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Causality Analysis between BIST-100, Investor Risk Appetite, Exchange Rate, Inflation and Interest Rate in Türkiye Economy

Türkiye Ekonomisinde BIST-100, Yatırımcı Risk İştahı, Döviz Kuru, Enflasyon ve Faiz Oranı Arasındaki Nedensellik Analizi

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ABSTRACT

In this study, econometric methods are used to investigate the causality relationships between key macroeconomic and financial indicators in Türkiye. The research focuses on the Türkiye economy and financial markets for the period 2011-2019. Monthly data of Borsa Istanbul (BIST-100), Investor Risk Appetite Index (RISE), exchange rate, inflation and interest rate are analyzed by using the Toda-Yamamoto causality test. Our findings show that there is one-way causality from BIST-100 index to inflation, exchange rate to inflation, investor risk appetite index to interest rate and BIST 100 index to investor risk appetite index. These results provide an understanding of the dynamic relationships between these indicators and provide implications for the Türkiye economy.

MAKALE BİLGİSİ

Makale Türü
Araştırma Makalesi

Anahtar Kelimeler
BIST-100 Endeksi
Enflasyon Oranı
Faiz Oranı
Yatırımcı Risk İştahı Endeksi
Döviz Kuru

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ÖZ

Bu çalışmada, Türkiye'deki temel makroekonomik ve finansal göstergeler arasındaki nedensellik ilişkilerini araştırmak için ekonometrik yöntemler kullanılmaktadır. Araştırma 2011-2019 dönemindeki Türkiye ekonomisi ve finansal piyasalarına odaklanmaktadır. Borsa İstanbul (BIST-100), Yatırımcı Risk İştahı Endeksi (RISE), döviz kuru, enflasyon ve faiz oranı aylık verileri Toda-Yamamoto nedensellik testi kullanılarak analiz edilmiştir. Bulgularımız, BIST-100 endeksinden enflasyona, döviz kurundan enflasyona, yatırımcı risk iştahı endeksinden faiz oranına ve BIST 100 endeksinden yatırımcı risk iştahı endeksine doğru tek yönlü nedensellik olduğunu göstermektedir. Bu sonuçlar, söz konusu göstergeler arasındaki dinamik ilişkilerin anlaşılması ve Türkiye ekonomisi için çıkarımlarda bulunulması noktasında ilgili literatüre katkıda bulunmaktadır.

1. Introduction

Globalizing financial markets contributes significantly to industries and trade in developing countries. Financial markets enable the transfer of liquidity from savers to households in need. Businesses and investors perform their transactions by taking into account many macroeconomic indicators such as economic growth, inflation, interest rates, and exchange rates while pricing their assets. According to the relationship between these variables, businesses and investors decide on future cash flow and investment transactions. This is important for issuers as well as investors. In general terms, monitoring macroeconomic indicators is of great importance in estimating stock

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prices and the prices of other investment instruments (Gögül and Yaman, 2020:256). An increase in interest rates in an economy not only increases the cost of borrowing but also causes pressure on cash flows. The decrease in cash flows also causes the prices of stocks to decrease. However, falling interest rates have a similar effect. Since the decrease in interest rates increases the profit expectation of the enterprises, it will reduce their orientation to stocks and cause the prices of the stocks to decline (Schwert,1990: 22).

The stock market is an important organization in terms of providing funds for industrialization and economic development. The key function of exchanges is to act as an intermediary between savers and borrowers. Transforming small savings into an efficient investment is realized through the stock market mechanism. Stock markets also constitute a source of liquidity for credit growth and domestic expansion (Sohail and Hussain, 2009: 183). In this context, any change in the stock markets is closely related to the changes in the real economy. Development in the real economy greatly affects the determination of the prices of stocks (Sarkar, 2012: 7).

With global financial liberalization, developments such as removing obstacles to capital flows and implementing the flexible exchange rate regime have revealed strong relations between stock markets and exchange rates (Nieh and Lee, 2001: 477-478). Together with the developments in international markets, the interdependence of foreign exchange markets and stock markets increases the diversity in investment opportunities, investment decisions, and the risk in the portfolio diversification process (Ansari and Changle, 2015: 3). According to Dornbusch and Fischer (1980), as fluctuations and changes in exchange rates affect the value of earnings, they also affect the competitiveness of producers, the cost of borrowing foreign currency, and thus their stock prices.

Changes in interest rates have an impact on stock market returns. Movements in interest rates, accordingly, affect the attractiveness of stocks. For example, low-interest rates reduce the interest in bonds, increasing the interest of investors in stocks and making them invest more (McDonald, 2002: 63). In the opposite case, capital owners begin to redirect their savings to banks that have begun to give high-interest returns. High interest also leads to decreased investments in the economy, which will increase borrowing costs. This situation can cause the price of stocks to fall. (Alam and Uddin, 2009: 43-44).

