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Analysis of cointegration and causality relations between gold prices and selected financial indicators: Empirical evidence from Turkey

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ABSTRACT

This paper explores the dynamic relationships between gold prices and selected financial indicators (such as prices, inflation rate, deposit interest rate, exchange rate, and the Istanbul Stock Exchange National 100 index) in Turkey between the 2000-2019 period using the Fourier Toda-Yamamoto causality tests. Firstly, the ADF unit root test is applied to examine the stationary of the variables. Then Gregory-Hansen and Arai-Kurozumi cointegration tests, the Dynamic Least Squares (DOLS) approach, are employed to determine the coefficient size and direction of the variables. The findings reveal that the relationship between the inflation rate and the BIST100 index is positive and significant, while the relationship between interest rates is negative and significant. Also, the relationship between exchange rates is negative and insignificant in the study. Additionally, the impacts of the global economic crisis of 2008, which is used as a dummy variable in the study, on gold prices in Turkey are found to be positive and significant. This study indicates that gold is the safe haven for investors from 2000 to 2019 in Turkey. The findings of this paper might contribute both to investors in Turkey and future research on the determination of gold prices.

1. Introduction

Throughout history, gold has been traded as a precious metal, is the basis of monetary systems, and most importantly, it is still used as a savings and investment tool on a world scale. Historically, gold coins were widely used as money for hundreds of years. During the gold standard period, banknotes were backed by gold, and money was defined by a fixed weight of gold. With the signing of the Bretton Woods agreement in 1944; the value of the US dollar was defined in relation to gold. Thus, the dollar became the world reserve currency depending on gold. While gaining financial power, the US government achieved the ability to delay its current account deficits by attracting capital from the rest of the world, and also had the ability to finance its budget deficits by selling government bonds to the rest of the world. However, collapsing of the Bretton woods system large global imbalances that occurred in the world economy, and the global financial crisis has exploded in 2008 in the US (Choudhry et al., 2015). Following the global crisis, the US started to apply unconventional monetary policies in order to combat the deepest post-war recession. The Federal Reserve Bank (FED) applied quantitative easing policies in order to stimulate the economy. FED lowered short-term interest rates to zero or nearly zero. Therefore, central banks reduced their share of US government bonds, which have zero and negative interest rates. Both private investors and central banks first increased their gold holdings in 2008 in order to protect their nation's wealth against volatility and high uncertainty. Since 1980 deregulation of the financial sector caused uncertainties, global imbalances, and a global financial crisis in 2008 (Oktay et al., 2016). Especially with high leverage ratios of hedge funds, the money quantity has been highly increased in the world. Derivative instruments have accelerated this process. Against the financial risks gold has been demanded as a hedging tool during crises (Serin et al., 2018; Levin et al., 2004). Thus economists have been focused on the analysis of factors affecting gold prices. In this context, the purpose of this study is to explore cointegration and causality relationships between gold and BIST 100 index (BIST), Consumer

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Prices index, the interest rate of time deposit, and USD/TRY exchange.

2. Literature review

Using daily data from December 1979 to March 1981, Koutsoyiannis (1983) explored the long-term relations between gold prices and inflation, USD, interest rate, silver price, Dow Jones index, oil price. This study reveals that there is a positive relationship between gold prices and inflation rate, oil prices, silver prices, and a negative relationship with the US dollar, interest rate, and Dow Jones index. In addition, in the study in which political crises and tensions were included, it was seen that political stability had an effect on gold prices. Baur and Lucey (2010) explored whether gold was a hedging tool or safe haven for investors in the US, Germany, and the UK. As a result of the analysis, it was concluded that gold was hedged against stocks, it was a safe haven in the stock market only for 15 trading days in case of a high shock occurred. Toraman et al. (2011) examined the factors affecting the increase in gold prices, which recently increased with the effect of financial crises. The study covers the period between 1992 and 2010. The monthly data used in the model are oil prices, US exchange rate, US inflation rate, and US real interest data. According to findings, there is a negative relationship between gold prices and the US exchange rate, and a positive relationship between gold prices and oil prices.

