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A Study on the Cointegration Relationship between Selected Global Stock Markets and Gold and Silver Futures

Ozan Kaymak[1,a,*]

[1]*Finance Banking and Insurance, Cermik Vocational School, Dicle University, Diyarbakır, Türkiye*
**Corresponding author*

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ABSTRACT

Globalization has enabled greater volume and frequency of economic and commercial practices to be implemented worldwide. As a result, with the expansion of the scope of capital expansion, the interdependence of financial markets increases. However, negative developments such as economic crises, epidemics, wars, and uncontrolled migrations cause the relations between markets to weaken and a significant number of investors to turn to commodity investments. This study aims to evaluate the validity of the Capital Asset Pricing Model (CAPM) theorem, which posits that the expected returns of financial assets are influenced by systematic and unsystematic risks within the context of the selected market data for the specified period. Specifically, the study seeks to analyze the potential cointegration and the effects of gold and silver futures returns on the returns of selected global stock markets using time-series analysis. The potential relationships between the monthly returns of selected global stock indices and the monthly returns of gold and silver futures were analyzed for the period from January 2014 to May 2024 using the Autoregressive Distributed Lag (ARDL) Bound Test method. By calculating the error correction coefficients, it has been determined how long it takes to restore the balance in case the balance between the stock markets and commodity markets is disrupted. As a result of the research, it was determined that there is a long-term cointegration relationship between gold and silver futures index returns and selected global stock index returns. In the case of a short-term imbalance in the relationship between the yields of selected global indices and the index returns of gold and silver-term transactions, the balance was recovered within 0.9042 months for the index return of gold-term operations and 0.6549 months for the index return of silver-term operations.

Keywords: Global Stock Markets, Gold and Silver Futures, ARDL Bond Test

Seçili Küresel Hisse Senedi Piyasaları ile Altın ve Gümüş Vadeli İşlemleri Arasındaki Bağımlılık Üzerine Bir Araştırma

Süreç

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ÖZ

Küreselleşme, ekonomik ve ticari pratiklerin dünya genelinde daha yüksek hacim ve frekansta uygulanabilmesine olanak tanımıştır. Bunun sonucunda sermaye yayılımlarının etki alanlarının genişlemesiyle, finansal piyasaların karşılıklı bağımlılıklarının arttığı söylenebilir. Ancak ekonomik krizler, salgın hastalıklar, savaşlar ve kontrolsüz göçler gibi olumsuz gelişmeler, piyasalar arasındaki ilişkilerin zayıflamasına ve anlamlı sayıda yatırımcının emtia yatırımlarına yönelmesine yol açmaktadır. Bu çalışmada; Sermaye Varlıkları Fiyatlandırma Modeli (CAPM), sistematik ve sistematik olmayan riskler karşısında seçilen finansal varlıkların beklenen getirilerinin değişeceği teoreminin seçilen piyasa verilerinin ilgili dönemde geçerli olup olmadığı araştırılmıştır. Çalışmanın amacı, altın ve gümüş vadeli işlem getirileri arasındaki olası eşbütünleşmeyi ve bunların seçilmiş küresel hisse senedi piyasaları getirileri üzerindeki etkisini zaman serisi analizleri ile incelemektir. Bu çalışmanın amacı; seçili küresel hisse senedi piyasaları ile altın ve gümüş vadeli işlemleri arasındaki muhtemel eşbütünleşme ilişkisinin zaman serisi analizleri ile incelenmesidir. 2014 Ocak ile 2024 Mayıs döneminde, seçili küresel hisse senedi endekslerinin aylık getirileri ile altın ve gümüş vadeli işlemleri aylık endeks getirileri arasındaki muhtemel ilişkiler Gecikmesi Dağıtılmış Otoregresif Sınır Testi (ARDL) Yöntemine göre incelenmiştir. Hata düzeltme katsayılarının hesaplanmasıyla, hisse senedi piyasaları ile emtia piyasaları arasındaki dengenin bozulması durumunda, dengenin ne kadarlık bir sürede yeniden sağlanabildiği tespit edilmiştir. Araştırmanın sonucunda altın ve gümüş vadeli işlemleri endeks getirileri ile seçili küresel hisse senedi endeks getirileri arasında uzun dönemli eşbütünleşme ilişkisinin var olduğu tespit edilmiştir. Seçili küresel endekslere ait getiriler ile altın ve gümüş vadeli işlemleri endeks getirileri arasındaki ilişkide kısa dönemde dengenin bozulması durumunda, altın vadeli işlemleri endeks getirileri için 0.9042 ay, gümüş vadeli işlemleri endeks getirileri için ise 0.6549 içinde dengenin yeniden sağlandığı tespit edilmiştir.

Anahtar Kelimeler: Küresel Hisse Senedi Piyasaları, Altın ve Gümüş Vadeli İşlemleri, ARDL Sınır Testi

[a] kaymak.ozan@gmail.com 0000-0001-5492-2877

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Introduction

The spread of trading and investment practices worldwide and economic integration have strengthened the interdependence between stocks and other financial assets traded on global markets. This situation has strengthened the correlation between global financial assets and caused a decrease in the gains of stock investors through diversification (Badshaha et al., 2018; 16-18). The interactions of financial markets with the real sector are related to national macroeconomic indicators and countries' production and employment levels becoming more unstable (Blanchard, 1981). In addition, capital markets can be more affected by macro-economic developments and the price volatility of commodity assets than others (Waheed et al., 2020; 5). During periods of global financial crises in the last two decades, high volatility movements have been observed in stock exchanges and commodity assets around the world. Price movements in global stock markets and shocks in commodity prices influenced each other (Moshirian, 2011; 503-504). This situation may have led to changes in macroeconomic indicators around the world. (Choudhry et al., 2016; 90). Research on this subject suggests that shocks in commodity prices increase the volatility of global stock markets, and as a result, the production level in developing economies decreases and inflation rates increase (Fernández et al., 2018; 99).

Emerging markets and economies have a more sensitive and fragile response to global economic fluctuations. This fragility stems from the fact that these economies and markets are partially dependent on commodity exports. Business processes and capital flows in these economies are significantly affected by fluctuations in commodity prices (Reinhart & Trebesch, 2016; 577). The process that causes simultaneous movements in capital flows, commodity prices, and economic crises on a global scale is called the Global Financial Cycle (GFD). Current academic research claims that GFD is significantly related to fluctuations in commodity prices (Davis et al., 2021). However, it is not yet clear how global shocks, together with fluctuations in commodity prices, affect the economies of developing countries (Agrippino & Rey, 2022; 4). Global stock markets are developed financial markets according to the number of investors, the number of transactions, and transaction volume. The relationships between the price movements in these markets and the movements of commodity prices such as gold, silver, and oil are a subject that researchers focus on. (Cong et al., 2008; 3546; Sheikh et al., 2023; 5). Gold, which is often associated with price movements in global markets, is considered a stable investment option by investors due to some of its features (Jaffe, 1989; 56). Gold is seen as an asset that can protect savings against risks and provide stable returns in periods of high inflation and exchange rate instability (Shaik et al., 2023; 8). Some academic studies suggest that gold and silver have similar price movements. Silver prices may be affected by macroeconomic developments and the volatilities of other precious metals. In addition, silver is the most used precious metal after gold as a store of value (Paul et al., 2023; 8-10).