The inflation rate is another macroeconomic variable that affects the markets and consequently the stock market. Changes in inflation rates affect the decisions of investors and naturally affect the price movements of stocks (Yurttançıkmaz, 2012: 395). When the studies using these variables in the literature are analyzed, it is seen that there are different views. Some studies have concluded that inflation causes losses in stocks and that there is a negative relationship between them (Unro, 1998; Crosby, 2001; Gençtürk, 2009). The reason for this is that high inflation leads to an imbalance in the amount of demand, negatively affecting the asset allocation of companies and causing deterioration in their balance sheets (Yurttançıkmaz, 2012: 400). However, some studies argue that there is a positive relationship between inflation and stock returns. In these studies, it is indicated that during periods of inflationary pressure, companies in the stock market react to protect themselves from inflation and the value of stocks increases proportionally in proportion to the increase in inflation (Horasan, 2008; Zügül and Şahin, 2009). Investors' perspective on risk is one of the other factors affecting investment decisions. Investors' interpretation of market news and what kind of risk they are ready to take in the face of this interpretation is related to investors' risk appetite. The concept of risk appetite explains how much risk investors are willing to take. Investors' risk preferences and attitudes towards risk also differ. In a general framework, both the risk appetite and other indicators in the economy closely affect the price formation and changes in securities (Çifci and Reis, 2020: 390).

This study contributes to the existing literature by investigating the causality relationships between selected macroeconomic and financial indicators in Türkiye for the period 2011-2019. The

novelty of this study is that it focuses on the Türkiye economy and financial markets by using monthly data to examine the relationships between the Borsa Istanbul (BIST-100) index, Investor Risk Appetite Index (RISE), exchange rate, inflation and interest rate. The Toda-Yamamoto causality test method was used in the study.

This study consists of six sections. As following to introduction section, in the second section, we provide a literature review of the studies that examine the relationship between the main macroeconomic and financial indicators subject to analysis. In the third section, we introduce the methodology used in the analysis. In the fourth section, we represent the dataset used in the study. In the fifth section, we show the findings obtained from the analysis. Finally, in the conclusion section, we discuss the findings and make recommendations.

2. Empirical Literature Review

In the literature, there are many studies investigating the causality relationship between macroeconomic and financial indicators. Among these studies, Muhammad and Rasheed (2002) examined the long-run and short-run relationships between stock prices and exchange rates for four Asian countries using data from 1994-2000. They used monthly data and applied cointegration, error correction modelling approach and standard Granger causality tests. They concluded that there is no long-run and short-run relationship between stock prices and exchange rates for Pakistan and India. No short-term relationship was found for Bangladesh and Sri Lanka. However, for Bangladesh and Sri Lanka, there is a bidirectional long-term causality between these variables. According to the general results obtained, stock prices and exchange rates are uncorrelated in South Asian countries and therefore investors cannot use the information obtained from one market to predict the behavior of the other market.

Ayvaz (2006) investigated the relationship between stock market and exchange rate in Türkiye. In the study, data on dollar exchange rate, ISE 100 index and sectoral stock indices were used. The cointegration test revealed that there is a stable long-run relationship between the exchange rate and the national 100 index, the exchange rate and the financial sector index and the exchange rate and the industrial sector index. However, no relationship was found between the exchange rate and the services sector index. Moreover, according to the causality test results, there is a bidirectional causality between exchange rate and stock price indices.

Pan et al. (2007) examined the dynamic linkages between exchange rates and stock prices for seven East Asian countries including Hong Kong, Japan, Korea, Malaysia, Malaysia, Singapore, Taiwan and Thailand using data from 1988-1998. The study finds that there is a causality relationship from exchange rates to stock prices for Hong Kong, Japan, Malaysia and Thailand before the 1997 Asian financial crisis. In addition, a causal relationship from the stock market to the foreign exchange market was found for Hong Kong, Korea and Singapore. The findings also show that the relationship between the variables differs across economies depending on the exchange rate regimes, trade size, degree of capital controls and the size of the stock market.

Yurttançıkmaz (2012) investigates whether inflation and exchange rates are effective on stock returns by using data on exchange rate, consumer price index (CPI) and stock variables for the period 1994:1-2010:12 for Türkiye. According to the results of the analysis, it is concluded that inflation has a high level and positive effect on the ISE index, whereas exchange rates have a low level and negative effect. These results are also consistent and consistent when evaluated within the framework of the Türkiye economy and the structure of the ISE.

Poyraz and Tepeli (2015), using data for the period December 1995-November 2011, investigate the relationship between stock prices and some macroeconomic variables that are accepted in the literature such as inflation, money supply, currency basket, Gold prices, treasury

bill interest rate and industrial production index representing GNP, With the help of multiple regression model, correlation analysis and Granger Causality tests, they tried to investigate the relationship, direction and severity of the relationship and to reveal what influences the movements of stock prices. According to the results obtained from the study, it was found that treasury bill interest rates and exchange rate are the most important variables affecting stock prices, there is a positive relationship between money supply and CPS and BIST index, while CPI has almost no effect on the BIST Index.