Polat (2013) investigated the factors affecting gold prices by using monthly data for the period from 1988 to 2013. In the study, while international gold prices are taken as dependent variables, inflation rates, exchange rates, Dow Jones Index, oil prices, and interest rates are used as independent variables. As a result of the causality analysis, the variable inflation rate, which affects gold prices mostly and positively, the second most affecting variable is the exchange rate, but it has a negative effect. While the variable that affected gold prices the least is the Dow Jones Index, all variables except interest rates were found to have a significant relationship with gold prices. Elmas et al. (2014) investigated the demand-side factors affecting gold prices. The study was conducted with monthly data for the period 1988-2013. In the analysis, an analysis was made on the factors affecting the gold price, the exchange rate, the Dow Jones Index, the interest rate, the inflation rate, the silver price, and the oil price, with time series. It was determined that oil prices, silver prices, and the inflation rate positively affect gold prices, while the exchange rate, the Dow Jones Index, and the interest rate negatively affected gold prices. According to the results of the analysis, the effect of factors other than the interest rate on the gold price was found to be significant.

Khan et al. (2016) tested the relationship between gold prices in Pakistan Karachi Stock Exchange and oil prices and the KSE100 stock return index by Regression analysis using monthly series for the period 2000-2013. In the study, a positive relationship was found between the KSE100 return index and oil prices, and a negative relationship between the KSE100 return index and gold prices.

Wen and Cheng (2018) analyzed the relationship between the MSCI indices of China, India, Brazil, Chile, Malaysia, Russia, Czech Republic, South Africa, and Thailand and the yields of gold and the US dollar exchange rate. According to findings both gold and the US dollar were safe investment instruments, also the US dollar was more reliable than gold in most cases. Bakhsh and Khan (2019) investigated the interactions of the gold price, exchange rate, stock index, and crude oil price in Pakistan using monthly series for the period from1997 to 2018. Unit root test, correlation test, co-integration technique, vector autoregressive model, and granger test were applied to analyze the trend of variables in the study. As a result of the analysis, it was seen that there was no long-term relationship between all variables. However, it has been revealed that the crude oil price and the gold price have a significant effect on the exchange rate and the stock exchange is affected by the exchange rate. This study has guided politicians and investors to stabilize financial variables against fluctuations in the economy.

Küçükçolak et al. (2019) analyzed the long-term relationship between variables by cointegration tests with using the series between gold prices and stock index for the period 2009-2017. As a result of the analysis, a negative correlation was found between variables. Based on the findings of the analysis, gold commodities were requested to be included in the stock portfolio in order to be less affected by conjunctural fluctuations and to be used in portfolio diversification.

Lan et al. (2019) examined the relationship between gold prices in the Chinese economy and the exchange rate, stock market, and crude oil. In this study, using 18-year secondary data for the 2001-2018 period, they analyzed the correlation relationship between gold price return and these variables with regression equation, Breusch-Godfrey series correlation, and the heteroscedasticity test. As a result of the analysis, it was concluded that the gold price was significantly significant with 1% and 10% crude oil prices and the KSE-100 index, respectively, and that gold prices were negatively but negligibly related to the exchange rate.

Kharusi and Basci (2019) examined the relationship between gold prices and the stocks of countries within the Gulf Cooperation Council. In the study, cointegration and Granger causality tests were applied by using a daily series between the 2010-2016 periods. As a result of the analysis, the existence of cointegration has been revealed and the evidence of the granger causality test has emerged between gold prices and different stocks.

3. Methodology

This paper aims to explore the relationship between gold prices and inflation rate, exchange rate, interest rate, BIST100 index in Turkey's economy, with following logarithmic-linear model was investigated by using monthly data from June 2000 to December 2012. The relevant unit root tests in our study were generally used as a method in many studies and were not included in the study as a methodology.

$$LnAL_t = \alpha_t + \beta\_1\, lnENF_t + \beta_2 DÖV_t + \beta\_3\, FO_t + \beta\_4\, BIST_t + \mathcal{E}_t \quad (1)$$

where, AL indicates gold prices, ENF inflation rate, FX exchange rate (USD purchase), FO interest rate, BIST BIST100 index, α_t is the constant term, $\mathcal{E}_t$ is the error term. In this study, gold prices, inflation rates, exchange rates, and monthly data of interest rate were obtained from the electronic data distribution system of the Central Bank of Turkey (EDDS) and also BIST100 monthly data were obtained from the ınvestıng.com address. The cointegration method, which was proposed by Gregory and Hansen as the first method to investigate the long-term relationship between variables, and which allows a single break in the test of the cointegration relationship was used (Gregory and Hansen, 1996). Gregory and Hansen (1996) developed the standard cointegration test approach by modeling structural breaks internally. He defined dummy variables to model structural breaks as follows:

$$\emptyset_{1\tau} = \begin{cases} 0 \; if \; t \leq \; [n\tau], \\ 1 \; if \; t > \; [n\tau], \end{cases} \quad (2)$$

where, $\tau \in (0,1)$ denoting the unknown parameter is the date of the structural change. Under these conditions, the cointegration equation can be written to take into account the break in constant:

$$y_{1t} = \mu_1 + \mu_2\varphi_{1\tau} + \alpha y_{2t} + e_t \quad (3)$$

where, μ_1 and μ_2 respectively express the change in the constant before and after the structural break. It is possible to extend this model to include the change in trend as in Eq. 4:

$$y_{1t} = \mu_1 + \mu_2\varphi_{1\tau} + \beta t + \alpha^T y_{2t} + e_t \quad (4)$$

Within the scope of the Gregory-Hansen cointegration method, 3 statistics are calculated:

$$ADF^* = \underset{\tau \in T}{inf} ADF(\tau) \quad (5)$$

$$Z_\alpha^* = \underset{\tau \in T}{inf} Z_\alpha(\tau) \quad (6)$$

$$Z_\alpha^* = \underset{\tau \in T}{inf} Z_t(\tau) \quad (7)$$

In the Gregory-Hansen approach, ADF and PP tests are applied to the residues obtained from the regression and the absence hypothesis of "there is no cointegration relationship in the presence of structural break" is tested against the alternative hypothesis "there is a cointegration relationship in the presence of structural break"

In the investigation of the existence of cointegration, as the second method, the cointegration test developed by Arai and Kurozumi (2007) and which allows a single break in constant or trend and constant was used. Arai and Kurozumi (2007) followed a similar testing strategy to Gregory and Hansen in their study. In this context, the dummy identification process in Eq. 7 is also valid in the Arai-Kurozumi procedure. To investigate the existence of cointegration under the assumption of a break in constant and break in constant and trend, Arai and Kurozumi (2007) used the data definition process as in Eqs. 8 and 9, respectively:

$$y_{1t} = \mu_1 + \mu_2\varphi_{t\tau} + \beta' y_{2t} + \textstyle\sum_{i=-K}^{K} \pi' \, \Delta y_{2t-i} + \varepsilon_{5t}^* \quad (8)$$

$$y_{1t} = \mu_1 + \mu_2\varphi_{t\tau} + \alpha t + \beta' y_{2t} + \textstyle\sum_{i=-K}^{K} \pi' \, \Delta y_{2t-i} + \varepsilon_{5t}^* \quad (9)$$

where, μ_1 and μ_2 respectively express the constant before and after the structural break, while π_i is the parameter vector of size $(m \times 1)$ for $-K \leq i \leq K$. In the Arai-Kurozumi approach, the KPSS stationarity test is applied to the residuals obtained from the regression, and the absence hypothesis that "there is a cointegration relationship in the presence of structural break" is tested against the alternative hypothesis "there is no cointegration relationship in the presence of structural break". Therefore, contrary to the conventional cointegration tests, it tests the existence of a cointegration relationship in the null hypothesis because of the application of an inverse hypothesis stationary test to the residuals.

The Dynamic Ordinary Least Squares (DOLS) estimator proposed by Saikkonen (1991) and Stock and Watson (1993) was used to estimate the long-term relationship between gold prices and inflation rates, exchange rates, interest rates, and BIST100. The DOLS estimator solves the concurrency problem that causes the internality problem between series and allows the series to be in a higher-order cointegration relationship. The general equation for the DOLS estimator is (Chikalipah and Okafor, 2019; Stock and Watson, 1993):

$$Y_t = \beta_0 + \beta_1 X_t + \textstyle\sum_{i=-K}^{K} \varsigma_i \, \Delta X_{t-i} + \varepsilon_{7t} \quad (10)$$

where, Y indicates the dependent variable, X indicates the parameter set, and K indicates the lead-delay values of the difference parameter set.

Finally, in the study, in order to test the causality between dependent and explanatory variables. The Fourier Toda-Yamamoto Causality test developed by Nazlioglu et al. (2016) was used. The Fourier Toda-Yamamoto causality test is basically based on the Toda-Yamamoto (Toda and Yamamoto, 1995) causality test, and gradually models the structural breaks in variables by defining Fourier functions. Therefore, in the approach, it is not necessary to know the history and form of a structural break as a priori knowledge.