In this study, possible cointegration relationships between global stock markets and global gold and silver futures index returns are examined. Capital Asset Pricing Model (CAPM) was considered to develop a model based on the theorem that the expected returns of financial assets will change in the face of systematic and unsystematic risks. In the study, it was examined whether undesirable situations arising from market risk had a combined effect on selected assets. Thus, it was investigated whether selected assets were affected in the same direction or level by the developments in the relevant time period. According to the results, the relationships between entities were evaluated according to the assumptions of the CAPM theorem. The aim of the study is to examine the possible cointegration between and the impact of the gold and silver futures returns on selected global stock markets returns with time-series analyses Unit root test results show that the series of selected global stock indices are non-stationary at level but become stationary at first-order differences. It has been determined that global gold and silver futures index returns are stationary series at level. According to these results, the possible cointegration between commodities index returns and global stock indices was studied by the Autoregressive Distributed Lag Bound Test (ARDL) method. Two different Vector Autoregression (ARDL) models are estimated, where the series of gold and silver futures index returns are the dependent variable and selected global stock indices are the independent variable. Specification tests for both models, which are the normality test, autocorrelation test, heteroscedasticity test, regression model specification error test (Ramsey-RESET), CUSUM Test, and CUSUM of Square tests, were applied. The ARDL bound test results show that there is a cointegration relationship between global stock indices and gold and silver futures index returns in both models. Additionally, error correction coefficients were estimated for both models.

Literature ReviewChen and Qi (2024) examined the relationship between Chinese energy stocks, renewable energy stocks, and commodity markets by using dependency and causality processes. As a result of the study, they suggested that volatility in commodity prices could be used to predict the future price of stocks. Zapata, Betanco, Bampasidou and Deliberto (2023) examined the relationship between commodity markets and stock markets according to changes in the indices of these assets. They also evaluated the effects of the 2008 global economic crisis and the COVID-19 outbreak on capital markets. The results show that there was a cyclical relationship between stock markets and commodity markets for a period of 31 years. Sheth, Sushra, Kshirsagar and Shah (2022) examined the relationship between global economic developments, global stock prices, and commodity price changes. The results show that investment volumes decreased due to price shocks in stock markets during periods of global economic development and that prices of commodities other than gold showed an upward trend. Tiwari, Abakah, Karikari and Hammoudeh (2022) examined the degrees of time dependence between international commodity prices, Australian sectoral stock prices, crude oil, and natural gas prices. They found that the dependence between commodity prices and stock returns varies depending on time, according to the results of the study. They also suggested that commodity investments can protect investors against risks while portfolio diversification is made in financial investments. Enilov, Fazio and Ghoshray, (2021) examined the relationship between global commodity price shocks and national financial stock indices. The results of the study show that there is a causal relationship between global commodity prices and national stock indices, according to the Granger causality method. In addition, they argued that there is a causality relationship between the development levels of countries and global commodity price shocks, according to the results. Ali, Bouri, Czudaj and Shahzad (2020) examined the returns provided by diversification of commodities traded on the global stock exchange in 49 countries with different development degrees. The results show that commodities, especially gold and silver, could protect investors against loss of wealth against the risks arising from fluctuations in global financial markets. Kang, Ratti and Vespignani (2020) investigated the time-varying dynamics of volatility in global stock markets, commodity prices, domestic production, and consumer prices. According to the results, the volatility in global stock prices and commodity price shocks affect each other and the global economy in a gradual and internal adaptation process. They also found that this effect gained a stronger structure during periods of global economic crisis. Raharja and Darmansyah (2019) examined the effects of global stock index returns and global commodity index returns on the returns of stocks traded on the Indonesian Stock Exchange using the multiple linear regression technique. According to the results, the returns of global stocks and the returns of the global commodity index had a significant effect on the shares traded on the Indonesian Stock Exchange. Barunik et al. (2016) examined the cointegration between gold, silver and oil futures returns and stock returns asset pairs between 1987 and 2012 with time frequency analysis. As a result of the study, they found that the level of cointegration between these assets increased in periods when economic risks increased. Arauri et al. (2015) investigated global gold returns and return and volatility spreads in Chinese stock markets between 2004 and 2011 using the GARCH method. As a result of the study, they determined that it is an important parameter in determining global gold returns and conditional returns in the Chinese stock market. Bahardaj and Dunsby (2013) examined the relationship between price movements of stocks traded on global stock exchanges and changes in commodity prices. According to the results of the study, they found that the correlation between price movements of global stocks and changes in commodity prices is close to zero. However, they stated that this situation changed significantly as time progressed. They argued that stocks and commodities act in a cointegrated manner during economic crisis periods.

Materials and Methods

In this study, among the global stock markets located in different economic regions, indices belonging to the stock markets that are ahead of other markets as per the number of investors, market width, and transaction volume were selected. Standard & Poors 500 (SPX) from the United States, Standard & Poors Toronto Stock Exchange (GSPTSX) from Canada, Deutscher Aktieindex (GDAXI) from Germany, Financial Times Stock Exchange Group 100 (FTSE) from the United Kingdom, and Euro Stoxx 50 from the European Union region. (STOXX50E) indices were selected to be investigated. By providing logarithmic transformations of the monthly data of these indices for the date range of January 2014 to May 2024, a data set of 125 observations for each series was created. Among the indices of commodity futures, the gold (GCM4) and silver (SIN4) global indices were selected. Index returns were calculated based on the monthly values of these indices for the same date range. The series of gold and silver futures index returns consisting of 125 observations was created. Table 1. includes the names and symbols of the series of selected global stock indices and selected commodity futures index returns.

Table 1. Series of Gold and Silver Futures Index Returns and Selected Global Index Returns

Index	Symbol	Type	Region	Series
Standart&Poors 500	SPX	Stock	USA	LSPX
Standart&Poors Toronto Stock Exchange	GSPTSX	Stock	Canada	LGSPTSX
Deutscher Aktienindex	GDAXI	Stock	Germany	LGDAXI
Financial Times Stock Exchange Group 100	FTSE	Stock	United Kingdom	LFTSE
Euro Stoxx 50	STOXX50E	Stock	European Union	LSTOXX
Gold Futures - Jun 24	GCM4	Commodity	Global	RGCM4
Silver Futures - Jul 24	SIN4	Commodity	Global	RSIN4

After the series of variables is created, it will be studied whether there is a long-term cointegration relationship between the monthly values of selected global stock indices and the monthly returns of commodity futures indices between January 2014 and May 2024. For significant results in time series analysis, unit root tests must be performed to determine the appropriate method. To specify the level of stationarity of the series, Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests were carried out. According to the results, the series of global stock indices (LSPX, LGSPTSX, LGDAXI, LFTSE, and LSTOXX) were not stationary at the level, but the global stock index series became stationary at first differences. This means that the degree of integration of these series is one. It has been determined that the series of returns of gold and silver futures indices (RGCM4, RSIN4) are stationary at level. According to these results, the ARDL-Bound process is thought to be a suitable method to obtain statistically significant results in long-term cointegration analyses. Additionally, the error correction coefficient can be calculated after Bound Tests. Thus, if the balance between the series is disrupted, it can be calculated how long it will take to achieve balance.