Kaya and Coşkun (2015) analysed the effect of VIX index, which is accepted as an international volatility index, on Borsa Istanbul by Granger causality and Regression analysis for the period 1995-2014. The findings indicate that there is causality from the VIX index to the BIST 100 index. In addition, as a result of the regression analysis, it was determined that the VIX index negatively affected the BIST 100 index.

Yılmaz (2016) analysed the relationship between nominal exchange rate and inflation variables with monthly data covering the period between 1994 and 2014 with the sample of Türkiye. When the data of the study are evaluated, it is determined that increases in the nominal exchange rate affect inflation.

Bozdağlıoğlu and Yılmaz (2017), who stated that changes in exchange rates have an impact on variables such as growth and inflation as well as flows of goods, services and capital between countries, analysed the relationship between exchange rates and inflation in Türkiye for the period 1994-2014 using the VAR (Vector Autoregressive) method. According to the findings, it is observed that inflation is affected by increases in the nominal exchange rate. In addition, it is also revealed that shocks in the inflation variable have almost no effect on the nominal exchange rate.

Özmen (2017) analysed the relationship between stock returns and macroeconomic variables. In the study, Johansen cointegration analysis, VEC and Granger causality test were applied using monthly data for the period 1997-2017. As a result of the study, it was concluded that there is a one-way causality relationship from BIST100 to CPI.

Akgül and Özdemir (2018) analysed the relationship between inflation and interest rates and inflation and exchange rates in Türkiye for the period 2003-2016. According to the results of the study, while there is a bidirectional causality between inflation and interest rates in the 2003-2011 period, this relationship disappears after the break in 2011. After 2008, there is a causality from exchange rates to inflation.

Duman and Sağdıç (2019) investigated the relationship between exchange rate and inflation in Türkiye using quarterly data for the period 2003-2017 with time series analysis. In the study, VAR analysis, impulse-response functions, variance decomposition and Granger causality test analyses were performed. According to the findings obtained from the Granger causality analysis, there is a unidirectional causality relationship from the real effective exchange rate to inflation.

Çifci and Reis (2020) examined the causality relationship between risk appetite and BIST market index liquidity. The findings show that there is a one-way causality relationship between risk appetite and market liquidity and this relationship is from liquidity to risk appetite.

Balat (2020) analysed the relationship between BIST 100 index and risk appetite of domestic and foreign investors for the period 2013-2019. Johansen cointegration and error correction model findings indicate a long-run relationship in the relevant model, while the error correction model indicates a statistically significant and negative relationship. Moreover, the Granger causality test finding is from the BIST 100 index to both domestic and foreign investor risk appetite index.

Nur (2022) analysed the relationship between risk appetite (RISE) and BIST financial index for the period 2008-2011. According to the results of Toda Yamamoto Granger causality tests, it is

concluded that there is a one-way causality relationship from the BIST Financial index to the RISE index.

Demirci and Sinoplu (2023) examined the relationship between BIST investors' risk appetite and stock returns. In the study, the relationship between the Risk Appetite Index (RISE) for BIST investors and the stock returns of firms in the BIST 30 index was tested with panel regression analysis for domestic investors and foreign investors through two different models. According to the findings, while the change in risk appetite of domestic investors is a factor that statistically explains stock returns, the change in risk appetite of foreign investors is not a factor that explains stock returns.

Güngör Karyağdı and Aytekin (2023) analysed the relationship between the returns of financial investment instruments and inflation for the period 2005-2023 using the Lag Distributed Autoregressive bounds test and Toda-Yamamoto causality test. According to the findings of the analysis, BIST100 returns and US dollar returns are effective on inflation both in the short and long run and these effects are statistically significant. However, the effect of gold returns on inflation is statistically insignificant in both the short and long run. According to the findings of the Toda-Yamamoto causality test, there is a bidirectional causality relationship between inflation and US dollar returns in Türkiye. Moreover, a unidirectional causality relationship was found from US dollar returns and inflation to gold returns and from BIST100 returns to inflation.

When the findings in the literature are briefly evaluated, it is seen that there is no common finding in causality relations. It is thought that factors such as country samples, variables used and econometric tests applied may be important in not reaching a common finding.

