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Are Precious Metals Hedge Against Financial and Economic Variables?: Evidence from Cointegration Tests

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Abstract

This paper investigates the long run hedging ability of precious metals against the risks associated with adverse conditions of economic and financial variables for Pakistan, the USA, China, and India. Monthly data of gold, silver, platinum, stock returns, exchange rate, industrial production, and inflation was collected for the selected economies. Saikkonen and Lutkepohl (2002) unit root test was employed to access the unit root properties of the data series and identify the break dates. Furthermore, this study used the Johansen cointegration test with and without structural breaks to identify the long-run relationship between metals prices and different financial and economic variables. The findings suggest that the time series under study have unit root problem at level with and without structural breaks. Without considering structural breaks, the Johansen trace test indicates that in Pakistan and China, gold, silver, and platinum hold a cointegrating relationship with macroeconomic and financial variables. For the US, gold indicates cointegration which supports the hedging ability of gold against inflation, stock, and industrial production in the long run. The results of the cointegration test after incorporating the structural breaks provide even stronger evidence of the long-run relationship of precious metals and consumer prices, exchange rate, and stock prices.

Keywords: Co-Integration, Structural Breaks, Hedging, Precious Metals, Unit Root

JEL Classification Code: G15, G11, G12, E31

1. Introduction

Long-term investors are more interested in maintaining the purchasing power of their investment funds. In time series literature, cointegration analysis is used to investigate the long-run steady-state relationship between or among economic variables. If cointegration is found, the vector error correction models are used to model the short-run changes and simultaneously model deviation from the long-run equilibrium (Lee & Brahmasrene, 2019). Investors hold gold as a hedge against any economic, political, or currency crises and for diversification and financial arbitrage as traditional physical assets. Unlike financial assets, gold is considered the best way to hedge adverse economic conditions e.g. inflation and recession. Thus, long-term investors who want to safeguard their financial wealth against the deteriorating purchasing power of money and maintain the real value of their savings can protect themselves by holding precious metals, especially, gold. The precious metals are also found to protect investors against adverse conditions of stock markets since it is expected that any losses incurred in stock investment will be compensated by gains in precious metals prices. Precious metals also appear to provide a long-run hedge against weakening local currency.

Nowadays precious metals can be used as one of the sophisticated and alternative investment tools. Zhang and Wei (2010) emphasize that among other commodities, gold outperforms in terms of providing benefits to investors and carries a high status. The demand for gold as a physical asset is increasing and investors realize its importance due to its strong hedging ability against inflation as shown by Iqbal (2017) for the developed economies like the USA. Tung (2019) revealed that China and India are among the top ten countries of the world with the highest demand for gold in 2015. Ampomah, Gounopoulos & Mazouz (2014) underline the importance of precious metals against exchange rate risk; however, they found that industrial metals tend to outperform gold as hedging

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vehicles and safe-haven assets against losses in sovereign bonds but the economic shocks show some different attitudes toward gold. The unusual conditions like economic turmoil or global financial crisis appeal to researchers to specify hedging capabilities. Since the prices of precious metals are market-determined, after the collapse of the Bretton wood system in 1973, people are more likely to purchase gold and hold it for investment purposes. Inflation is also considered an important macroeconomic variable as it highlights the increase in prices of different commodities which eventually decreases the purchasing power of a common man (Wulandari et al., 2019).

The metal market is also gaining popularity for investment due to the unusual happenings that takes place in the form of economic turmoil, currency crisis, stock market crashes, etc. Therefore, to test the hedging ability of metals against financial and macroeconomic variables, sudden jerks must be incorporated. Using linear and nonlinear statistical methods, this study aims to identify whether precious metals possess a long-run relationship with the macroeconomic and financial variables. This study provides various contributions to existing research on the relationship between metal prices and stocks, exchange rate risk, inflation, and industrial production for developing and developed economies. Traditional cointegration techniques failed to confirm the presence of a long-run relationship between metal prices and stocks, exchange rate risk, inflation, and industrial production. The relationship between precious metals and financial and economic variables is expected to be nonlinear; these nonlinearities may occur due to the external events that take place globally. Although the prices of precious metals are designated into dollars, their fall and rise may leave marks on different economies. In the investigation of such events and to identify the reasons behind these events, it is very necessary to model the variables. The incorrect modeling of variables may affect the power of the statistical test. Thus, the selection of an appropriate statistical tool is a big task.

In this study, we applied both linear and nonlinear testing procedures to identify the relationship between variables under study. First, we consider the developments concerning the unit root properties revealed by Perron (1989) to test breaks exogenously by taking the unknown break dates in the series. The primary literature highlighting these features comprises the study of Christiano (1992) and Zivot and Andrews (1992). In the latest study of Maddala and Kim (1998), new direction towards the assessment of breaks in the nonlinear framework is proposed. Furthermore, developments by Saikkonen and Lutkepohl (2000) provides the framework to test breaks in a nonlinear way. Second, the cointegration test allowing for a structural break proposed by Johansen, Mosconi, and Nielsen (2000) is employed. This test is important to implement as it allows structural breaks in the series and provides evidence of the long-run relationship between precious metals and macroeconomic variables.

