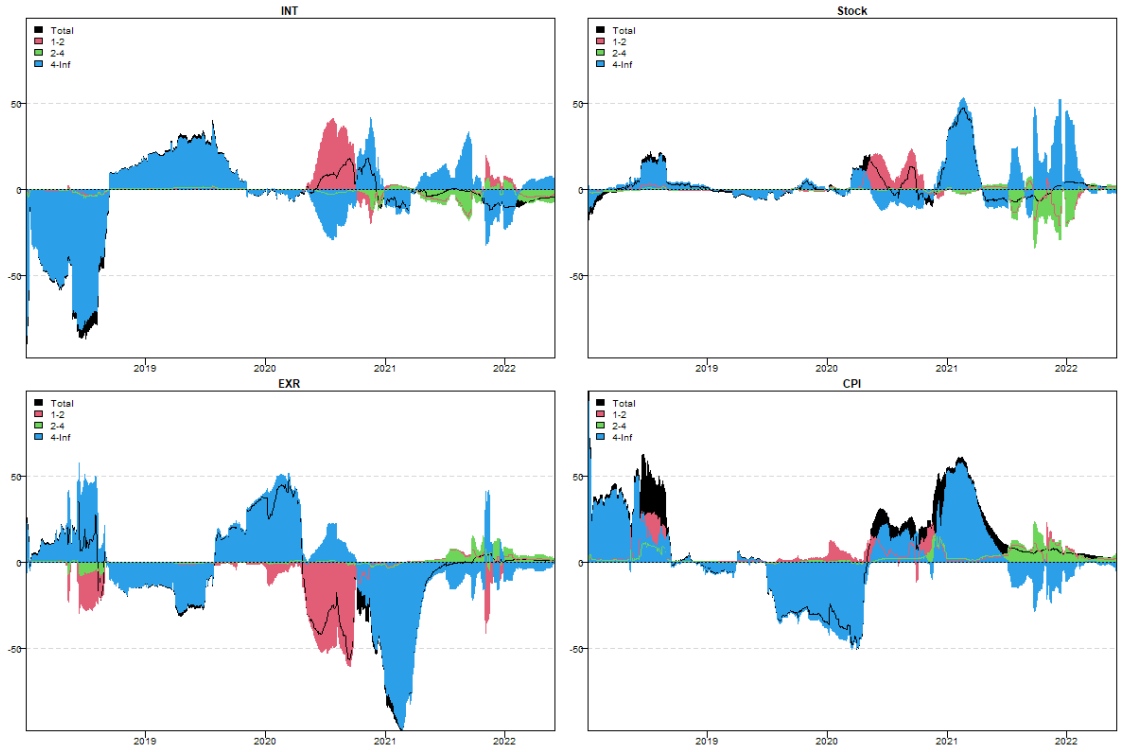
Figure 3. Dynamic to total directional connectedness



Note: Results are based on a TVP-VAR model with a 20-step-ahead generalized forecast error variance decomposition.

The results of the dynamic net total directional connectedness are illustrated in Figure 4. It explores that the interest rate has both transmitter and net receiver roles over the sample period. However, the transmitter of volatility shock is more pronounced during the pandemic. More specifically, the net receiving role of the interest rate is observed during 2018, which changes to transmitting from 2019 to 2021. In 2022, the role again converts to receiving. In the case of the stock market, shows that the market is the net transmitter of the shock throughout the period. However, it is noticed that the stock market appears to be a net receiver from the last quarter of 2021 to the end of the sample period. Similarly, the exchange rate assumes to have both roles in the sample period. During 2018 and 2020, it has the net transmitter role of the shock which coincides with the currency crisis and the beginning of COVID-19. While the remaining sample period shows the net receiver of the shocks. In terms of magnitude, the receiving of shock is highly prominent around 2021. On the other hand, the inflations have both roles, but transmission shock is more pronounced over the period. The receiving role is observed around 2020 maybe due to the uncertainty caused by the pandemic.