3. Econometric Method

Vector Autoregressive Models (VAR) analysis is a widely used technique in econometrics and time series analysis. One of the key applications of VAR models is to examine the causal relationship between two or more variables. The Granger Causality Test is a popular method for testing the causality between variables using VAR models. However, the validity of the hypothesis tests depends on the stationarity of the time series. If the series is not stationary, the test results may not be reliable. When dealing with stationary series, the Granger Causality Test uses the F statistic to determine the causality between variables. However, if there is cointegration between the variables, the F statistic may not follow the standard distribution. Cointegration implies that the variables have a long-term equilibrium relationship, which can affect the test results. In such cases, the Toda-Yamamoto Causality Test can be used as an alternative (Bose et al., 2017).

In case the variables contain a unit root, VAR analysis is performed by using the level values of the variables. The degree of cointegration of the variables or whether they are cointegrated and whether they have unit roots is not known in advance. For this reason, many pre-tests are required in the Granger Causality Test (Toda and Yamamoto, 1995).

By determining the optimal lag length (k) and the maximum stationarity degree (d_{max}) of the analyzed series, the VAR model is estimated in ($k + d_{max}$) dimension. In order for the Toda-Yamamoto Causality Test to give reliable results, the optimal lag length k and the maximum stationarity degree of the analyzed series, (d_{max}), must be correctly determined.

Toda–Yamamoto Causality test equations where x_1 and x_2 are two variables;

$$x_{2t} = \omega_1 + \sum_{i=1}^{k+d_{max}} \gamma_{1i} x_{1,t-i} + \sum_{i=1}^{k+d_{max}} \theta_{1i} x_{2,t-i} + \varepsilon_{1t} \quad (1)$$

$$x_{1t} = \omega_2 + \sum_{i=1}^{k+d_{max}} \gamma_{2i} x_{1,t-i} + \sum_{i=1}^{k+d_{max}} \theta_{2i} x_{2,t-i} + \varepsilon_{2t} \quad (2)$$

are expressed as.

Here, the constant coefficients ω_1 and ω_2, γ_{1i} and γ_{2i}, $i = 1,2,3,\dots,k+d_{max}$, constant coefficients of the lags of the variable x_{1t}, and θ_{1i} and θ_{2i}, $i = 1,2,3,\dots,k+d_{max}$ represents the constant coefficients of the lags of the variable x_{2t}.

$H_0 = \gamma_{11}=\gamma_{12}=\cdots=\gamma_{1k}$

H_1 = At least one γ_{1k} is different from the others.

$H_0 = \theta_{21} = \theta_{22} = \cdots = \theta_{2k}$

H_1 = At least one θ_{2k} is different from the others.

We use the Wald test to test the hypotheses, which has a chi-square distribution with ($k+d_{max}$) degrees of freedom. Therefore, to obtain reliable results, it is crucial to correctly determine the optimal lag length (k) and the maximum stationarity degree (d_{max}) of the analyzed series (Toda and Yamamoto, 1995).

In conclusion, the Toda-Yamamoto Causality Test provides a useful alternative for testing causality between variables when the series may not be stationary or when cointegration exists. However, it is essential to accurately determine the optimal lag length and maximum stationarity degree to obtain reliable results.

4. Data Set

This study aims to precisely identify and analyze the directional causal relationships among specific macroeconomic and financial indicators within the context of Türkiye. The focus is on understanding the causal links between Borsa Istanbul (BIST-100) index, Investor Risk Appetite Index (RISE), exchange rate, inflation, and interest rate. By employing the Toda-Yamamoto causality test, our goal is to provide a nuanced examination of how these key indicators influence each other during the period of 2011-2019. This study seeks to contribute to the existing body of knowledge by offering detailed insights into the dynamic interactions shaping Türkiye's economic and financial landscape.

The abbreviations of the series related to macroeconomic and financial indicators and the sources from which the series are obtained are given in Table 1.

Table 1: Information About the Series

Series	Shortcode	Logarithmic Shortcode	Reference
BIST-100	BIST	lnBIST	Electronic Data Distribution System of the Central Bank
Investor Risk Appetite Index	RISE	lnRISE	Central Registry Agency Data Analysis Platform
Inflation Rate (Consumer Price Index)	INF	lnINF	Electronic Data Distribution System of the Central Bank
Interest Rate	lNT	lnINT	Electronic Data Distribution System of the Central Bank
CPI Based Real Effective Exchange Rate	EXCR	lnEXCR	Electronic Data Distribution System of the Central Bank