2. Literature Review

The emergence of time series modeling has brought a revolution in econometric research. Specifically, when time series possess unit root properties, the significance of econometric models get enhanced. Research on the unit root properties of macroeconomic variables underwent renewed interest following the seminal work by Nelson and Plosser (1982). However, the findings were challenged by Perron (1989) who argued that most macroeconomic series are not characterized by unit root rather persistence arises only from large and infrequent shocks and that the economy returns to a deterministic trend after small and frequent shocks. According to Perron (1989), most macroeconomic time series are not characterized by the presence of a unit root. This argument brought innovations that insist researchers test for a structural break of unknown timing, estimate the timing of a structural break, and test to distinguish unit-roots from broken time trends. Hansen (2001) considered that innovations have dramatically altered the face of applied time series econometrics.

Previous precious metal studies have considered a linear framework to access long-run and short-run dynamics after examining the unit root properties. Worthington and Pahlavani (2007) test the inflation hedging ability of gold for the USA. They use monthly time series and split it into two eras spanning from 1945 to 2006 and from 1973 to 2006. The main objective of their study was to test the long-run relationship between gold and the consumer price index of the USA incorporating the structural breaks in the series. They investigated the break dates through the unit root test proposed by Zivot and Andrews (1992) and cointegration is accessed through the nonlinear cointegration test proposed by Saikkonen and Lutkepohl (2000, a, b, c). The study reveals the relationship between gold and inflation; thus, they concluded that gold is a good hedge against inflation in the USA. However, the study is limited to the developed economy while this study bridges this gap by taking developing countries in the analysis. Moreover, Wang, Lee, and Thi (2011) determined the short-run and long-run inflation hedging effectiveness of gold for developed countries such as the USA and Japan by utilizing monthly data from January 1971 till January 2010.

Engle and Granger (1987) employed the linear cointegration test and non-linear threshold cointegration test to accomplish their objectives. The authors suggested investors not to hold gold in their portfolios for a long time as the inflation hedging ability of gold is not effective for all markets at any time. Similarly, gold is not fully a hedge against inflation in the short-run for the Japanese market. Beckmann and Czudaj (2013) examined four developed economies - the UK, the USA, Europe, and Japan. This study covered the period from December 1969 to December 2011.

They applied the Markov-Switching Error Correction Model (MS-VECM) to assess the relationship between the price of gold, CPI, and PPI. The study found that gold can partially hedge inflation in the long-run, especially for the US and the UK as compared to Japan and Europe. The deterministic trend is present in prices of gold, CPI, and PPI; thus, they considered the two trends specification for each model. The first configuration had a restricted trend and the second set had an unrestricted constant in the cointegration space. Moreover, they used the Johansen cointegration approach to estimate the cointegration relationship and found that the gold price is not significant although they considered the time-varying coefficients for gold prices which revealed that gold is partially able to hedge future inflation in the long-run for the US and the UK as compared to Japan and Europe. They estimated the MS-VECM model for each setting and established the cointegration relations with a restricted trend for those countries whose trend is significant (the USA and Europe) and used the unrestricted constant for insignificant trends (Japan and the UK). The transition probabilities were highly significant for the four countries; thus, regimes are generally persistent in each case and concluded that gold can effectively be used to hedge against inflation.

Considering only gold as a precious metal, Michis (2014) examined the benefits of gold by adding it to the portfolio consisting of gold, bonds, and short-term treasury bills. Monthly data of the USA, the UK, and Germany was taken from September 1991 till December 2012. Using the wavelet analysis, the author concluded that investors can reap the benefits of gold in the long-run as it effectively reduces the variance of the portfolio. Eight different time scales were estimated for the equally weighted portfolios, and the study suggested that investors should not adopt the short-term strategies as gold outperforms in the long run. Shahbaz et al. (2014) used time-series data on gold prices, economic growth, and inflation for the period of 1997Q1–2011Q4. They applied the ARDL bounds testing approach to cointegration for the long-run, and the innovative accounting approach (IAA) to examine the direction of causality in variables. Their findings revealed that investment in gold is a good hedge against inflation not only in the long-run but also in the short-run. Bredin, Conlon, and Pot (2015) examined the hedge and safe-haven properties with a short and long-run horizon of gold against the traditional assets of stocks and bonds for the US, the UK, and Germany from January 1, 1980, till December 31, 2013. Using the wavelet multi-scale analysis, low correspondence between gold, stocks, and bonds was observed. The authors concluded that gold can act as a safe-haven asset for a long horizon of up to one year while it can serve as a short-run hedge for stocks and bonds.