In addition, since bootstrap distribution is used in the method, it can produce resistant test statistics in cases where the variables contain unit root or are cointegrated. Within the scope of the study, the standard vector autoregressive process is expanded as in equation 11 so that the constant does not change over time, it includes the change in the constant:

$$y_t = \alpha(t) + \beta_1 y_{t-1} + \cdots \beta_{p+d} y_{t-(p+d)} + \varepsilon_{8t} \quad (11)$$

where, $\alpha(t)$ is a function of time and includes any structural inclusion in the dependent variable. In this context, the Fourier expansion can be expressed as follows to capture the structural change in the constant term:

$$\alpha_t = \alpha_0 + \sum_{k=1}^{n} \gamma_{1k} \sin(2\pi kt/T) + \sum_{k=1}^{n} \gamma_{2k} \cos(2\pi kt/T) \quad (12)$$

Here n denotes the number of frequencies. If Eq. 12 is arranged to contain a single frequency:

$$\alpha_t = \alpha_0 + \gamma_1 \sin(2\pi kt/T) + \gamma_2 \cos(2\pi kt/T) \quad (13)$$

where, k indicates the number of Fourier frequencies. Substituting Eq. 13 in Eq. 11 gives the main form of the Fourier Toda-Yamamoto causality test:

$$y_t = \alpha_0 + \gamma_1 \sin(2\pi kt/T) + \gamma_2 \cos(2\pi kt/T) + \beta_1 y_{t-1} + \cdots + \beta_{p+d} y_{t-(p+d)} + \varepsilon_{8t} \quad (14)$$

4. Findings

Within the scope of the study, the analyses were first started by performing traditional unit root tests. ADF test estimates are reported in Table 1. According to the results, all variables contain unit roots in both constant and trend models and become stationary when taken as the 1st difference.

Table 1: ADF results

	Constant		Constant +Trend	
Variables	Level	1st Difference	Variables	Level
LNAL	-1,59 (0,48)	-13,027 (0,00)	-0,67 (0,97)	-13,10 (0,00)
LNENF	-2,55 (0,10)	-11,68 (0,00)	-2,24 (0,45)	-11,75 (0,00)
LNUSD	-1,76 (0,39)	-15,34 (0,00)	-1,52 (0,81)	-15,37 (0,00)
LNFA	-2,45 (0,12)	-27,27 (0,00)	-3,03 (0,12)	-27,23 (0,00)
LNBIST	-0,91 (0,78)	-17,77 (0,00)	-2,41 (0,37)	-17,74 (0,00)

On the other hand, the PP test results are presented in Table 2. The results point to the findings parallel to the ADF test, and while the unit root process is displayed in both the constant and the trend+constant model, it becomes stable at different significance levels when the first differences are taken. With this information; it is concluded that the effects of possible shocks are permanent on gold prices, exchange rate, BIST100 index, interest rates, and inflation rates in Turkey.

Table 2: PP test results

	Constant		Constant+Trend	
Variables	Level	1st Difference	Variables	Level
LNAL	-1,46(0,54)	-4,12 (0,00)	-0.85 (0,95)	-4,23 (0,00)
LNENF	-2,50 (0,11)	-3,45 (0,01)	-2,23 (0,46)	-3,40 (0,05)
LNUSD	-1,73 (0,41)	-4,04 (0,00)	-1,40 (0,85)	-4,07 (0,00)
LNFA	-1,51 (0,52)	-4,57 (0,00)	-1,62 (0,77)	-4,57 (0,00)
LNBIST	-0,86 (0,79)	-4.13 (0,00)	-2,18 (0,49)	-4,12 (0,00)

Note: Probability values are shown in parentheses. The most suitable delay number in the PP test was determined with the Newey-West correction delay option

The unit root test analysis with a structural break was first performed with the unit root test developed by Lee and Strazicich (2003). Model results considering the break in the constant are presented in Table 3. The results can be summarized as follows:

- The null hypothesis as "There is a unit root for gold prices at 5% and 1% significance level" cannot be rejected.
- The null hypothesis that "there is a unit root for inflation rates" is strongly accepted.
- The null hypothesis of "There is a unit root for the exchange rate, interest rates, and the BIST100 index" is rejected, and the alternative hypothesis that indicates stagnation is strongly accepted.
- In addition, when the first difference between gold prices and inflation rates is taken, it becomes stable.