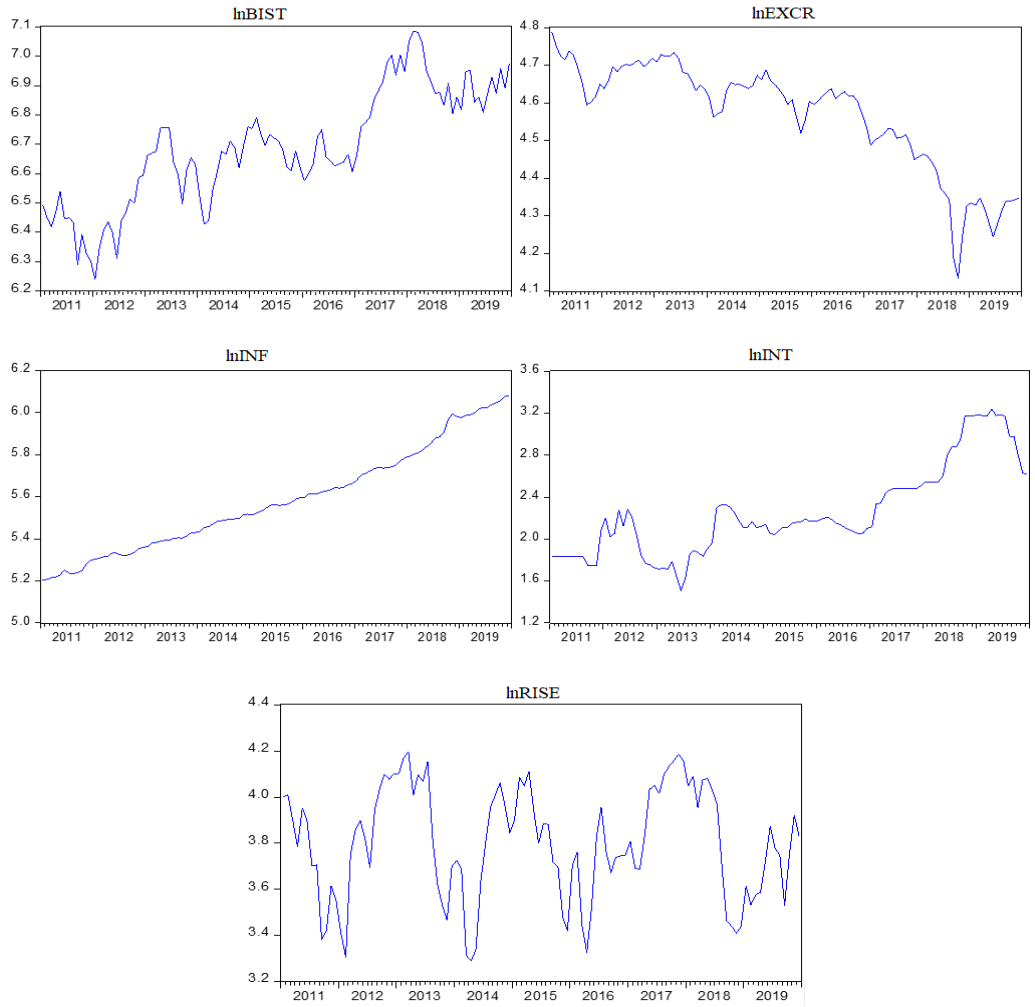
In the research, CPI Based Real Effective Exchange Rate (2003=100), the Consumer Price Index (2003=100), and the Central Bank of the Republic of Türkiye Weighted Funding Rate were taken as the interest rate. Borsa Istanbul-100 (BIST-100) and Investor Risk Appetite Index (RISE) are taken as financial indicators. These indicators are obtained from the Türkiye Central Bank Electronic Data Distribution System and the Central Registry Agency Data Analysis Platform databases. Descriptive statistics are presented in Table 2.

Table 2: Descriptive Statistics

	BIST	EXCR	INF	INT	RISE
Mean	821.3517	96.7706	277.3411	10.64176	46.27278
Maximum	1195.290	115.82	440.5000	25.50000	66.29000
Minimum	512.6700	62.46	182.6000	4.520000	26.92000
Std.Dev.	162.4313	13.1153	72.32687	5.376591	10.63984
Skewness	0.310	-0.733	0.738	1.497	-0.028
Kurtosis	2.398	2.490	2.483	4.258	1.929
Jarque-Bera	3.347549	10.849	11.00262	47.44594	5.175451
Probability	0.187538	0.0044	0.004081	0.00	0.075191
Observations	108	108	108	108	108

We used the natural logarithm of the series in the analysis. Figure 1 shows the time path graphs of the series. When the time path graphs of the series are analyzed, it is seen that the lnBIST series moves upwards even though it shows fluctuations. It has been observed that the lnEXCR series depreciated significantly in parallel with the depreciation of the Türkiye Lira. It is seen that the lnINF series has risen in a certain trend over the years. Finally, lnRISE has been found to fluctuate in a certain band gap throughout the research period.

Figure 1: Time Path Plots of Series



The correlation matrix of the analysed series is given in Table 3. lnINF series is positively correlated with lnBIST and lnINT series. lnEXCR series is highly correlated with lnINF and lnINT series. It is observed that lnEXCR has similar long-term trends with lnINF and lnINT, which causes them to move together over time.