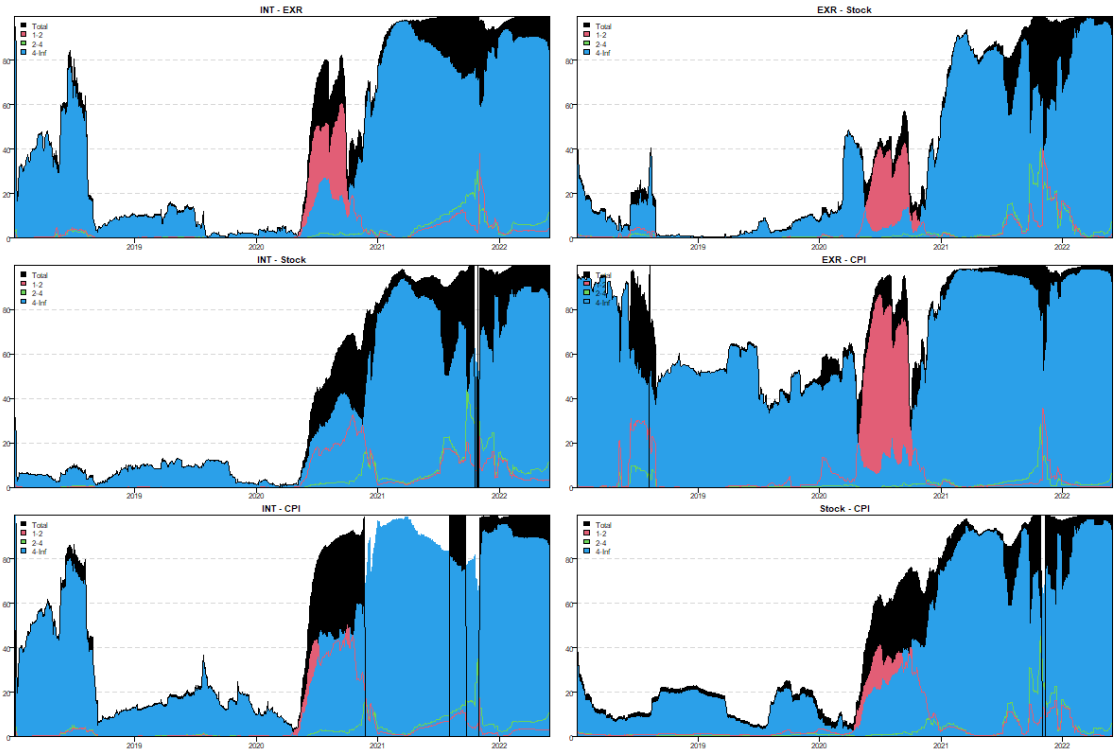
Figure 4. Dynamic net total directional connectedness



Note: Denotes net transmitting and receiving roles

Next, it is looked into dynamic net pairwise connectedness results in Figure 5. The interest rate has an important transmitter of a shock to stock and exchange rate. While the spillover remains low in the case of inflation. Moreover, the exchange rate assumes both roles with all other series. It means that the exchange rate not only affects others but is also equally responsive to the shocks of other markets. On the other hand, the stock market is persistent throughout the period.