The gold futures index returns series (RGCM4) is appointed as the dependent variable, and the selected global stock index series (LSPX, LGSPTSX, LGDAXI, LFTSE, and LSTOXX) are the independent variables. The model of the series was estimated according to the ARDL method. The model was used to examine the relationships between selected series because it is a convenient method for investigating the developments and correlations between multiple time series. ARDL model is a method that allows examining the differences in the selected variable depending on the selected variable's own lag and the different lags of other variables (Sims, 1980). The estimated model was named Model 1. In the other model, the silver futures index returns series (RSIN4) is appointed as the dependent variable, and LSPX, LGSPTSX, LGDAXI, LFTSE, and LSTOXX series are independent variables. The estimated model was named Model 2. In addition, error correction coefficients for Model 1 and Model 2 were determined. Specification tests were applied for the estimated Model 1 and Model 2.

Results and Discussion

ADF, PP and KPSS unit root tests have been applied to the monthly data for the date range of January 2014 to May 2024 of selected global stock indices and selected commodity futures index returns series. The results from unit root tests showed that it was determined that the integration degrees of the series of global stock indices were 1 ($I = 1$) and the commodity futures index returns series were stationary at level ($I = 0$). It was decided to examine the cointegration relationships and determine the error correction coefficients with the ARDL process. ARDL is a method where it is not necessary for the stationarity degrees of the series to be at the same level. In the next stage, two different ARDL models were estimated. In Model 1, the gold futures index return series is the dependent variable, and selected global stock index return series are appointed as the independent variable. In Model 2, the silver futures index return series is the dependent variable, and the selected global stock index return series are the independent variable. Specification tests were conducted for two estimated models. Normality test, autocorrelation test, heteroscedasticity test, regression model specification error test (Ramsey-RESET), cumulative total control table (CUSUM) test, and (CUSUMQ) of Squares test were applied. Specification tests have shown that there are no specification problems for both models. Thus, long-term cointegration relationships between the series were studied with the bounds test for both models. In the last stage, error correction coefficients were calculated for both models.

ADF and PP Unit Root Tests of Series

ADF and PP tests were applied to specify the level of stationarity of the series. In both processes, the series was studied at level and first difference with constant and trend, with only constant and without constant and trend models. The ADF test results are given in Table 2.

Table 2. ADF Unit Root Test Results of Series at Level and 1st Difference

At Level		LFTSE	LGDAXI	LGSPTSX	LSPX	LSTOXX	RGCM4	RSIN4
With Constant	t-Statistic	-2,094	-1,323	-1,026	-0,562	-1,455	-12,123	-10,975
	Prob,	0,248	0,618	0,743	0,874	0,553	0,000	0,000
	Result	n0	n0	n0	n0	n0	***	***
With Constant & Trend	t-Statistic	-2,542	-3,406	-2,971	-3,279	-2,766	-12,129	-10,970
	Prob,	0,308	0,055	0,145	0,075	0,213	0,000	0,000
	Result	n0	*	n0	*	n0	***	***
Without Constant & Trend	t-Statistic	0,602	1,188	1,168	2,181	0,914	-12,010	-10,994
	Prob,	0,845	0,939	0,937	0,993	0,903	0,000	0,000
	Result	n0	n0	n0	n0	n0	***	***
At First Difference		d(LFTSE)	d(LGDAXI)	d(LGSPTSX)	d(LSPX)	d(LSTOXX)	d(RGCM4)	d(RSIN4)
With Constant	t-Statistic	-11,914	-11,478	-12,337	-12,873	-11,834	I=0	I=0
	Prob,	0,000	0,000	0,000	0,000	0,000		
	Result	***	***	***	***	***		
With Constant & Trend	t-Statistic	-11,900	-11,444	-12,313	-12,830	-11,835	I=0	I=0
	Prob,	0,000	0,000	0,000	0,000	0,000		
	Result	***	***	***	***	***		
Without Constant & Trend	t-Statistic	-11,935	-11,399	-12,252	-12,395	-11,806	I=0	I=0
	Prob,	0,000	0,000	0,000	0,000	0,000		
	Result	***	***	***	***	***		

The ADF unit root test's H_0 hypothesis represents that the series has a unit root if the prob. coefficient of the t-statistic is greater than 0.05. In the alternative hypothesis, it is concluded that the series does not contain a unit root, that is, the series is stationary (Dickey & Fuller, 1979; 429-430). The results in Table 2 for the LSPX, LGSPTSX, LGDAXI, LFTSE, and LSTOXX series of the probability values of ADF t-statistics are greater than 5% according to all three models. Thus, H_0 is accepted. In other words, the series has no unit root at level. In the RGCM4 and RSIN4 series, ADF t-statistic probability values are less than 5%, according to all three models at level. According to this result, H_0 is rejected. In other words, gold and silver futures index return series are stationary at the level. This result means that the degree of integration of the RGCM4 and RSIN4 series is 0. At first differences of the global stock index series in the ADF unit root test show that all probability values of the t-statistics are less than 5%, according to all three models. In this case, the ADF test H_0 hypothesis is rejected. The results show that the level of integration of the LSPX, LGSPTSX, LGDAXI, LFTSE, and LSTOXX series is 1 ($I = 1$). To support the results of the ADF unit root test, the Phillips-Perron (PP) unit root test was applied, and the results are shown in Table 3.

In PP tests, if the probability values of t-statistics obtained from unit root calculations of the series are greater than 5% ($p > 0.05$), the H_0 hypothesis is accepted. This represents that the series contains a unit root. (Phillips & Perron, 1988; 343-345). According to Table 3, the PP t-statistic probability values of the LSPX, LGSPTSX, LGDAXI, LFTSE, and LSTOXX series are greater than 5% for all three models. According to this result, the H_0 hypothesis cannot be rejected. This means that global stock index return series have unit root at the level in the PP unit root test. The series of gold and silver futures index returns are stationary series at level according to the PP unit root test. Thus, it can be said that the level of integration of the series is 0 ($I = 0$) It has been shown that the PP t-statistic probability values for the first-differences for three models of all global stock index series are less than 5%. In this case, the H_0 hypothesis is rejected. In other words, the series becomes stationary at the first difference. Thus, it was stated that the level of integration of the series was 1 ($I = 1$).

Table 3. PP Unit Root Test Results of Series at Level and 1st Difference

At Level		LFTSE	LGDAXI	LGSPTSX	LSPX	LSTOXX	RGCM4	RSIN4
With	t-Statistic	-2,015	-1,212	-0,811	-0,327	-1,455	-12,222	-11,470
Constant	Prob,	0,280	0,668	0,812	0,917	0,553	0,000	0,000
	Result	n0	n0	n0	n0	n0	***	***
With	t-Statistic	-2,518	-3,476	-2,920	-3,124	-2,805	-12,411	-11,577
Constant	Prob,	0,319	0,057	0,160	0,105	0,198	0,000	0,000
& Trend	Result	n0	*	n0	n0	n0	***	***
Without	t-Statistic	0,683	1,451	1,456	2,821	1,028	-12,010	-11,431
Constant	Prob,	0,862	0,963	0,964	0,999	0,920	0,000	0,000
& Trend	Result	n0	n0	n0	n0	n0	***	***
At First Difference		**d(LFTSE)**	**d(LGDAXI)**	**d(LGSPTSX)**	**d(LSPX)**	**d(LSTOXX)**	**d(RGCM4)**	**d(RSIN4)**
With	t-Statistic	-11,971	-11,606	-12,601	-13,357	-11,880	I=0	I=0
Constant	Prob,	0,000	0,000	0,000	0,000	0,000		
	Result	***	***	***	***	***		
With	t-Statistic	-11,966	-11,573	-12,620	-13,327	-11,913	I=0	I=0
Constant	Prob,	0,000	0,000	0,000	0,000	0,000		
& Trend	Result	***	***	***	***	***		
Without	t-Statistic	-11,987	-11,449	-12,384	-12,404	-11,843	I=0	I=0
Constant	Prob,	0,000	0,000	0,000	0,000	0,000		
& Trend	Result	***	***	***	***	***		

