Dynamic relationships between the price of oil, gold and financial variables in Japan: a bounds testing approach

Le, Thai-Ha and Chang, Youngho
Nanyang Technological University

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DYNAMIC RELATIONSHIPS BETWEEN THE PRICE OF OIL, GOLD AND FINANCIAL VARIABLES IN JAPAN: A BOUNDS TESTING APPROACH

Thai-Ha Le*, Youngho Chang

Division of Economics, Nanyang Technological University

Singapore 639798, Singapore

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Abstract

This study employs the bounds testing approach to cointegration to investigate the relationships between the prices of two strategic commodities: gold and oil and the financial variables (interest rate, exchange rate and stock price) of Japan – a major oil-consuming and gold-holding country. Our results suggest that the price of gold and stock, among others, can help form expectations of higher inflation over time. In the short run, only gold price impacts the interest rate in Japan. Overall the findings of this study could benefit both the Japanese monetary authority and investors who hold the Japanese yen in their portfolios. For instance, our findings imply that the optimal choice in a long term for those investors who buy the Japanese yen would be to include either gold or oil or both in their portfolios.

Key words: oil price, gold price, interest rate, exchange rate, stock price, bounds test to cointegration.

JEL Classifications: C32, E4, F31.

*Corresponding author. Tel: +65-822 69 879. Email: thai1@e.ntu.edu.sg.

1. INTRODUCTION

The volume of studies on the prices of oil and gold has grown in the last few years, partly due to the recent surge in oil and gold prices. Oil and gold are the two strategic commodities and commonly expected to have irreplaceable roles to the global economy. Oil is the most traded commodity in the world. It could be observed empirically that oil price fluctuations have not only been associated with major developments in the world economy, but also a trigger for inflation and recession. For instance, the oil price hike in 1974 and 1979 played critical roles in slowing down the world economy, at the same time, inflation was also rising. Until lately when people believe that we are living in a lower inflation world, recent increases in oil prices have caused many concerns that they could alter this good situation.

Gold, which is considered the leader in the market of precious metals, is an investment asset as well as an industrial commodity. Gold is commonly known as a "safe haven" to avoid high risk in financial markets and thus one of risk management tools in hedging and diversifying commodity portfolios. The special characteristic of gold lies in its less susceptibility to exchange rate fluctuations. In this regard, gold has the ability to resist changes in the internal and external purchasing power of the domestic currency. Since gold price is often thought to rapidly adjust to changes in inflation rate, gold has the value-preserving ability. On examining the role of gold in the global financial system using a sample spanning from 1979 to 2009, Baur and McDermott (2009) found that gold is a strong "safe haven" during the peak of the recent financial crisis for most developed markets such as major European and the US stock markets, but not for large emerging markets like BRIC countries[1].

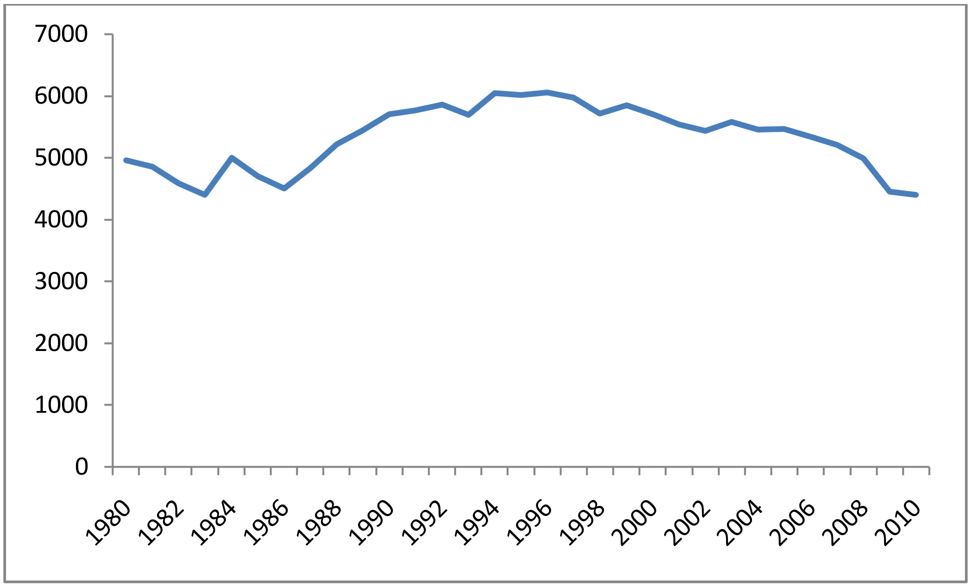
[1] In economics, "the BRIC countries", refers to the countries of Brazil, Russia, India and China, which are all deemed to be at a similar stage of newly advanced economic development.