Choudhry, Hassan, and Shabi (2015) studied the non-linear behavior of gold and stock markets of the USA, the UK, and Japan. A bivariate non-linear causality test was employed to examine the relationship between stock market returns and volatility with gold returns. They divided the total sample period into two sub-periods. The first period was considered as pre-financial crisis period taken from January 2000 to June 2007, and the second period was named as financial crisis period spanning from July 2007 till March 2014. By adding the three-month interest rates i.e. (LIBOR), the authors applied a non-linear granger causality test for multivariate causality testing. The result indicated that for the pre-financial crisis period, causality is significant only from gold to stock for the USA and from stock to gold for the UK respectively. Similarly, there is no evidence of bi-directional causality for the three markets studied. Moreover, for the crisis period, bi-directional causality was evident only at a 1% level of significance. Thus, the non-linear causality test showed that gold cannot serve as a safe-haven during the global financial crisis, while it can serve as a hedge during the crisis. Multivariate test also showed that gold does not play the role of a safe-haven asset for the USA and the UK during the global financial crisis and limited causality was observed between stocks, gold, and LIBOR rates.

3. Methodology

3.1. Unit Root Test

The pre-testing for unit root is essential to analyze the existence of a cointegration relationship among variables. The stationarity of variables at the same order of integration is necessary for the application of the cointegration tests. The recent developments of the unit root test procedure resulted in investigating the unit root properties of the series by allowing structural breaks. In this study, we applied both testing procedures to analyze the variables i.e. with and without structural breaks. To check the stationarity of the series, several statistical tests have been developed. The most common methods of testing procedure are the Augmented Dickey-Fuller tests (Dickey & Fuller, 1979, 1981) and Phillips-Perron test (1988), and Perron test (1988).

The following ADF test model allows testing the null hypothesis that series contains a unit root (α=0) against an alternative that series is stationary (α<0).

$$\Delta \boldsymbol{x}_t = \boldsymbol{\alpha} \boldsymbol{x}_{t-1} + \sum_{i=1}^{k} \boldsymbol{\beta}_i \Delta \boldsymbol{x}_{t-1} + \boldsymbol{\epsilon}_t \quad (1)$$

Where Δ shows the first difference, ***xt*** is the series needs to be tested, t time trend and k are the optimal numbers of lags which may be chosen according to some model selection criteria.

Phillips and Perron (1988) and Perron (1988) have developed a non-parametric testing procedure similar to the ADF test but allowing the correction to the ADF test by incorporating the auto-correlated residuals in the model. Since the pioneering work of Perron (1989, 1990) structural breaks gain importance in the literature of economics. In unit root and co-integration analysis, the results will mislead by ignoring such structural breaks. The voluminous literature has been documented on testing unit root and co-integration testing procedure by incorporating such breaks. For this purpose, various tests have been proposed which help to reduce the bias in the conventional unit root tests by determining the time of the structural shift. Structural breaks can be due to some exogenous shocks that have occurred at a known date as explained by Perron (1989, 1990), Saikkonen and Lutkepohl (2002), and Lutkepohl, Muller, and Saikkonen (2001). Similarly, break dates can be modeled endogenously through the Zivot and Andrews (1992) testing procedures.

The Zivot and Andrews (1992) test proposed a sequential procedure to endogenously determine the break points in the series. It proceeds to test the unit root with a drift that eliminates the structural shift against an alternative series which is stationary with the following three specifications of regression models namely Model A, allows a one-time structural break in the intercept of the series; Model B, allows a one-time structural break in the trend of the series, and Model C, allows a one-time structural break in both the trend and intercept.

$$\Delta x_t = \alpha + \rho x_{t-1} + \mu t + \theta du_t + \sum\nolimits_{p=1}^{i} D_p \Delta x_{t-p} + \mu_t \quad \text{Model A} \quad (2)$$

$$\Delta x_t = \alpha + \rho x_{t-1} + \mu t + \delta dT_t + \sum\nolimits_{p=1}^{i} D_p \Delta x_{t-p} + \mu_t \quad \text{Model B} \quad (3)$$

$$\Delta x_t = \alpha + \rho x_{t-1} + \mu t + \delta du_t + \varphi dT_t + \sum\nolimits_{p=1}^{i} D_p \Delta x_{t-p} + \mu_t \quad \text{Model C} \quad (4)$$

Where du_t indicates a dummy variable created for a mean shift obtaining at break dates of the series and takes value 1 if t is greater than the corresponding break date and 0 elsewhere. $\mathbf{dT}_t$ shows the trend shift variable.