Table 4. KPSS Unit Root Test Results of Series at Level and 1st Difference

At Level		LFTSE	LGDAXI	LGSPTSX	LSPX	LSTOXX	RGCM4	RSIN4
With Constant	t-Statistic	0,87618	1,19462	1,18700	1,32804	0,94829	0,04818	0,14548
	1% level	0,73900	0,73900	0,73900	0,73900	0,73900	0,73900	0,73900
	5% level	0,46300	0,46300	0,46300	0,46300	0,46300	0,46300	0,46300
	10% level	0,34700	0,34700	0,34700	0,34700	0,34700	0,34700	0,34700
At First Difference		d(LFTSE)	d(LGDAXI)	d(LGSPTSX)	d(LSPX)	d(LSTOXX)	d(RGCM4)	d(RSIN4)
With Constant	t-Statistic	0,07293	0,04989	0,06361	0,04706	0,07987	0,25240	0,34815
	1% level	0,73900	0,73900	0,73900	0,73900	0,73900	0,73900	0,73900
	5% level	0,46300	0,46300	0,46300	0,46300	0,46300	0,46300	0,46300
	10% level	0,34700	0,34700	0,34700	0,34700	0,34700	0,34700	0,34700

KPSS unit root test is used to investigate whether the time series examined is stationary according to its trend. The basic hypothesis of the KPSS test represents that the series examined is stationary (Kwiatkowski et al., 1992; 1-3). According to the results in Table 4, the t-statistic values of the LFTSE GDAXI LGS PTSX LSPX STOXX series are calculated to be greater than the critical values of 1%, 5%, and 10%. According to this result, the H_0 hypothesis is rejected. In other words, the series are not stationary at level. The t-statistic values of the RGCM4 and RSIN4 series were calculated to be lower than the critical values. In this case, the H_0 hypothesis is accepted. In other words, the RGCM4 and RSIN4 series are stationary at level. It is calculated that the t-statistic value is smaller than the critical values for the first-degree differences of the LFTSE GDAXI LGS PTSX LSPX STOXX series. In this case, the stationarity degree of the series is 1 ($I = 1$).

Autoregressive Distributed Lag Bound Test (ARDL)

ARDL Boundary Test is a method developed by Pasaran and Shin in 2001. While in other cointegration tests, the stationarity degrees of the series of variables must be the same, in the ARDL Boundary Test, cointegration relationships can be examined between more than two series with different degrees of integration (Pesaran & Shin, 2001; 293). In addition, the ARLD test is a method that investigates long- and short-term causality relationships between series (Sam, McNown and Goh, 2019; 133-136).

$$\Delta Y_t = c_0 + c_1 t + \pi_{yy} y_{t-1} + \pi_{yx.x} x_{t-1} + \sum_{i=1}^{p-1} \varphi \, \Delta Z_{t-i} + \omega' \Delta x_t + \theta w_t + u_t \quad \textbf{(1)}$$

In Equation 1; c_0 is autonomous parameter, t is trend variable, π_{yy} / $\pi_{yx.x}$ is long term multipliers, $Z_t = (y_{t,}\ x_t)'$ is variables, ω_t is Shadow variable, u_t is error term without autocorrelation. In the ARDL bounds test, the H_0 hypothesis means no cointegration between the series of variables ($H_0 = \pi_{yy} = \pi_{(yx.x)} = 0$). In case of the t-statistic value from the estimated model in the ARDL bound test is superior than the upper critical value, the basic hypothesis is rejected. If the t-statistic coefficient is between the lower and upper critical values, series needs to be studied on unit roots with other process. (Narayan, 2005; 1983-1988).

ADF, PP and KPSS tests results indicate that the stationarity levels of the RGCM4 and RSIN4 series (depended variable) and LSPX, LGSPTSX, LGDAXI, LFTSE and LSTOXX series (independent variables) are different from each other. The degrees of integration of the dependent variables were calculated as 0 ($I = 0$), and the degrees of integration of the independent variables were calculated as 1 ($I = 1$). This result supports that the ARDL test to be applied is an appropriate cointegration method for this study (Pesaran & Shin, 2001; 293). In this study, the global stock indices series (LSPX, LGSPTSX, LGDAXI, LFTSE and LSTOXX) with integration degrees of 1 between January 2014 and May 2024 are the independent variables, and the gold and silver futures index returns series (RGCM4, RSIN4) are the dependent variables. Two different models will be estimated with the ARLD approach (Model 1 and Model 2).

Estimating the ARDL Models of Gold and Silver Futures Indices Returns Series and Global Stock Index Series Model 1 and Model 2

Model 1; In the date range from January 2014 to May 2024, the global gold futures index returns series (RGCM4) is the dependent variable. Series created by logarithmic transformations of the monthly values of selected global stock indices in the same period (LSPX, LGSPTSX, LGDAXI, LFTSE and LSTOXX) are independent variables. For the ARDL bounds test, a model consisting of defined series is estimated. ARDL model values for Model 1 are in Table 5.

Table 5. Estimating the ARDL Model (Model 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
RGCM4(-1)	-0,0649	0,0890	-0,7291	0,4676
RGCM4(-2)	0,0773	0,0876	0,8834	0,3790
RGCM4(-3)	-0,1184	0,0793	-1,4929	0,1385
LFTSE	0,0247	0,0232	1,0615	0,2909
LFTSE(-1)	0,0097	0,0287	0,3388	0,7354
LFTSE(-2)	-0,0717	0,0274	-2,6173	0,0102
LFTSE(-3)	0,0540	0,0220	2,4569	0,0157
LGDAXI	-0,0055	0,0380	-0,1460	0,8842
LGDAXI(-1)	-0,0370	0,0408	-0,9066	0,3667
LGDAXI(-2)	0,0534	0,0191	2,7919	0,0062
LGDAXI(-3)	-0,0440	0,0149	-2,9483	0,0039
LGSPTSX	0,0347	0,0258	1,3437	0,1819
LGSPTSX(-1)	-0,0717	0,0222	-3,2273	0,0017
LSPX	0,0252	0,0101	2,4894	0,0144
LSTOXX	-0,0501	0,0395	-1,2691	0,2072
LSTOXX(-1)	0,0721	0,0393	1,8321	0,0698
C	0,1434	0,0873	1,6425	0,1035

The ARDL model (Model 1), with a date range of January 2014 to May 2024, in which the dependent variable is the gold futures return series (RGCM4) and the series of global stock indices (LSPX, LGSPTSX, LGDAXI, LFTSE and LSTOXX) is the independent variable, is estimated with maximum lag length is 4. Akaike information criterion (AIC) was used as the model selection method. The significant model to be selected in the model estimation made with Eview's is ARDL (3, 3, 3, 1, 0, 1). This model is named Model 1.

ARDL (3, 3, 3, 1, 0, 1) Model 1 specification tests

Before conducting long- and short-term cointegration analyses according to the estimated Model 1, specification tests of the model were carried out. Model 1. A normality test was performed to determine whether the residuals of the series in Model 1 had a normal distribution. The results are in Table 6.