Breaking dates are determined by LS structural break test in Table 3. LS Test. According to Model A constant break; while the first break dates of the variables show 2013 (gold prices), 2006 (inflation rates), 2003 (USD dollar rate, interest rates, and BIST 100 index), the second break dates; similarly emerged as 2013 (gold prices and interest rates), 2006 (inflation rate), 2003 (USD-dollar rate and BIST 100 index). Breaking dates are determined by LS structural break test in Table 3. LS Test. According to Model A constant break; while the first break dates of the variables show 2013 (gold prices), 2006 (inflation rates), 2003 (USD dollar rate, interest rates, and BIST 100 index), the second break dates; similarly emerged as 2013 (gold prices and interest rates), 2006 (inflation rate), 2003 (USD-dollar rate and BIST 100 index).

On the other hand, the findings obtained for the fixed and trended model are presented in Table 4. According to the findings:

- The absence hypothesis of "There is a unit root for gold prices, interest rates and the BIST100 index" cannot be rejected at the 1% significance level. In addition, these variables show a stationary process when the first-order differences are taken.

- On the other hand, for inflation rates and exchange rates, an alternative hypothesis indicating stagnation is accepted, that is, the trend exhibits a stable process.

According to Table 4, the LS test shows the first break dates of financial variables 2005 (gold prices), 2004 (inflation rates and USD dollar rate), 2009 (interest rates), 2003 (BIST 100 index) according to Model C fixed and trend break; the second break dates are; similarly, 2013 (interest rates), 2012 (gold prices), 2016 (inflation rate), 2005 (USD-dollar rate and BIST 100 index).

Similarly, as in the LS structural break test, the breaking dates were tried to be determined by the CIS structural break tests. In the CIS test, the first and second break dates were determined as both a fixed model and a fixed and trend model as in LS.

Table 3: Lee and Strazicich test results

Model A: Constant Refraction						
Test	Level	1st Difference	Fraction 1 (λ)	Fraction 2 (λ)	B1	B2
LNAL	-3,82*	-6,75***	0,65	0,66	2013-4	2013-6
LNENF	-3,23	-7,87***	0,30	0,31	2006-5	2006-7
LNUSD	-4,548***	-	0,16	0,17	2003-7	2003-10
LNFA	-5,12***	-	0,16	0,68	2003-7	2013-9
LNBIST	-4,75***	-	0,16	0,17	2003-8	2003-11

Note: For the table of critical values of the Lee and Strazicich Test (Lee and Strazicich, 2003). *, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. B1: First Break Date, B2: 2nd Break Date

Table 4: Lee and Strazicich test results

Model C: Fixed and Trend Refraction						
Test	Level	1st Difference	Fraction 1 (λ)	Fraction 2 (λ)	B1	B2
LNAL	-6,03**	-7,71***	0,25	0,61	2005-5	2012-5
LNENF	-7,73***	-	0,21	0,83	2004-8	2016-10
LNUSD	-25,66***	-	0,22	0,27	2004-9	2005-9
LNFA	-6,32**	-8,04***	0,45	0,67	2009-4	2013-8
LNBIST	-5,81**	-6,91***	0,14	0,25	2003-4	2005-5

Note: For the table of critical values of the Lee and Strazicich Test (Lee and Strazicich, 2003). *, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. B1: First Break Date, B2: 2nd Break Date

The results of the Carrion-i Silvestre and Sanso test for the fixed model are reported in Table 5. According to the findings:

- The null hypothesis that the series is stationary is strongly accepted for all variables. In this context, all variables exhibit a stationary process.

Looking at Table 5, according to the Model A fixed break CIS test shows the first breaking dates of the variables 2013 (gold prices), 2004 (USD dollar rate), 2003 (inflation rate, interest rate, and BIST 100 index). The second breaking dates are; similarly, which emerged as 2015 (gold prices), 2017 (inflation rate), 2009 (interest rate), 2005 (USD-dollar rate and BIST 100 index).