This study also applied the results of Saikkonen and Lutkepohl (2002) and Lanne, Lutkepohl, and Saikkonen (2002) to study the unit root properties and identify the possible break dates for the time series under study. In this test Saikkonen and Lutkepohl (2002) and Lanne, Lutkepohl and Saikkonen (2002) assumed that the shift in the series is deterministic in general in a nonlinear form, therefore, incorporating the shift function to the deterministic term and testing the following model for testing the properties of the unit root;

$$x_t = \alpha_0 + \alpha_1 t + f_t(\varphi)'\beta + \mu_t \quad (5)$$

Where φ and β are unknown parameters, μ_t are errors resulting from an AR (p) process and $f_t(\varphi)'\beta$ shows the shift function based on the three provided specifications;

$$f_t^{(1)}(\varphi) = \begin{cases} 0, & t < T_B \\ 1, & t \geq T_B \end{cases} \quad (6)$$

$$f_t^{(2)}(\varphi) = \begin{cases} 0, & t < T_B \\ 1 - \exp\{-\varphi(t - T_B + 1)\}, & t \geq T_B \end{cases} \quad (7)$$

$$f_t^{(3)}(\varphi) = \left[\frac{D_{1,t}}{1-\varphi L} : \frac{D_{1,t-1}}{1-\varphi L} \right] \quad (8)$$

Equation 3 shows the simple shift dummy variable having a shift date $\mathbf{T}_B$. Equation 4 is the second specification for shift function allowing the nonlinear gradual shift to a new level starting at a time $\mathbf{T}_B$ and based on the exponential distribution function. The rational function in the lag operator practiced shifting dummy D_{1t} as explained by equation 5.

3.2. Cointegration Tests

Engle and Granger (1987) proposed the most important development in time series econometrics for testing the cointegration relationships between the non-stationary variables. They defined that the two non-stationary variables at the level may be cointegrated if their linear combination produces a variable lower order of integration. The two common approaches to test the cointegrating relation are Engle-Granger two-step methods (Engle & Granger, 1987) and the Johansen procedure (Johansen, 1988, 1991: Johansen & Juselius, 1990). The power of these tests may be distorted due to the presence of breaks and structural shifts that are exhibited in many economic time series. Thus, various tests of cointegration in a single equation and a system's context have been developed.

Under the Johansen system, there are two test statistics for testing the cointegration in bivariate and multivariate framework namely, the trace test and the maximum eigen-value test. The trace test allows testing that the number of cointegrating vectors less than or equal to k against an alternative that there is a greater than k cointegration relationship. The maximum eigen-value test that the number of cointegrating vectors is k versus an alternative of k+1 cointegration relationship. Johansen, Mosconi, and Nielsen (2000) extended the cointegration test developed by Johansen (1995). They proposed the cointegration analysis in the presence of structural breaks in the deterministic trend. They developed a cointegration model with known break points by dealing with three types of shifts occurring in the series initially considered by Perron (1989, 1990). The first shift occurs in the level of the process, the second occurs in the change of the trend slope, and the third occurs where both shifts occur. Johansen, Mosconi, and Nielsen (2000) developed a likelihood ratio test for the cointegrating rank and considered the three-shift cases in a Gaussian vector autoregressive framework. We considered this test for the unknown break date and the dates were identified by the Saikkonen and Lutkepohl (2002) unit root test.

4. Estimation results

This section explains the estimation results obtained by the methods explained in the previous sections.

4.1. Data Description and Summary of Statistics

We collected monthly data on precious metals i.e. gold, silver, and platinum prices designated in US Dollar. Monthly stock prices, consumer price index, exchange rate, and industrial production have been taken for the selected countries - Pakistan, USA, India, and China. The time span for the selected variables are considered according to the availability of the data i.e. for Pakistan the time spans from January 1994 to December 2014; for the USA, the time spans from January 1990 till December 2014; for India, the time spans from June 2005 to December 2014; and for China, the time spans from January 1992 till December 2014. For the stock market index, we use the S&P500 index, Shanghai A-share Index, Pakistan stock exchange (formerly known as Karachi stock exchange), and Bombay Stock exchange for the USA, China, Pakistan, and India respectively. All the variables are considered in logarithmic form.

Table 1 reports the summary statistics of the monthly data of the first difference of the log of precious metal prices, consumer price index, stock market index, and industrial production for the selected countries. The table contains the name of the country, the name of variables, the number of observations, the mean, the median, the standard deviation, the minimum and the maximum of the daily returns. The average log return of the stock market of the developed economy i.e. the US is lower than the emerging markets of China, Pakistan, and India respectively. The standard deviation of China is higher as compared to other countries, indicating that the equity market of China is at greater risk. The average economic growth of India is more than the average economic growth of Pakistan.

Table 1: Summary statistics of log returns in the US, China, Pakistan, and India.