If the probability value of the normality test statistic is higher than 5% ($prob > 0.05$), the basic hypothesis, which represents that the series are normally distributed, is accepted. (Jarque & Bera, 1987; 166). According to the results in Table 6, the probability value of the Jarque-Bera test statistic is 0.633371. Since this value is greater than 0.05, the basic hypothesis cannot be rejected. In other words; it was determined that the residues of the series in ARDL (3, 3, 3, 1, 0, 1) Model 1 were normally distributed. The Breusch-Godfrey Serial Correlation LM Test was used to specify whether there is an autocorrelation problem in Model 1. The results of the serial correlation LM test are in Table 7.

Breusch-Godfrey autocorrelation LM test The H_0 hypothesis means no autocorrelation between the series at the specified lag length. In case of the probability coefficient of the F-stat. is higher than 0.05 ($prob > 0.05$), H_0 is accepted (Breusch, 1978; 336; Godfrey, 1978; 1296). In (3, 3, 3, 1, 0, 1) Model 1, the probability value of the F-statistic is 0.3966. According to this result, the Breusch-Godfrey autocorrelation LM test H_0 hypothesis is accepted in Model 1 and it has been observed that there is no autocorrelation between the series. (3, 3, 3, 1, 0, 1) Model 1.

Breusch-Pagan-Godfrey Heteroscedasticity test was applied to search on any heteroscedasticity between the series in ARDL (3, 3, 3, 1, 0, 1) Model 1. The results are in Table 8.

In the Breusch-Pagan-Godfrey Heteroscedasticity Test, H_0 hypothesis means that the series has constant variance. In cases where the prob. coefficient of the F-stat. is higher than 0.05 ($prob > 0.05$), the H0 hypothesis expressing constant variance cannot be rejected (Breusch & Pagan, 1979; 1289-1291). The probability value of Model 1's heteroscedasticity test F-statistic (Prob.F) is 0.2530. According to these results, H_0 is accepted. In other words, the series in Model 1 had a constant variance.

Regression Model Specification Error Test (Ramsey-RESET) was used to observe whether there was a specification error in ARDL (3, 3, 3, 1, 0, 1) Model 1. Results are in Table 9.

By using this test, it can be determined whether there is a specification error in a linear regression model. In the Ramsey-RESET test, it is investigated whether non-linear combinations of independent variables are sufficient to explain the dependent variable. In this test, if the prob. coefficient of the F-stat. is superior than 0.05 ($prob > 0.05$), this means the model specification is significant (Ramsey, 1969; 352-359). The probability value of the Ramsey-RESET test F-statistic for Model 1 is 0.8476. According to this result, the specification for ARDL (3, 3, 3, 1, 0, 1) Model 1. is significant.

Table 6. ARDL (3, 3, 3, 1, 0, 1) Model 1 Normality Test

Skewness	Kurtosis	Jarque-Bera	Prob.
0,157647	2,717045	0,912323	0,633371

Table 7. ARDL (3, 3, 3, 1, 0, 1) Model 1 Autocorrelation LM Test

Statistics	Results	Statistics	Results
F-statistic	0,93307	Prob. F(2,102)	0,39660
Obs*R-squared	2,17105	Prob. Chi-Square(2)	0,33770

Table 8. ARDL (3, 3, 3, 1, 0, 1) Model 1 Heteroscedasticity Test

F-statistic	1.2371	Prob. F(17,104)	0.2530
Obs*R-squared	19,3502	Prob. Chi-Square(17)	0,2509
Scaled explained SS	12,3054	Prob. Chi-Square(17)	0,7227

Table 9. ARDL (3, 3, 3, 1, 0, 1) Model 1 Ramsey-RESET Test

	Value	df	Probability
t-statistic	0,1926	104	0,8476
F-statistic	0,0371	(1, 104)	0,8476
Likelihood ratio	0,0435	1	0,8348

Cumulative Total Control Table (CUSUM) test was applied in ARDL (3, 3, 3, 1, 0, 1) Model 1. This test is used to determine whether the parameter estimates in the estimated model meet the stability condition. Test results show whether the parameter estimates are within 95% confidence limits (Page, 1954; 100-115). ARDL (3, 3, 3, 1, 0, 1) Model 1 CUSUM test results are given in Figure 1.

In Figure 1. it is observed that the parameter estimates in Model 1 were for confidence limits. Thus, it can be said that the parameter estimates in Model 1 are stable. Cumulative Total Control Table of Squares Test (CUSUMSQ) test was applied to support the fact the fact that the parameter estimates of ARDL (3, 3, 3, 1, 0, 1) Model 1 meet the stability conditions. Using the CUSUMQ test, it can be checked whether the squares of the parameter estimates in the model are within the confidence intervals (Lu et al., 2008; 236). The CUSUMSQ test results of the parameter estimates for Model 1 are shown in Figure 2.

According to the CUMUMQ test results, the squares of the parameter estimates in Model 1 are within the confidence limits.

ARDL (3, 3, 3, 1, 0, 1) Model 1 Bounds Test Results and Long-Term Forecast

The equation for long-term relationship prediction in the ARDL Bounds test is as follows.

$$Y_t = \alpha_0 + \sum_{i=1}^{m} a_{1i} Y_{t-1} + \sum_{i=0}^{m} a_{2i} M_{t-i} + \sum_{i=0}^{m} a_{3i} E_{t-i} + u_t \quad \textbf{(2)}$$

Y: The dependent variable, E and M: Independent variables

The F-statistic table is created using appropriate delays according to Equation 2. If the F-stat. coefficient is superior to the upper limit of the F table value, the H_0 null hypothesis is rejected. This means there is a long-term cointegration relationship between the series (Pesaran & Shin, 2001; 293). In addition, if the F-stat. coefficient is higher than the upper critical values of 10%, 5%, and 1%, there is a cointegration relationship between the series. Long Run from and Bond Test (F-Boundary Test) is applied for ARDL (3, 3, 3, 1, 0, 1) Model 1. The results are in Table 10.

According to the results in Table 10. the bounds test F-statistic for ARDL (3, 3, 3, 1, 0, 1) Model 1 is 9.825351. This coefficient is superior to the upper critical values: 3.50 for 10%, 4.015 for 5%, and 5.163 for 1%. According to this result, the H_0 hypothesis is rejected. This means there is a long-term cointegration relationship between the gold futures index return series (RGCM4) and global stock indices (LSPX, LGSPTSX, LGDAXI, LFTSE, LSTOXX) at levels of 1%, 5%, and 10%.

ARDL (3, 3, 3, 1, 0, 1) Model 1 Error Correction Model

For ARDL (3, 3, 3, 1, 0, 1) Model 1, the error correction coefficient was investigated by applying the ARDL Error Correction Regression test. The results of the test with constant and no trend for Model 1 are in Table 11.

In Table 11, the error correction coefficient of Model 1 is shown as CointEq(-1)*. It is important for the evaluation that this coefficient be negative and statistically significant ($Prob. < 0.05$). However, in order to determine the reliability of the probability values of t-statistics, a separate bounds test should be performed for t-statistic values. The results of the t-statistic bounds test of the error correction coefficient for Model 1 are given in Table 12.