Table 5: Carrion-i Silvestre and Sanso test results

Model A: Refraction						
Test	Level	1st Difference	Fraction 1 (λ)	Fraction 2 (λ)	B1	B2
LNAL	0,06	-	0,66	0,77	2013-5	2015-6
LNENF	0,02	-	0,17	0,85	2003-10	2017-1
LNUSD	0,25	-	0,22	0,23	2004-10	2005-1
LNFA	0,07	-	0,17	0,45	2003-9	2009-3
LNBIST	0,03	-	0,17	0,25	2003-11	2005-4

Note: For the critical values table for the carrion-i Silvestre and Sanso test (Carrion and Sanso, 2007). *, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. B1: First Break Date, B2: 2nd Break Date

On the other hand, the results of the Carrion-i Silvestre and Sanso test for the fixed and trended model are reported in Table 6. According to the findings obtained:

- The alternative hypothesis that "there is a unit root for the exchange rate" is strongly accepted.
- The null hypothesis that "the series is stationary for all variables except the exchange rate" is strongly accepted.

According to Table 6, the first break dates of financial variables in terms of CIS test Model C fixed and trend breakage 2005 (gold prices), 2003 (inflation rate), 2004 (USD dollar rate), 2001 (interest rates), 2002 (BIST 100 index) as shown. The second breaking dates are; similarly emerged as 2013 (gold prices), 2016 (inflation rate), 2011 (interest rates), 2005 (USD-dollar rate), and 2006 (BIST 100 index).

In this case, according to the findings obtained from both conventional and structural breakage tests:

- For the gold price variable, the unit root process was accepted in six of the eight tests.
- For the inflation rate variable, the unit root process was accepted in five of the eight tests.
- For the exchange rate variable, the unit root process was accepted in five of the eight tests.

- For the interest rate variable, the unit root process was accepted in five of the eight tests.
- For the BIST100 variable, the unit root process was accepted in five of the eight tests.

In this case, it can be stated that all of the variables are I (1) process. This situation necessitated the investigation of a possible joint movement between variables, that is, the existence of a cointegration relationship.

Table 6: Carrion-i Silvestre and Sanso test results

Model C: Constant and Trend Fraction						
Test	Level	1st Difference	Fraction 1 (λ)	Fraction 2 (λ)	B1	B2
LNAL	0,01	-	0,28	0,65	2005-11	2013-3
LNENF	0,02	-	0,17	0,84	2003-11	2016-12
LNUSD	0,34***	0,28	0,21	0,24	2004-8	2005-3
LNFA	0,01	-	0,05	0,58	2001-5	2011-11
LNBIST	0,10	-	0,13	0,30	2002-12	2006-4

Note: For the critical values table for the carrion-i Silvestre and Sanso test (Carrion and Sanso, 2007). *, **, *** indicate statistical significance at the 10%, 5% and 1% level, respectively. B1: First Break Date, B2: 2nd Break Date

Gregory-Hansen and Arai-Kurozumi tests were applied in order to test the existence of cointegration between variables. While the Gregory-Hansen approach tests the absence of cointegration in the absence hypothesis, the Arai-Kurozumi approach tests the existence of cointegration. In this context, the application of two cointegration approaches with inverse hypothesis has provided more consistent and convincing evidence for the presence or absence of cointegration.

In this context, the findings for the break-in constant model are presented in Table 7. According to the findings, the absence hypothesis that there is no cointegration according to three statistics within the scope of the Gregory-Hansen test was rejected at different significance levels. On the other hand, according to the Arai-Kurozumi test, the absence hypothesis such as "there is cointegration" was accepted. Breaking dates mostly indicate the 10th month of 2009 according to the Gregory-Hansen approach, and the 12th month of 2010 according to the Arai-Kurozumi approach.

Table 7: Gregory-Hansen and Arai-Kurozumi Cointegration test results

Model A: Constant Fraction			
Test	Statistics	Fraction (λ)	B1
Gregory-Hansen Test (ADF)	-5,43*	-	2003-7
Gregory-Hansen Test (Za)	-6,35**	-	2009-10
Gregory-Hansen Test (Zt)	-65,51**	-	2009-10
Arai and Kurozumi Test	0,06	0,03	2010-12

Note: The Gregory-Hansen ADF and Za Test values of 1%, 5% and 10% are (-6.05), (-5.56), (-5.31), for Zt (-70.18), respectively., (-59,40), (-54,38), for Arai and Kurozumi Test (0.13), (0.08), (0.07). *, **, *** denote statistical significance at the 10%, 5% and 1% level, respectively. B1: First Break Date

The Gregory-Hansen and Arai-Kurozumi cointegration test results summarized in Table 7 Model A indicate the existence of a cointegration relationship between variables. Both tests show the existence of the cointegration relationship as a breaking date. In this context, we can say that the variables for the period 2000 and 2020 are cointegrated. When we look at the breaking dates of Gregory-Hansen and Arai-Kurozumi cointegration tests, it shows the year 2009 in Gregory-Hansen tests and 2010 in Arai-Kurozumi.