Countries	Variables	Obs	Mean	Median	Standard Deviation	Minimum	Maximum
US	Gold	300	0.162	0.074	1.930	-6.255	8.187
	Silver	300	0.160	-0.198	3.555	-14.008	11.002
	Platinum	300	0.136	0.191	2.684	-14.205	9.298
	Inflation	300	0.088	0.085	0.145	-0.839	0.527
	Industrial Production	300	0.074	0.090	0.280	-1.911	0.881
	S & P 500 Index	300	0.265	0.477	1.839	-8.062	4.594
China	Gold	267	0.195	0.074	1.971	-6.256	8.188
	Silver	267	0.210	-0.113	3.644	-14.009	11.002
	Platinum	267	0.203	0.199	2.734	-14.206	9.298
	Inflation	267	-0.006	0.000	0.310	-1.133	0.886
	Industrial Production	267	-0.004	0.000	1.575	-9.167	7.116
	Shanghai A-Share Index	267	0.367	0.135	4.645	-15.100	28.956
Pakistan	Gold	252	0.195	0.056	2.013	-6.256	8.188
	Silver	252	0.199	-0.068	3.681	-14.009	11.002
	Platinum	252	0.195	0.196	2.804	-14.206	9.298
	Inflation	252	0.294	0.254	0.329	-0.578	1.426
	Industrial Production	252	0.117	-0.278	4.278	-12.226	15.340
	PSE 100 Index	252	0.459	0.891	3.870	-18.233	11.174
India	Gold	117	0.389	0.374	2.403	-6.256	5.838
	Silver	117	0.305	0.129	4.473	-14.009	11.002
	Platinum	117	0.128	0.247	3.375	-14.206	9.298
	Inflation	117	0.301	0.300	0.292	-0.508	1.943
	Industrial Production	117	0.219	0.407	2.703	-7.361	6.047
	BSE	117	0.546	0.488	3.268	-13.057	11.824

4.2. Unit Root Properties

The assessment of unit root properties of precious metals, industrial production, inflation, and stock index for the US, China, Pakistan, and India have been carried out through ADF and Phillips-Perron (PP) tests. From Table 2, results of ADF and PP test are reported for Pakistan, the US, China, and India respectively. All the variables for Pakistan and the US get stationary at the first difference. Results reveal that all variables are non-stationary at the level and become stationary at the first difference. Results of the unit root test for China show that at level gold, silver, and platinum prices along with macro variables are non-stationary, while at the first difference all these variables get stationary. While the PP test reveals that except for industrial production of China all variables become stationary at the first difference. The results of India indicate that all the variables are integrated of order 1.

To test the stationarity of selected variables in the presence of structural breaks, the Saikkonen and Lutkepohl (2002) unit root test was applied. Due to the space constraint, Table 3 only reports the results of the Saikkonen and Lutkepohl (2002) unit root test at the first difference for the selected economies. For Pakistan, gold and silver are found stationary at the first difference for three-shift functions. Platinum gets stationary at the first difference only when a simple shift dummy is included in the model. All the variables for the US except platinum are non-stationary at levels for three-shift functions while at the first difference variables get stationary. For China, gold, silver, platinum, inflation, stock, and exchange rate are non-stationary at the level for three-shift functions and become stationary at the first difference. Industrial production shows different behavior as it is already stationary at the level for all three-shift functions. Except for platinum, all variables get stationary at the first difference in the Indian case.

Table 2: Conventional Unit Root Tests

		ADF		PP test	
Variable	**Countries**	**Level**	**first difference**	**Level**	**first difference**
		T-Statistic	**T-Statistic**	**T-Statistic**	**T-Statistic**
lgold	Pakistan	-0.063(0.950)	-17.626(0.000)**	-0.063(0.950)	-17.698(0.000)**
lsilver		-1.016(0.747)	-16.967(0.000)**	-0.949(0.771)	-17.016(0.000)**
lplatinum		-1.134(0.702)	-14.207(0.000)**	-1.218(0.667)	-14.202(0.000)**
lcpi		0.278(0.976)	-5.960(0.000)**	0.275(0.976)	-13.580(0.000)**
ler		-1.392(0.586)	-12.668(0.000)**	-1.381(0.591)	-12.791(0.000)**
lip		-0.356(0.912)	-7.834(0.000)**	-1.451(0.556)	-19.309(0.000)**
lstock		0.413(0.983)	-15.216(0.000)**	0.388(0.982)	-15.213(0.000)**
lgold	USA	0.056 (0.961)	-18.834(0.000)**	0.198(0.972)	-18.898(0.000)**
lsilver		-0.892(0.789)	-13.712(0.000)**	-0.790(0.819)	-18.585(0.000)**
lplatinum		-0.852(0.802)	-15.710(0.000)**	-0.910(0.784)	-15.720(0.000)**
lcpi		-1.939(0.313)	-10.912(0.000)**	-2.667(0.081)	-8.911(0.000)**
lip		-1.490(0.537)	-4.557(0.000)**	-1.568(0.497)	-15.846(0.000)**
lstock		-1.358(0.602)	-16.157(0.000)**	-1.377(0.593)	-16.220(0.000)**
lgold	China	-0.077(0.949)	-18.144(0.000)**	0.045(0.960)	-18.197(0.000)**
lsilver		-1.072(0.727)	-17.798(0.000)**	-0.990(0.757)	-17.872(0.000)**
lplatinum		-1.180(0.683)	-14.976(0.000)**	-1.248(0.653)	-14.938(0.000)**
lcpi		-1.858(0.351)	-5.8342(0.000)**	-1.824(0.368)	-13.656(0.000)**
ler		-2.009(0.282)	-16.153(0.000)**	-2.039(0.269)	16.154(0.000)**
lip		-2.648(0.084)	-14.692(0.000)**	-10.008(0.000)	-37.509(0.000)**
lstock		-3.009(0.035)	-11.989(0.000)**	-2.971(0.038)	-11.366(0.000)**
lgold	India	-2.206(0.205)	-11.870(0.000)**	-2.323(0.166)	-11.906(0.000)**
lsilver		-2.135(0.231)	-10.786(0.000)**	-2.126(0.234)	-10.793(0.000)**
lplatinum		-2.846(0.055)	-8.880(0.000)**	-2.690(0.078)	-8.901(0.000)**
lcpi		0.360(0.980)	-9.247(0.000)**	0.299(0.977)	-9.244(0.000)**
ler		-0.557(0.874)	-7.568(0.000)**	-0.199(0.934)	-7.496(0.000)**
lip		-3.157(0.025)	-1.851(0.354)	-2.762(0.066)	-24.430(0.000)**
lstock		-2.235(0.195)	-9.456(0.000)**	-2.307(0.171)	-9.516(0.000)**