Error correction coefficient: CointEq(-1) The absolute value of the t-stat. coefficient for the limit test must be higher than the upper critical value. Table 12. shows that the t-statistic of the error correction coefficient of Model 1 is -7.858712. This result is higher in absolute value than -3.86 for 10%, -4.19 for 5%, and -4.79 for 1%. Accordingly, the error correction coefficient CointEq(-1) of Model 1 is statistically significant. CointEq(-1) value of ARDL (3, 3, 3, 1, 0, 1) Model 1 is -1.1059. This coefficient ($1/-1.1059 = 0.9042$) means that if the balance is disrupted in the short term, the balance will be restored after 0.9042 months.

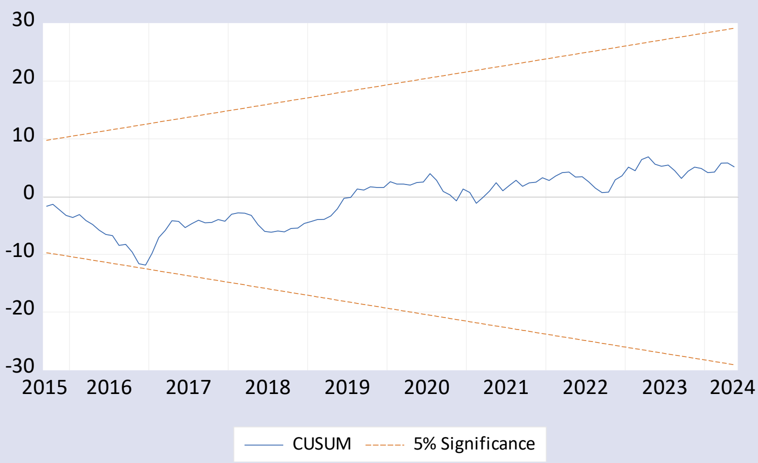

Figure 1. ARDL (3, 3, 3, 1, 0, 1) Model 1 CUSUM Test

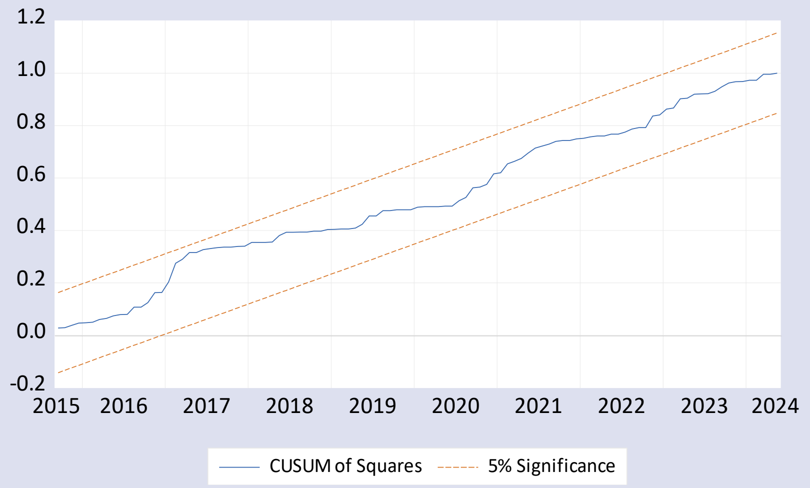

Figure 1. ARDL (3, 3, 3, 1, 0, 1) Model 1 CUSUMSQ Test

Table 10. ARDL (3, 3, 3, 1, 0, 1) Model 1 F-Bound Test Results

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	9,825351	10%	2,260	3,350
k	5	5%	2,620	3,790
		1%	3,410	4,680
			Finite Sample: n=80	
Actual Sample Size	122	10%	2,355	3,500
		5%	2,787	4,015
		1%	3,725	5,163

Table 11. ARDL (3, 3, 3, 1, 0, 1) Model 1 Error Correction Regression Testing

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0,1434	0,0183	7,8527	0,0000
D(RGCM4(-1))	0,0411	0,1100	0,3734	0,7096
D(RGCM4(-2))	0,1184	0,0753	1,5719	0,1190
D(LFTSE)	0,0247	0,0215	1,1448	0,2549
D(LFTSE(-1))	0,0176	0,0197	0,8926	0,3741
D(LFTSE(-2))	-0,0540	0,0204	-2,6460	0,0094
D(LGDAXI)	-0,0055	0,0352	-0,1577	0,8750
D(LGDAXI(-1))	-0,0094	0,0139	-0,6753	0,5010
D(LGDAXI(-2))	0,0440	0,0138	3,1793	0,0019
D(LGSPTSX)	0,0347	0,0213	1,6330	0,1055
D(LSTOXX)	-0,0501	0,0372	-1,3452	0,1815
CointEq(-1)*	-1,1059	0,1407	-7,8587	0,0000

Table 12. ARDL (3, 3, 3, 1, 0, 1) Model 1 Error Correction Coefficient t-statistic Boundary

Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-7,858712	10%	-2,570	-3,860
		5%	-2,860	-4,190
		2,50%	-3,130	-4,460
		1%	-3,430	-4,790

ARDL Model Estimate for Silver Futures Index Return Series and Global Stock Indices Series (Model 2)

Global silver futures index return series (RSIN4) is appointed as the dependent variable for the date range of January 2014 to May 2024. Selected global stock index series (LSPX, LGSPTSX, LGDAXI, LFTSE and LSTOXX) in the same period range were determined as independent variables. The ARDL test will be applied to investigate possible cointegration relationships between the series. For this purpose, the model, consisting of series of variables, is estimated. The estimated model is named Model 2. Specification tests for Model 2 were carried out, and then long-term relationships between the variables were researched. Finally, the error correction model was estimated, and the error correction coefficient was calculated. The values of the ARDL model estimation, where the silver futures index return series (RSIN4) is the dependent and the global stock index series (LSPX, LGSPTSX, LGDAXI, LFTSE and LSTOXX) are the independent variables, are in Table 13.

The ARDL model (Model 2), where the dependent variable is the silver futures return series (RGCM4) and the series of global stock indices (LSPX, LGSPTSX, LGDAXI, LFTSE and LSTOXX) is the independent variable, is estimated with lag length of 4. The model is estimated with the values of the series for the period between January 2014 and May 2024. The Akaike information criterion (AIC) was used as the model selection method. The significant model to be selected in Model 2 estimation is ARDL (4, 0, 3, 3, 0, 1) Model 2.

ARDL (4, 0, 3, 3, 0, 1) Model 2 Specification Tests

According to the estimated ARDL (4, 0, 3, 0, 1), Model 2 specification tests for Model 2 were carried out before examining the cointegration relationships in the long run between the series and estimating the error correction model.

In cases where the Skewness coefficient is between -2 and +2 and the Kurtosis is between +7 and -7, the residuals of the series are normally distributed (Byrne, 2010). In ARDL (4,0,3,3,0,1) Model 2 Jarque - Bera. normality test, skewness is 0.72804 and kurtosis is 4.34171. It is observed that the residuals of Model 1 had a normal distribution.

To search for an autocorrelation problem between the series in ARDL (4,0,3,3,0,1) Model 2, the Breusch-Godfrey Autocorrelation LM Test was applied, and the results are in Table 15.

The probability value of the ARDL (4,0,3,3,0,1) Model 2 F-statistic is 0.3347. According to this result, the Breusch-Godfrey Autocorrelation LM Test H0 hypothesis is accepted for Model 1. In this case, there is no autocorrelation problem between the RGCM4 and LSPX, LGSPTSX, LGDAXI, LFTSE, and LSTOXX series (Breusch, 1978; 336; Godfrey, 1978; 1978; 1296).