On the other hand, the findings for the fixed and trend break model are presented in Table 8. According to the findings, ADF and Za test statistics in the Gregory-Hansen test were rejected at the 10% and 5% significance level, respectively, of the absence hypothesis of "no cointegration" On the other hand, the absence hypothesis that there is no cointegration according to the Zt statistic is accepted. Finally, according to the Arai-Kurozumi test statistics, the absence hypothesis that there is cointegration is accepted. Breaking dates mostly indicate the 9th month of 2005 according to the Gregory-Hansen approach, and the 10th month of 2010 according to the Arai-Kurozumi approach. When we look at the breaking dates of Gregory-Hansen and Arai-Kurozumi cointegration tests, it shows 2003 and 2005 in Gregory-Hansen tests and 2010 in Arai-Kurozumi. Both in the relevant year of crisis in February 2001 is a period that significantly affects the economy of Turkey as well as the 2008 US mortgage crisis. As a result, it can be said that Gregory-Hansen and Arai-Kurozumi cointegration tests have identified breaking periods of the Turkish Economy correctly.

Table 8: Gregory-Hansen and Arai-Kurozumi Cointegration test results

Model C: Constant and Trend Fraction			
Test	Statistics	Fraction (λ)	B1
Gregory-Hansen Test (ADF)	-5,65*	-	2003-9
Gregory-Hansen Test (Za)	-6,09**	-	2005-9
Gregory-Hansen Test (Zt)	-58,43	-	2005-9
Arai ve Kurozumi Test	0,03	0,02	2010-10

Note: For Gregory-Hansen ADF and Za Test, 1%, 5% and 10% critical values are (-6.36), (-5.83), (-5.59), for Zt (-76.95), respectively. (-65.44), (-60.12), (0.08), (0.05), (0.04) for the Arai and Kurozumi Test. *, **, *** indicate statistical significance at the 10%, 5% and 1% level, respectively. B1: First Break Date

In Model C summarized in Table 8, Gregory-Hansen and Arai-Kurozumi's cointegration test results show the existence of a cointegration relationship between variables. Both tests show the existence of the cointegration relationship as a fixed and trend break date. In this context, we can say that the variables of the period 2000: 06-2019: 12 are cointegrated and act together. When we look at the breaking dates of the Gregory-Hansen and Arai-Kurozumi cointegration tests, it is seen that this date is 2003 and 2005 in the Gregory-Hansen tests, while it is 2010 in the Arai-Kurozumi test. Due to the fact that these periods were the February 2001 crisis and the 2008 USA Mortgage crises, our country's economy was significantly affected.

In our study, the DOLS estimation method, which takes into account the endogeneity of long-term cointegration coefficients between series, was used. The estimated results of long-term coefficients are presented in Table 9. In light of these findings:

- A 1% increase in the BIST100 index increases gold prices by 0.27%.
- A 1% increase in inflation rates increases gold prices by 0.19%.
- A 1% increase in interest rates reduces gold prices by 0.48%.
- A 1% increase in the dummy variable increases gold prices by 0.22%.

Table 9: DOLS prediction results

	Coefficient	t Statistic	Probability
BIST	0.278	3.077	0,076
ENF	0.198	1.793	0,002
FA	-0.489	-3.753	0,000
USD	-0.011	-1.025	0,306
Dummy2009/10	0.228	1.846	0.066
Constant	4.527	4.996	0.000

Note: the maximum delay and leader length in DOLS estimation were calculated using the Schwarz information criterion. Long-term consistent variance estimation was made using Bartlett Kernel and Newey-West correction

According to the results of the long-term cointegration analysis, the effect of the inflation rate on gold prices was found to be significant and positive. Accordingly, a 1% increase in the inflation rate increases the gold prices by 0.19%. The effect of the interest rate on gold prices was found to be significant and negative. Accordingly, a 1% increase in the interest rate decreases gold prices by 0.48%. The effect of the BIST 100 index on gold prices has been determined to be significant and positive. Accordingly, a 1% increase in the BIST 100 index increases gold prices by 0.27%. The effect of the US exchange rate on gold prices is found to be insignificant and negative. The effect of the dummy variable subject to analysis on gold prices is statistically significant and positive. In the aftermath of the 2008 global mortgage crisis in the US 2008 resulting in economic shocks experienced in Turkey's economy, it has made an upside effect on gold prices.