Notes: lgold, lsilver, lplatinum represents the log of gold, silver, and platinum prices while,lcpi, ler, lip, and lstock represents the log of the consumer price index, exchange rate, industrial production, and stock index. The maximum lag period is 15 and the appropriate lag lengths are selected by using SIC in the ADF test. For the PP test, the bandwidth was determined by using the Newey-West correction. The values in parentheses are the p values from MacKinnon (1996). ** shows the significance at 5%level of significance.

Table 3: Results of Saikkonen and Lutkepohl (2002) Unit Root Test for Pakistan, the US, China and India

Variable	Country	Break Dates	Test Statistic		
			$f_t^1\gamma$	$f_t^2(\theta)\gamma$	$f_t^3(\theta)^2\gamma$
lgold	Pakistan	2008 M12	-3.514***	-3.567*	-4.910*
	USA	2008 M12	-3.943**	-3.977**	-5.495**
	China	2008 M12	-3.814**	-3.856**	-5.374**
	India	2009 M1	-3.294**	-3.427**	-4.451**
lsilver	Pakistan	2011 M5	-4.933*	-4.864*	-6.797*
	USA	2011 M5	-3.682**	NA	-5.668**
	China	2011 M5	-4.961**	-4.916**	-6.969**
	India	2011 M6	-3.893**	-3.837**	-5.307**
lplatinum	Pakistan	2008 M12	-2.881***	-2.716	-2.584
	USA	2008 M12	-1.6255	-1.4716	-5.398**
	China	2008 M12	-3.082***	-2.865**	-2.646
	India	2009 M1	-2.414	-2.424	-2.29
lcpi	Pakistan	2008 M3	-4.087*	-4.179*	-3.847***
	USA	2008 M8	-3.685**	-2.880**	-2.932**
	China	1994 M3	-4.997**	-5.066**	-7.075**
	India	2010 M3	-2.913***	-2.888***	-4.418**
lstock	Pakistan	2009 M2	-4.049*	-3.925*	-3.778*
	USA	2009 M3	-4.446**	-4.385**	-6.431**
	China	1992 M12	-3.5446 ***	-3.492**	-8.498**
	India	2009 M1	-3.820**	-3.736**	-3.684**
ler	Pakistan	2000 M10	-4.286*	-4.249*	-5.815*
	USA	NA	NA	NA	NA
	China	1994 M2	-1.7381	-1.7193	-5.7640 **
	India	2008 M12	-3.878**	-3.833**	-4.401**
lip	Pakistan	2000 M1	-4.371*	-4.364*	-7.116*
	USA	2009 M7	-4.326**	-4.323**	-5.205**
	China	1994 M1	-5.044**	-5.216**	-10.855**
	India	2009 M4	-4.570**	-4.622**	-6.489**

Note: lgold, lsilver, lplatinum represents the log of gold, silver, and platinum prices while,lcpi, ler, lip, and lstock represents the log of the consumer price index, exchange rate, industrial production, and stock index. *, **, *** shows significance with critical values from Lanne et.al (2002) for 1%, 5% and 10% are-3.55,-3.03 and -2.76 respectively. All results are at first difference.

4.3. Johansen Linear and Nonlinear Co-Integration Tests

The previous result indicates that the variables generally satisfy the pre-requisite condition for the application of the Johansen cointegration test as both the unit root tests with and without structural breaks indicate that the series considered are integrated of order 1. The Johansen Trace test was performed to identify the cointegration relation between the variables. This test is performed for a multivariate model to analyze the number of cointegrating relations between the variables.