Table 3: Correlation Matrix of Series

	lnBIST	lnEXCR	lnINF	lnINT	lnRISE
lnBIST	1				
lnEXCR	-0.6661	1			
lnINF	0.8285	-0.9126	1		
lnINT	0.6378	-0.9254	0.8891	1	
lnRISE	0.3104	0.2346	-0.0630	-0.2238	1

In the econometric findings, which is the next stage of the research, first of all, the stationarity properties of the series were tested with Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) traditional unit root tests. Considering the unit root test results of the stationarity conditions of the series, the causality relationships between macroeconomic and financial indicators were tried to be tested.

The VAR (Vector Autoregressive Model) model developed by Granger (1969) is used for levelly stationary series to determine the causality between the series (Akkas and Sayılgan, 2015: 575). When the series are made stationary by taking their differences, there may be a lack of information in revealing the causality. A cointegration relationship should be sought for series that are not stationary at the level and become stationary at the same degree when their difference is taken. Toda-Yamamoto causality test is based on the VAR model, and the degree of stationarity of the series and the existence of cointegration relationships do not affect the causality analysis (Gazel, 2017: 291).

5. Findings

In time series analysis, unit root tests of the series are applied in the first stage of econometric analysis. The stationarity determined by the unit root test results is one of the factors affecting the progress of the econometric analysis (Mert and Çağlar, 2019: 97). Stationarity, tested through unit root tests, refers to a situation where the mean, variance, and covariance of a series do not change over time (Gujarati, 1999: 913). In this study, stationarity tests of macroeconomic and financial indicators were tested with Augmented Dickey-Fuller (ADF) and Philips Perron (PP) unit root tests. In the ADF and PP unit root tests, two hypotheses are tested: "*H_0: The series have unit root*" and "*H_1: The series are stationary* ". In order to apply the Toda-Yamamoto (1995) causality test, first of all, the maximum integration level (d_{max}) of the series and the appropriate lag length (k) should be determined with the help of the VAR model. The maximum integration levels of the series were calculated by establishing the constant model and constant and trend model of the ADF and PP unit root tests, and the results are given in Table 4.

By comparing test statistics and critical values, it can be tested whether the series contains a unit root. If the calculated test statistic is greater than the critical values, the H_0 null hypothesis cannot be rejected. This shows that the series contains a unit root, that is, it is not stationary. According to Table 4, at the 1%, 5% and 10% significance levels, lnBIST, lnEXCR, lnINF and lnINT series contain unit roots in their level values and become stationary when the first difference is taken. LNRISE series, on the other hand, seem to be stationary at the level. As a result, according to ADF and PP unit root test results, lnBIST, lnEXCR, lnINF and lnINT series were found to be stationary at first difference I(1) and LNRISE at level I(0). The fact that the series is stationary at different level values has prepared the ground for the application of the Toda-Yamamoto causality test and the maximum integration level (d_{max}) has been determined as 1.

Table 4: Unit Root Test Results

Series		ADF Test		PP Test	
		Constant	Constant & Trend	Constant	Constant & Trend
lnBIST	At Level	-1.3794 (0.5898)	-3.2266 (0.0848)	-1.2273 (0.6606)	-3.2315 (0.0839)
	At First Difference	-11.0524 (0.0000)	-11.0032 (0.0000)	-11.5206 (0.0000)	-11.4430 (0.0000)
lnEXCR	At Level	-0.7712 (0.8227)	-2.3310 (0.4135)	-0.9988 (0.7517)	-2.5292 (0.3137)
	At First Difference	-8.2868 (0.0000)	-8.2599 (0.0000)	-7.4753 (0.0000)	-7.4380 (0.0000)
lnINF	At Level	2.4582 (1.0000)	-0.4485 (0.9844)	1.9838 (0.9999)	-0.7018 (0.9700)
	At First Difference	-5.9270 (0.0000)	-6.6059 (0.0000)	-7.8738 (0.0000)	-8.0988 (0.0000)
lnINT	At Level	-1.3106 (0.6226)	-1.6921 (0.7482)	-1.5256 (0.5170)	-2.2646 (0.4491)
	At First Difference	-8.4104 (0.0000)	-8.3841 (0.0000)	-8.4811 (0.0000)	-8.4553 (0.0000)
lnRISE	At Level	-3.9380 (0.0025)	-3.9180 (0.0146)	-3.5566 (0.0083)	-3.5362 (0.0406)
	At First Difference	-	-	-	-

Notes: Contents in parentheses ( ) indicate probabilities. In the ADF and PP unit root tests, the critical values were -3.492523 (1%), -2.888669 (5%) and -2.581313 (10%) for the constant model; for the constant and trend model, it is -4.046072 (1%), -3.452358 (5%) and -3.151673 (10%). The optimal lag in all tests was decided by Schwarz Information Criterion (SIC). In addition, in the PP test, the Bartlett Kernel is decided for the Spectral Estimation Method, while the Bandwith options are used for the Newey-West Method.