In ARDL (4,0,3,3,0,1) Model 2, the Breusch-Pagan-Godfrey Heteroscedasticity Test was used to observe whether the series were heteroskedastic, and Table 15. includes the coefficients.

The probability value of the ARDL (4,0,3,3,0,1) Model 2 heteroscedasticity test F-statistic (Prob.F) is 0.4393. According to this result, H_0 cannot be rejected. This means that the series in Model 2 had constant variance (Breusch & Pagan, 1979; 1289-1291).

Ramsey-RESET Test is applied to be performed to study a specification error in ARDL (4,0,3,3,0,1) Model 2. Table 17. includes the results.

The probability value of the Ramsey-RESET test F-statistic of ARDL (4,0,3,3,0,1) Model 2 is 0.6617. According to this result, ARDL (4,0,3,3,0,1) Model 2 has no specification error. (Ramsey, 1969; 352-359).

In ARDL (4,0,3,3,0,1) Model 2, the Cumulative Total Control Table (CUSUM) test was used to determine whether the parameter estimates met the stability condition. The results are in Figure 3.

Table 13. Estimating the ARDL Model (Model 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
RSIN4(-1)	-0,17907	0,09345	-1,91612	0,05810
RSIN4(-2)	-0,09272	0,09205	-1,00729	0,31610
RSIN4(-3)	-0,09486	0,08534	-1,11156	0,26890
RSIN4(-4)	-0,16026	0,08252	-1,94204	0,05480
LFTSE	0,04176	0,04603	0,90721	0,36640
LGDAXI	0,19020	0,17074	1,11395	0,26790
LGDAXI(-1)	-0,32087	0,19111	-1,67899	0,09620
LGDAXI(-2)	0,24437	0,09418	2,59486	0,01080
LGDAXI(-3)	-0,22061	0,06926	-3,18529	0,00190
LGSPTSX	0,26167	0,10861	2,40935	0,01770
LGSPTSX(-1)	-0,22618	0,12296	-1,83955	0,06870
LGSPTSX(-2)	-0,39942	0,12395	-3,22248	0,00170
LGSPTSX(-3)	0,20491	0,09701	2,11225	0,03710
LSPX	0,11413	0,04578	2,49316	0,01420
LSTOXX	-0,37257	0,17557	-2,12204	0,03620
LSTOXX(-1)	0,39920	0,17521	2,27844	0,02470
C	1,05424	0,37938	2,77888	0,00650

Table 14. Normality Test of Residuals of ARDL (4, 0, 3, 3, 0, 1) Model 2

Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
-2,31E-16	-0,00200	0,08193	-0,05479	0,02114	0,72804	4,34171

Table 15. ARDL (4, 0, 3, 3, 0, 1) Model 2 Autocorrelation LM Test

Obs*R-squared	F-statistic	Prob. F(2,102)	Prob. Chi-Square(2)
2,568921	1,106255	0,3347	0,2768

Table 16. ARDL (4, 0, 3, 3, 0, 1) Model 2 Heteroscedasticity Test

F-stat.	Obs*R2	Scaled explained	Prob. F	Prob. Chi-Sq(16)	Prob. Chi-Sq(16)
1.022899	16,45253	20,30799	0,4393	0,4218	0,2067

Table 17. ARDL(4, 0, 3, 3, 0, 1) Model 2Ramsey-REST Test

	Value	df	Probability
t-statistic	0,4388	103	0,6617
F-statistic	0,1925	(1, 103)	0,6617
Likelihood ratio	0,2260	1	0,6345

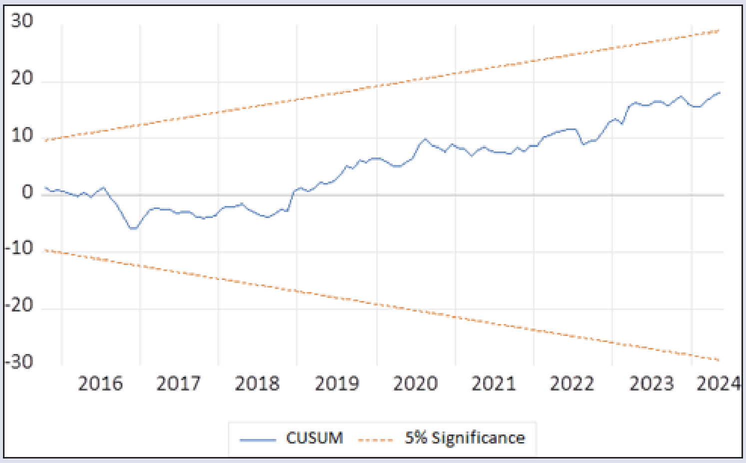

Figure 3. ARDL (4, 0, 3, 3, 0, 1) Model 2 CUSUM Test

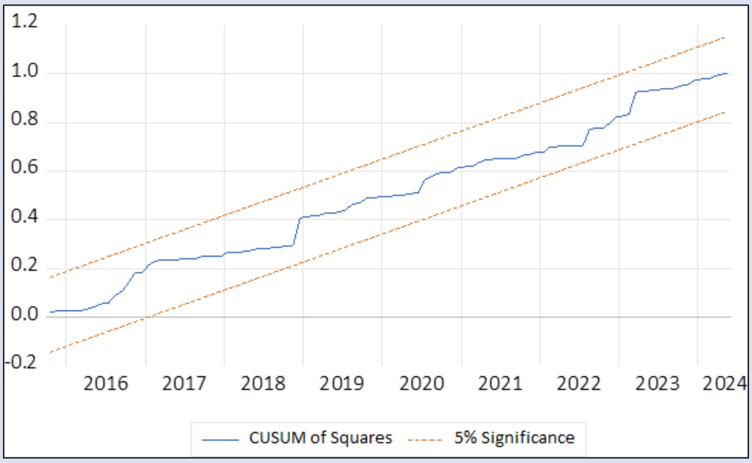

Figure 4. ARDL(4, 0, 3, 3, 0, 1) Model 2 CUSUMSQ Test

According to Figure 2., it was observed that the parameter estimates in Model 2 were for confidence limits. This means the parameter estimates in Model 2 are stable. The CUSUMQ test was applied to search on the squares of the parameter estimates of ARDL(4,0,3,3,0,1) Model 2 was within the confidence intervals, and the results are in Figure 4.

According to Figure 4., it is seen that the squares of the parameter estimates of Model 2 are within the confidence intervals.

ARDL (4, 0, 3, 3, 0, 1) Model 2 Bounds Test and long term forecast

For ARDL (4,0,3,3,0,1) Model 2, Long Run from and Bond Test was applied (F-Boundary Test) and the results are Table 18.