Johansen, Mosconi, and Nielsen (2000) introduced the trace test for multivariate cointegration when the data shows structural breaks. This test allows to test two types of breaks namely break in levels i.e. which permits a one-time change in the level of the series and break in levels and trend jointly i.e. combines one-time changes in the level and the slope of the trend function of the series with single and two known break dates. This test is run at constant and shifts occur in the level of the series. We incorporated the break dates suggested by Saikkonen and Lutkepohl (2002) unit root test to identify the possible cointegration among the variables. Table 4 presents the result of the Johansen Trace test for Pakistan, India, China, and the US. The aim of using this test is to examine the relationship between gold, silver, and platinum with inflation, stock, exchange rate, and industrial production of Pakistan. Results reveal that gold, silver, and platinum hold one cointegrating relationship with the variables under study. The Johansen Trace test also indicates the number of cointegrating equations.

For Pakistan, three metals hold a single cointegrating equation with the financial and macro-economic variables. This indicates that gold, silver, and platinum have the ability to hedge the risk associated with inflation, stock, exchange rate, and industrial production of Pakistan in the long-run.

The results of the Johansen Trace test for the US indicates that the prices of gold and platinum appear to have a long linkage with inflation, stock, and industrial production of the US. One cointegrating equation hold between the variables under study. Thus, gold and platinum can protect investors in the long-run as they show the cointegrating relation. Silver does not appear to possess long-run hedging ability. For China, all three metals shine as cointegration was evident from the results. One cointegrating equation exists each between gold, silver, and platinum with inflation and stock exchange rate of China. Thus, the hedging ability of precious metals was evident in China. The order of cointegration of platinum is not 1 in India, thus, we excluded this for the test. Silver indicates no long-run relationship with inflation, stock index, exchange rate, and industrial production of India. Thus, among the precious metals considered, only gold establishes a long-run relation with financial and macroeconomic variables in India.

Table 5 presents the result of the Johansen Trace test with break dates for all countries. For Pakistan, it can be seen that the break dates in gold and platinum models are found to be associated with the global financial crisis. It shows that the prices of precious metals may be affected by this crisis. It has been observed that the prices of gold rose remarkably after the global financial crisis. The results of the Johansen Trace test after incorporating the break dates in the model look different from the test performed without break dates. Gold, silver, and platinum hold a long-run relationship with the consumer price index, exchange rate, industrial production, and stock index of Pakistan. Thus, three metals can be beneficial for the investors of Pakistan in the long-run. For the USA, in the long-run, three metals shine. Results reveal that cointegration holds between precious metals and the consumer price index, industrial production, and stock index of the US. Gold and silver both have 2 cointegrating equations with the consumer price index, exchange rate, industrial production, and stock index. Platinum holds 3 cointegrating equations with the consumer price index, exchange rate, industrial production, and stock index. For China, the Johansen Trace test with breaks has been applied and all three metals show their hedging ability as they possess cointegration with the consumer price index, exchange rate, and stock index of China. Results of India reveal the evidence of cointegration among gold and silver prices with the consumer price index, exchange rate, industrial production, and stock index of India. Thus, gold can benefit the investors in India by adding it to their portfolios.

Table 4: Johansen Trace Test Without Structural Breaks

Model		Countries	Trace Test				
			r=0	r=1	r=2	r=3	r=4
lgold	lcpi,ler,lstock,lip	Pakistan	134.754**	46.056	13.91	3.85	0.09
lsilver			131.337**	34.548	11.319	4.272	0.854
lplatinum			132.228**	42.634	16.516	7.848	0.7497
5% Critical Value			69.818	47.856	29.797	15.494	3.841
lgold	lcpi,ler,lstock,lip	India	67.685**	39.821	22.409	10.918	3.393
lsilver			65.433	35.854	20.961	8.145	3.382
5% Critical Value			69.818	47.856	29.797	15.494	3.841
lgold	lcpi,lstock,lip	USA	55.751**	25.845	7.596	2.557	
lsilver			40.893	19.092	7.289	2.416	
lplatinum			62.977**	24.348	11.26	2.609	
5% Critical Value			47.856	29.797	15.495	3.841	
lgold	lcpi,ler,lstock	China	87.020**	45.933	20.89	7.672	
lsilver			79.642**	47.007	24.323	10.19	
lplatinum			79.959**	43.241	21.289	10.098	
5% Critical Value			69.818	47.856	29.797	15.494	

Notes: lgold, lsilver, lplatinum represents the log of gold, silver, and platinum prices while,lcpi, ler, lip, and lstock represent the log of the consumer price index, exchange rate, industrial production, and stock index. r is the number of cointegrating vectors. ** indicates the significance with a 5% critical value.