In Table 5, the optimal lag length is determined based on various criteria such as Sequential Modified LR Test Statistic (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SC) and Hannan-Quinn Information Criterion (HQ). The number of lags marked with an asterisk (*) in the table indicates the lag order selected by the criterion. It is common in practice to use more than one criterion to ensure consistency in lag length selection. The selected lag length of 6 lags is considered optimal based on the evaluation of these criteria.

Table 5: Determining The Optimal Lag Length with The VAR Model

Lag	LR	FPE	AIC	SC	HQ
0	NA	1.79e-09	-5.950617	-5.820358	-5.897899
1	1099.603	2.46e-14	-17.14852	-16.36697*	-16.83222
2	97.03362	1.37e-14	-17.73879	-16.30595	-17.15889*
3	30.15419	1.59e-14	-17.59777	-15.51363	-16.75428
4	47.46495	1.46e-14	-17.69859	-14.96316	-16.59151
5	38.83119	1.47e-14	-17.72334	-14.33661	-16.35267
6	44.77898*	1.32e-14*	-17.87231*	-13.83429	-16.23805
7	29.46611	1.47e-14	-17.83271	-13.14341	-15.93487
8	27.44353	1.66e-14	-17.79786	-12.45726	-15.63642

Notes: * indicates lag order selected by the criterion. LR: Sequential Modified LR Test Statistic (each test at 5% level), FPE: Final Prediction Error, AIC: Akaike Information Criterion, SC: Schwarz Information Criterion, HQ: Hannan-Quinn Information Criterion.

It is necessary to test the autocorrelation and stationarity conditions of the model in the number of lags suggested by the information criteria. In the autocorrelation LM test, "*H_0: There is no autocorrelation"* and *"H_1: There is autocorrelation"* tests are tested. According to Table 6, the probability value at the 6nd lag length was tested at the 5% significance level and the H_0 null hypothesis was accepted since it was 0.7617>0.05. It has been determined that there is no autocorrelation problem in the VAR (6) model. The series must also satisfy the constant variance

condition. The Chi-square and probability values of the VAR (6) model are 896.7487 and 0.5243, respectively. It is an indication that the constant variance condition is met at the 5% error level.

Table 6: Autocorrelation Test Results

Lag	LM F-statistic	Prob.
1	26.63792	0.3742
2	29.50912	0.2432
3	28.00294	0.3077
4	24.46983	0.4924
5	17.22707	0.8734
6	19.71243	0.7617
7	34.33789	0.1009

The null hypothesis (H_0) states that there is no changing variance and implies that the variances of the variables in the vector autoregression (VAR) model are constant over time. On the other hand, the alternative hypothesis (H_1) suggests the presence of changing variance in the model. The test statistics reveal that the Chi-Square Test Statistic value is 89.67487 and the associated probability (Prob.) is 0.5243. According to these results, we cannot reject the null hypothesis since the probability exceeds the conventional significance level of 0.05. Therefore, the evidence from Table 7 shows that the model does not exhibit changing variance and the variances of the variables remain consistent over time.

Table 7: VAR Variance Joint Test Result

Chi-Square Test Statistic	Prob.
89.67487	0.5243

In Table 8, the causality relationships between the series subject to the research are found by Toda-Yamamoto test. Accordingly, an extended VAR model was constructed by summing the maximum degree of integration (d_{max}=1) obtained from the unit root tests and the optimal lag length (k=6) obtained from the VAR model. For example, the null hypothesis stating that there is no causality from exchange rate to BIST-100 index (lnEXCR>>lnBIST) is accepted. Since the chi-square test statistic is 6.561460 and the probability value for this statistic is p= 0.3633>0.05, it is concluded that the exchange rate is not the cause of the BIST-100 index. Table 8 shows that there is a unidirectional causality from BIST-100 index to inflation, exchange rate to inflation, investor risk appetite index to interest rate and BIST 100 index to investor risk appetite index at 5% significance level.

The findings of the study are consistent with different studies in the literature. The findings of Kaya and Coşkun (2015) draw attention to the fact that fear and risk appetite indices act as barometers on the markets and guide investors. The findings of Özmen et al. (2017), who find a unidirectional causality relationship from stock markets to the inflation indicator, are also similar. Moreover, the finding of a causality relationship from the BIST-100 index to inflation in Güngör Karyağdı and Aytekin (2023) is consistent with this research. The findings of Akgül and Özdemir (2018) and Yılmaz (2016), who concluded that changes in exchange rates affect inflation rates, are also consistent with the findings of this study. Yılmaz (2016) supports this conclusion with the fact that central banks keep exchange rate movements under control and use them as a precautionary policy against inflation. Similarly, Bozdağlıoğlu and Yılmaz (2017), in their study showing that changes in the exchange rate have an impact on inflation, argue that exchange rate policies to be followed have become a strategic tool in terms of ensuring domestic and external balance. Duman and Sağdıç (2019) is another study that concludes that changes in exchange rates affect inflation. Balat (2020), who analyses the relationship between BIST100 and risk appetite, states that there is a significant relationship between the two variables. Both domestic and foreign investors shape

their risk appetite according to the BIST100 index. Nur (2022) concluded that changes in the RISE index affect the BIST100 index in the long run. It is also stated that the results obtained in the study coincide with the behavioural models expressing that they affect the decisions of investors.