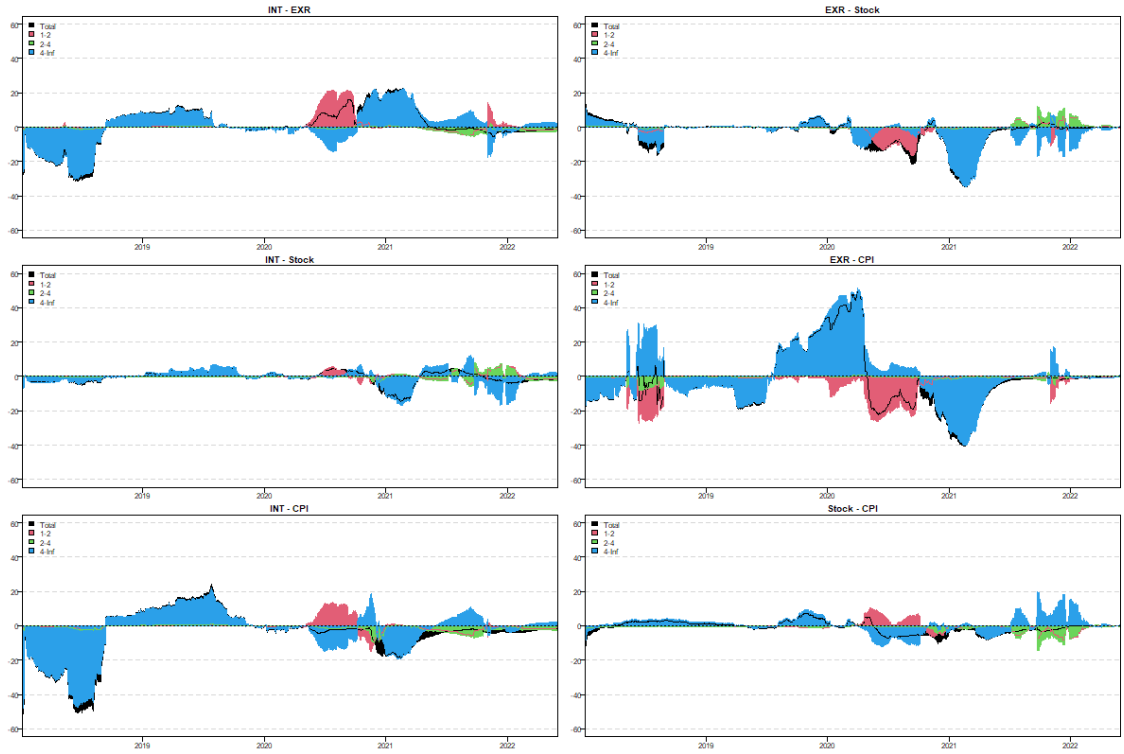
Figure 5. Dynamic pairwise directional connectedness



Notes: Denotes net transmitting and receiving roles

The pairwise directional connectedness is exhibited in Figure 6. It explores that interest rate has mostly transmitting role to the exchange rate while observing both the transmitting and receiving role of the stock market and inflation. Similarly, the exchange rate act as receives volatility shock from the stock market and transmitter to inflation. However, the transmitter role is detected from the stock market to inflation.

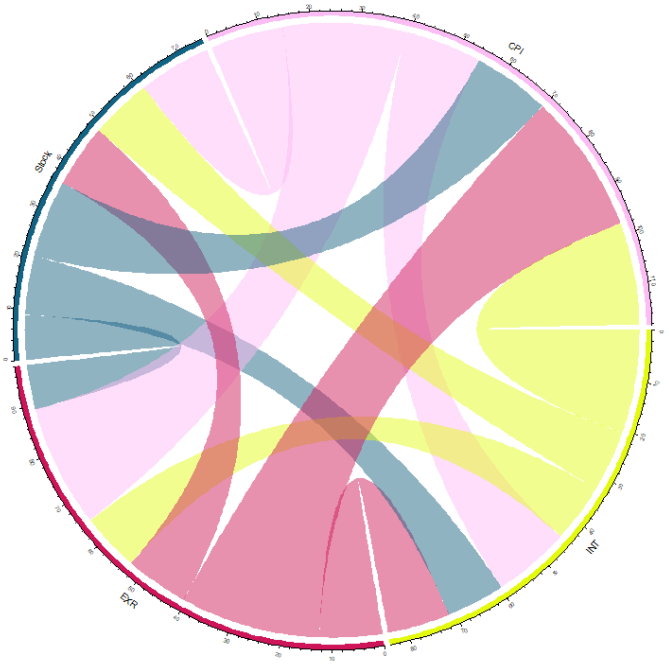
Figure 6. dynamic net pairwise directional connectedness