Table 18. ARDL(4, 0, 3, 3, 0, 1) Model 2 F-Bound Test Results

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	10,7604	10%	2,26	3,35
k	5,0	5%	2,62	3,79
		2,50%	2,96	4,18
		1%	3,41	4,68
Actual Sample Size	121		Finite Sample: n=80	
		10%	2,355	3,500
		5%	2,787	4,015
		1%	3,725	5,163

Table 19. ARDL(4, 0, 3, 3, 0, 1) Model 2 Error Correction Regression Test

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1,0542	0,1282	8,2255	0,0000
D(RSIN4(-1))	0,3478	0,1480	2,3507	0,0206
D(RSIN4(-2))	0,2551	0,1113	2,2926	0,0239
D(RSIN4(-3))	0,1603	0,0783	2,0462	0,0433
D(LGDAXI)	0,1902	0,1577	1,2057	0,2307
D(LGDAXI(-1))	-0,0238	0,0659	-0,3605	0,7192
D(LGDAXI(-2))	0,2206	0,0644	3,4260	0,0009
D(LGSPTSX)	0,2617	0,0905	2,8903	0,0047
D(LGSPTSX(-1))	0,1945	0,0959	2,0280	0,0451
D(LGSPTSX(-2))	-0,2049	0,0926	-2,2140	0,0290
D(LSTOXX)	-0,3726	0,1642	-2,2685	0,0254
CointEq(-1)*	-1,5269	0,1856	-8,2260	0,0000

Table 20. ARDL(4, 0, 3, 3, 0, 1) Model 2 Error Correction Coefficient T-Statistic Boundary

Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-8.225957	10%	-2,570	-3,860
		5%	-2,860	-4,190
		1%	-3,430	-4,790

According to the results in Table 18; ARDL (4,0,3,3,0,1) Model 2 bounds test F-statistic is 10.7604. This value is the upper critical value; it is greater than 3.50 for 10%, 4.015 for 5%, and 5.163 for 1%. According to this result, the H_0 null hypothesis is rejected. This means there is a long-term cointegration relationship between the silver futures index return series (RSIN4) and global stock indices (LSPX, LGSPTSX, LGDAXI, LFTSE, LSTOXX) at levels of 1%, 5%, and 10%.

ARDL (4, 0, 3, 3, 0, 1) Model 2 Error Correction Model

The error correction coefficient was investigated by applying the ARDL Error Correction Regression test for ARDL (4,0,3,3,0,1) Model 2. The results of the error correction regression test for Model 2 with a constant and no trend are given in Table 18.

In Table 19, the error correction coefficient of Model 2 is shown as CointEq(-1)*. It is important that this value is minus and statistically significant ($Prob. < 0.05$). However, in order to determine the reliability of the probability values of t-statistics, a separate bounds test should be performed for t-statistic values. The results of the t-statistic bounds test of the error correction coefficient for Model 2 are shown in Table 20.

The error correction coefficient CointEq(-1) t-statistic value must be greater than 10%, 5%, or 1% of the of the upper critical value in absolute value for the limit test. In Table 20, the t-statistic of the ARDL (4,0,3,3,0,1) Model 2 error correction coefficient is -8.225957. This is superior in absolute value to -3.86 for 10%, -4.19 for 5%, and -4.79 for 1% upper critical values. It is observed that the coefficient CointEq(-1) of (4,0,3,3,0,1) Model 2 is statistically significant. ARDL (4,0,3,3,0,1) Model 2 CointEq(-1) value is -1.5269. This coefficient means that if the balance is disrupted in the short term, the balance will be restored after 0.6549 months ($1/-1.5269 = 0.6549$).

According to the results obtained from the findings of the study, it has been concluded that there is a long-term cointegration relationship between Gold and Silver Futures returns and selected global stock market indices. Zapata et al. (2023) that there is a long-term cointegration relationship between commodity markets and stock markets. Enilov et al. (2021) are similar to their results that there is a Granger causality relationship between global commodity returns and national stock prices. Additionally, according to Barunik et al.

(2016), the determination of the cointegration relationship between gold, silver, and oil futures returns and stock return asset pairs is parallel to the results of the study. However, Bahardaj & Dunsby (2013) found that the relationship between price movements of global stocks and changes in commodity prices was close to zero, which differs from the results obtained from this study.

Conclusions

Globalization has accelerated with technological developments in recent years. This causes the integration and interdependence of economic and financial business processes to increase over time. Negative developments such as economic crises, epidemics, uncontrolled migrations, and wars cause deepening uncertainty and a rise in the level of systematic risk around the world. In the face of these, macro-economic indicators such as production levels, investment tendencies, inflation, unemployment, interest rates, and exchange rate instabilities are negatively affected, especially in developing economies.

There is a widespread perception that commodity assets are less affected by negative developments than other financial assets. In periods of increased global financial uncertainty, personal and institutional investors turn to regional financial markets and prefer commodity assets in their investment portfolios to avoid risk. In addition, the significant increase in cryptocurrency investments in recent years has caused a significant amount of savings to shift from financial markets to crypto assets. The volumetric weakening of global financial markets is among the reasons why they have become more sensitive and fragile to negative developments. For these reasons, commodity investments, which are seen as reliable investment areas in periods when uncertainty increases and the depth of risk increases, may be increasing in volume. If this result is associated with the CAPM model, it can be said that the markets in which the selected assets are traded are at a similar efficiency level. This may indicate that information in these markets affects asset prices at levels close to them. In addition, it can be considered that arbitrage opportunities are limited in the markets where selected assets are traded. In this case, the systematic risk levels of portfolios consisting of selected assets can be reduced by diversification.

This study focuses on analyzing the cointegration relationship between global gold and silver futures, selecting developed stock markets from the United States, Canada, the United Kingdom, Germany, and the European Union region. It has been detected that the index returns of selected market indices and gold and silver futures are significantly cointegrated in the long term. In addition, in the event of a breakdown in the balance between selected stock indices and commodity futures index returns, they can be balanced in less than a month. This shows that the balancing mechanism between global stock markets and gold and silver futures still exists. However, financial markets becoming more frequent, economic and financial crises occurring more frequently than in previous years, and their effects deepening may cause this cointegration relationship to change in the near future. In addition, technological developments and the proliferation of innovative assets such as cryptocurrencies and digital tokens may cause global financial markets to become more sensitive to negative developments. In recent years, especially during economic and financial crises periods, the level of trust in regulatory and supervisory elements has decreased significantly around the world. During these periods, savers started to look for new investment areas. It is still unclear whether it is a coincidence that cryptocurrencies emerged during the same period. In this context, examining the possible relationship between crypto asset investments and commodity investments during periods of global social and financial crisis will make a significant contribution to the literature.

Katkı Oranları ve Çıkar Çatışması / Contribution Rates and Conflicts of Interest

Etik Beyan	Bu çalışmanın hazırlanma sürecinde bilimsel ve etik ilkelere uyulduğu ve yararlanılan tüm çalışmaların kaynakçada belirtildiği beyan olunur.	**Ethical Statement**	It is declared that scientific and ethical principles have been followed while carrying out and writing this study and that all the sources used have been properly cited
Yazar Katkıları	Çalışmanın Tasarlanması: OK (%100) Veri Toplanması: OK (%100) Veri Analizi: OK (%100) Makalenin Yazımı: OK (%100) Makale Gönderimi ve Revizyonu: OK (%100)	**Author Contributions**	Research Design: OK (%100) Data Collection: OK (%100) Data Analysis: OK (%100) Writing the Article: OK (%100) Article Submission and Revision: OK (%100)
Etik Bildirim	iibfdergi@cumhuriyet.edu.tr	**Complaints**	iibfdergi@cumhuriyet.edu.tr
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Telif Hakkı & Lisans	Yazarlar dergide yayınlanan çalışmalarının telif hakkına sahiptirler ve çalışmaları **CC BY-NC 4.0** lisansı altında yayımlanmaktadır.	**Copyright & License**	Authors publishing with the journal retain the copyright to their work licensed under the **CC BY-NC 4.0**
Etik Kurul	Etik kurul iznine ihtiyaç bulunmamaktadır	**Ethics Committee**	Ethics committee approval is not required.

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