Table 8: Toda-Yamamoto Causality Test Results

Direction of Causality	Lag Length ($k + d_{max}$)	Chi-Square Test Statistic	Probability	Existence of Causality (5%)
lnEXCR >>> lnBIST	7	6.561460	0.3633	No causality
lnINF >>> lnBIST	7	3.131348	0.7922	No causality
lnINT >>> lnBIST	7	10.97839	0.0890	No causality
lnRISE >>> lnBIST	7	4.996314	0.5443	No causality
lnBIST >>> lnEXCR	7	6.985471	0.3222	No causality
lnINF >>> lnEXCR	7	6.889464	0.3312	No causality
lnINT >>> lnEXCR	7	1.122578	0.9805	No causality
lnRISE >>> lnEXCR	7	6.582132	0.3612	No causality
lnBIST >>> lnINF	7	13.81856	0.0317	There is causality from lnBIST to lnINF
lnEXCR >>> lnINF	7	38.23173	0.0000	There is causality from lnEXCR to lnINF
lnINT >>> lnINF	7	6.328419	0.3874	No causality
lnRISE >>> lnINF	7	1.278939	0.9728	No causality
lnBIST >>> lnINT	7	5.183810	0.5205	No causality
lnEXCR >>> lnINT	7	8.585090	0.1983	No causality
lnINF >>> lnINT	7	4.633193	0.5916	No causality
lnRISE >>> lnINT	7	16.64660	0.0107	There is causality from lnRISE to lnINT
lnBIST >>> lnRISE	7	31.13623	0.0000	There is causality from lnBIST to lnRISE
lnEXCR >>> lnRISE	7	7.294375	0.2945	No causality
lnINF >>> lnRISE	7	7.098225	0.3119	No causality
lnINT >>> lnRISE	7	8.096574	0.2311	No causality

6. Conclusion

This study aims to reveal the causality relationship between selected macroeconomic indicators and financial markets. CPI-based Real Effective Exchange Rate (2003=100), Consumer Price Index (2003=100) and interest rate are taken as macroeconomic indicators. BIST-100 and RISE are taken as financial indicators. The causality relationship between the variables is analysed by Toda-Yamamoto Causality Test.

ADF and PP unit root test results show that the first differences of lnBIST, lnEXCR, lnINF and lnINT series are stationary at I(1) level, while LNRISE is stationary at I(0) level. This indicates that these variables are integrated at the first level. According to the study, there is a one-way causality relationship from BIST-100 index to inflation, from exchange rate to inflation, from investor risk appetite index to interest rate and from BIST-100 index to investor risk appetite index.

When the findings of the study are evaluated, it is seen that the variables used in the analysis affect each other in different ways. The first result is that the changes in BIST100 affect the inflation rate. In other words, the economic activity resulting from BIST100 returns can affect the inflation rate. One of the structural problems in the Türkiye economy is that inflation dynamics are very sensitive to the exchange rate. This situation may make the economy more fragile, especially by

creating a pass-through effect of changes in the exchange rate to inflation. The results of the study also support this approach. Another result of the study is the unidirectional relationship from risk appetite to interest rates. This may be due to the fact that investors adjust their portfolios according to economic conditions and risk perceptions. Theoretically, an inverse relationship is expected between investor risk appetite and interest rates. That is, as investor risk appetite increases, demand for risky assets increases and interest rates fall. As investor risk appetite decreases, the demand for risky assets decreases and the interest rate increases. This suggests that there is a complex and dynamic relationship between investor risk appetite and interest rates. To understand this relationship, both macroeconomic and behavioral factors need to be taken into account. Finally, a causality from the stock market index to investor risk appetite implies that changes in the stock market index affect investors' propensity to hold risky assets. This relationship implies that investors change their risk perception according to market conditions. This is important as it affects stock market liquidity.

The results obtained in the study are considered to guide policy makers in decision-making processes regarding the relationship between macroeconomic and financial indicators in Türkiye. Although the research has important implications for policymakers, it has three main limitations. Firstly, a limited number of macroeconomic and financial variables were used in the study, but the number of variables can be considered to be increased in future studies. Secondly, the 2011-2019 period of the study is considered as the data period. Finally, different causality tests and models can be constructed for future studies and the literature in this field can be enriched.

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