Notes: Denotes net transmitting and receiving roles

A chord diagram represents flows or connections between several entities (called nodes). Each entity is represented by a fragment on the outer part of the circular layout. Then, arcs are drawn between each entity. The size of the arc is proportional to the importance of the flow. It shows that the exchange rate has a large node, while the arc reveals its flow to other variables in the network. The exchange rate arc has the largest flow to the inflation and interest rate in the highest quantiles respectively, which implies that changes in exchange rate lead to rapid changes in inflation and interest rate. Similarly, the exchange rate flow is detected in the stock market in the medium quantile, suggesting the average flow of spillover. On the other hand, the interest rate has a spillover impact on the inflation and exchange rate in the medium quantiles. Furthermore, the inflation volatility has the biggest impact on the stock market in upper quantiles and vice versa.

Figure 7: Total pairwise directional connectedness



Note: Denotes net transmitting and receiving roles

6. Conclusion

The currency crisis and pandemics have increased the level of volatility in Turkey. The increased spillover effect among the financial indicators has contagion in the markets and has a large negative effect in the country. The study is conducted to accomplish the objective connectedness among Turkey's exchange rate, interest rate, inflation and stock returns. For this purpose, the TVP-VAR approach is employed to measure connectedness across the different financial indicators which are appropriate for detecting connectedness. The model provides refined measurements of connectedness and does not suffer from the deficiencies of the typical rolling-windows method. The results explore the highest value of TCI during 2018 and 2021 which coincides with the currency crisis and COVID-19. It demonstrates that TCI is responsive to large economic events and that connectedness increases as uncertainty increases, validating the return connectedness. The results of the dynamic from the total directional connectedness reveal that TCI has greater connectedness with interest rate and exchange rate during 2018 and 2021-2022. Similarly, the TCI has a strong connection with the stock market and inflation during 2021-2022. Similarly, the results of the dynamic to TCI show that all the indicators have contributed to the TCI during 2021-2022. The dynamic net total directional connectedness results explore that the interest rate, exchange rate, inflation

and stock returns have both transmitter and net receiver roles over the sample period. The pairwise directional connectedness explores that interest rate has a transmitting role to the exchange rate while observing both the transmitting and receiving role of the stock market and inflation. Similarly, the exchange rate act as receives volatility shock from the stock market and transmitter to inflation.

The study contributes significant policy suggestions in the following ways. The deviations of pricing instruments from equilibrium for a certain period cause the economy to face various problems. The fact that deviation of one of these variables from equilibrium causes deterioration in the internal and external balances of the economy and affects the alternative costs, causing the general economic structure to be adversely affected. Knowing the severity of the negative results occurring in one of the pricing mechanisms affecting the others or the level of being affected by a shock occurring in the others is important for establishing a stable macroeconomic policy. The sensitivity level between pricing mechanism instruments may also vary due to the different economic structures of the economy. The transmitting role of exchange rates to inflation confirms the high level of dependency on imported inputs and that the price increases in import goods in response to exchange rate changes are reflected in inflation in Turkey. In addition, the pairwise directional connectedness shows the reality of the vicious circle of these variables in Turkey. Since the results show that interest rate has a transmitting role to the exchange rate while observing both the transmitting and receiving role of the stock market and inflation, the right interest rates policy and the stabilization of interest rates appears to be the decisive factor in the stability of prices and other variables. The study can extend to examine the causal impact of the currency crisis on the major indicators in the country. The study will evaluate the scenario absence of the crisis and compare the extent of the impact of the crisis.

7. Declarations

Compliance with Ethical Standards:

1. **Funding:** Currently this research paper did not receive any financial aid from any source.
2. **Ethical approval:** This article does not contain any studies with human participants or animals performed by any of the authors.
3. **Author's contribution:** This article is a one-author article.
4. **Conflict of interest:** There is no conflict of interest
5. **Data availability statement:** I can provide the data if demanded

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