Table 5: Johansen Trace Test with Structural Breaks

Model			Break Date	Trace Test				
				r=0	r=1	r=2	r=3	r=4
lgold	lcpi,ler,lstock,lip	Pakistan	2008 M12	170.286**	106.621**	63.379**	27.25	6.378
				(-95.55)	-69.52	-47.43	-29.11	-14.34
lsilver			2011 M05	158.159**	93.719**	50.989**	22.091	8.59
				-95.89	-69.72	-47.54	-29.17	-14.4
lplatinum			2008 M12	189.970**	107.689**	60.880**	32.499*	7.357
				-95.55	-69.52	-47.43	-29.11	-14.34
lgold	lcpi,ler,lstock,lip	India	2009 M1	124.291**	68.197	39.694	23.127	9.05
				-94.28	-68.46	-46.56	-28.44	-13.95
lsilver			2011 M06	104.395**	54.689**	33.535	19.691	5.988
				-94.45	-68.61	-46.69	-28.54	-14.01
lgold	lcpi,lstock,lip	USA	2008 M12	88.047**	48.990**	18.019	6.52	
				-69.92	-47.74	-29.34	-14.48	
lsilver			2011 M05	93.456**	53.718**	22.96	5.518	
				-69.22	-47.12	-28.84	-14.22	
lplatinum			2008 M12	99.898**	64.698**	34.287*	7.638	
				-69.92	-47.74	-29.34	-14.48	
lgold	lcpi,lstock,ler	China	2008 M12	151.089**	62.778	31.958	13.597	
				-95.87	-69.77	-47.62	-29.26	
lsilver			2011 M05	149.617**	70.160**	38.37	19.534	
				-95.62	-69.48	-47.34	-29.01	
lplatinum			2008 M12	168.890**	70.598**	39.69	22.176	
				-95.87	-69.77	-47.62	-29.26	

Notes: lgold, lsilver, lplatinum represents the log of gold, silver, and platinum prices while,lcpi, ler, lip, and lstock represents the log of the consumer price index, exchange rate, industrial production, and stock index. r is the number of co- integrating vectors. The 5% critical values are in parentheses. ** indicates the significance with a 5% critical value.

Generally, it has been observed that the cointegration tests which incorporate structural breaks provide stronger empirical evidence in favor of the long-run relationship between precious metals and exchange rate, consumer prices, and stock market index. Thus, they are found to provide a long hedge against the adverse conditions in the macroeconomic and financial markets of the selected countries. This is especially an interesting result for long-term investors who do not follow an active portfolio management strategy for short-run gains on their investment, however, want to protect themselves against the adverse conditions in the stock market, consumer price inflation, the deteriorating value of the local currency against the US dollar.

5. Conclusion

This paper analyzed the hedging ability of precious metals against the selected financial and macroeconomic variables for Pakistan, the US, China, and India. The graphical inspection of the series motivates us to apply linear as well as nonlinear statistical methods to identify the hedging ability of precious metals. The unit root properties of the series with and without breaks provide evidence of the non-stationarity of the series at levels. Johansen Trace test with and without breaks was performed to identify the long-run relationship by observing the number of cointegrating equations among the variables. Results look different for both tests as breaks may distort the usefulness of traditional statistical approaches.

This paper has contributed to economic and financial literature by analyzing the long-run hedging potential of precious metals against inflation, exchange rate, and stock market risks for four countries namely Pakistan, the US, China, and India. The long-run relationship of gold, silver, and platinum with economic variables was observed by conducting linear as well as nonlinear co-integration tests. Several studies provided insight to the investors by investigating the hedging ability of metals but they mainly focused on the gold market. In this study, we also consider silver and platinum markets. Shahbaz et al. (2014) investigated whether gold prices can hedge against inflation in the presence of a structural break in Pakistan.

Our study aims to investigate the hedging ability of gold, silver, and platinum not only in the presence of structural breaks but also, we apply cointegration test to identify the relationship of metals with different financial and economic variables in the long-run. Our findings suggest that the selected series has a unit root problem at levels with and without structural breaks. Without considering structural breaks, the Johansen Trace test indicates that in Pakistan and China, gold, silver, and platinum hold one cointegrating relationship with macro-economic and financial variables. For the US, gold indicates cointegration which supports the hedging ability of gold against inflation, stock, and industrial production in the long-run.

The results of the cointegration test after incorporating the structural breaks were identified by Saikkonen and Lutkepohl (2002), in that, the unit root test gives a different interpretation. For Pakistan, gold and silver hold two cointegrating relationships while platinum holds three cointegrating relationships with inflation, stock, exchange rate, and industrial production. Thus, the number of cointegrating relationships increases after incorporating the structural breaks in the test. It shows that breaks can affect the relationship between the variables. For China, silver and platinum show more hedging ability as compared to gold. Our results confirmed that metal prices are a good hedge against inflation, stock market risk, and industrial production in the US. Thus, analyzing the long-run relationship between the variables with break dates plays an important role.

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