Finally, to investigate the causality relationship between variables, the Fourier Toda-Yamamoto causality test was performed and the findings are reported in Table 10. According to the findings:

- The null hypothesis that "inflation rates are not the cause of gold prices" was accepted.
- The null hypothesis that "Gold prices are not the cause of inflation rates" was rejected at the 10% significance level. Accordingly, there is a 10% level of causality from gold prices to inflation rates
- The null hypothesis that "the exchange rate is not the cause of gold prices" was accepted.
- The null hypothesis that "gold prices are not the cause of the exchange rate" was accepted.
- The null hypothesis that "interest rates are not the cause of gold prices" was rejected at the 10% significance level. Accordingly, there is a 10% level of causality from interest rates to gold prices.
- The null hypothesis that the "BIST100 index is not the cause of gold prices" was accepted.
- The absence hypothesis that "Gold prices are not the cause of the BIST100 index" was accepted.

5. Conclusion and discussion

Considered as one of the most precious metals in the world, gold has been used by various civilizations for centuries as a means of exchange and investment. The changes in gold prices have attracted the attention of governments, investors, and researchers for many reasons such as gold being a safe investment tool, being included in the reserves of central banks, and is an investment tool traded in stock exchanges. The economic recession and uncertainties experienced after the 2008 global financial crisis caused investors to turn to gold as a safe haven. In this context, it has been a matter of curiosity for the investors of our country whether the traditional, simple and understandable gold is really a safe investment tool. For these reasons, this study seeks to answer the question of how effective gold prices are in protecting investors against inflation, interest, exchange rate, and volatility in variables such as the BIST100 index.

In the study, the relationships between gold prices and the variables that are likely to affect gold prices under our country's conditions have been examined in the empirical part. In the study, in which traditional and structural unit root tests and cointegration tests were used, the impact of the factors affecting the gold price was revealed by determining the breaking dates. The analysis showed that there is a positive and statistically significant relationship between the inflation rate and BIST 100 index and gold prices in Turkey. In addition, the relationship between gold prices and interest rates is negative and statistically significant. However, it was determined that the relationship between gold prices and the US exchange rate is negative and statistically insignificant. The relationship between the 2009/10 dummy variable, which was determined as the effect of the 2008 crisis, and the gold prices in the period subject to the analysis, was found to be positive and statistically significant. As a result, unidirectional causality was found from gold prices to inflation and from interest to gold prices, while no causality was observed between gold prices and the BIST100 index and exchange rate. According to the analysis findings, in times of high inflation and crisis, the trend will be an increase in the price of gold in Turkey and I can say gold will be seen as a safe haven by investors. Similarly, in periods of low deposit interest rates, gold will be demanded as an alternative investment tool, on the contrary, the demand for gold will decrease. The stability of gold prices in our country depends on the inflation targeting policies of monetary authorities, the success of the financial policies implemented by the government, and structural reforms that will be affected at a minimum level from global uncertainties and geopolitical risks.

Table 10: Fourier Toda Yamamoto causality test results

Causality	Wald Statistics	Bootstrap Probability Value	Optimal Frequency	Optimal Delay
$LNENF \neq> LNAL$	1,49	0.89	3	5
$LNAL \neq> LNENF$	11.01	0.051	3	5
$LNDOV \neq> LNAL$	13.04	0.17	3	9
$LNAL \neq> LNDOV$	7.72	0.55	3	9
$LNFA \neq> LNAL$	17.88	0.09	3	11
$LNAL \neq> LNFA$	12.01	0.34	3	11
$LNBIST100 \neq> LNAL$	7.43	0.20	3	5
$LNAL \neq> LNBIST100$	10.50	0.48	3	5

Note: Not the cause. The maximum delay length is calculated using the Schwarz information criterion

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Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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