The special features and roles of oil and gold make it of practical significance to investigate how the price of these two commodities altogether influences macroeconomic variables in the economy. However, it is surprising that little research has been conducted on the subject. In an attempt to fill this gap, our paper examines the relationship between the price of oil, gold and the financial variables in Japan.

Oil is the most consumed energy resource in Japan even though its annual consumption has been falling recently and its share of total energy consumption has decreased from about 80% in the 1970s to 46% in 2008 (Refer to Figure 1 and 2). This fact arises from structural factors, such as fuel substitution (i.e. the shift to natural gas in the industrial sector), an aging population and government-mandated energy efficiency targets. Still, Japan is the third largest net oil importer in the world behind the US and China, as of March 2011.[2] Japan is also the third biggest oil consumer with the daily oil consumption of 4.4 million barrels in 2010.[3] The country, however, has very limited domestic oil reserves of 44 million barrels as of January 2011 which is a decline from the 58 million barrels in 2007.[4] Consequently, it had to rely heavily on oil imports to meet 45% of its energy consumption needs in 2009.[5] Further, the 9.0 magnitude earthquake and resulting tsunami in March 2011 has adversely affected the country in general and severely damaged its energy infrastructure such as nuclear power stations, electric grid, refineries, and gas and oil-fired power plants in particular. Therefore, Japan will likely require additional energy (natural gas, oil) to provide electricity despite its declined power demand in the short term due to the destruction of homes and businesses.

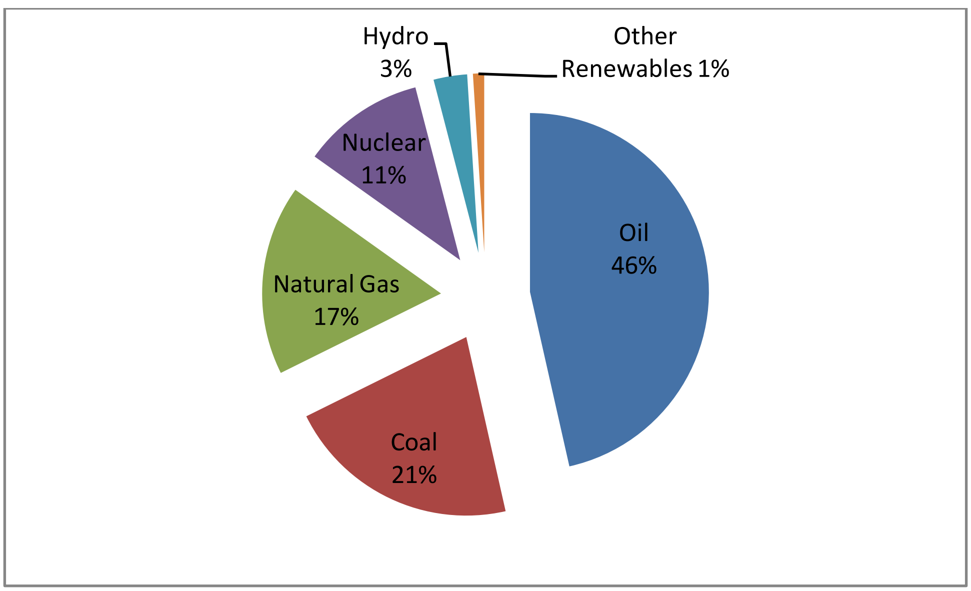
[2]Source: EIA, International Energy Statistics.
[3] Source: EIA, International Energy Statistics.
[4] Reported by the Oil and Gas Journal – OGJ.
[5] Source: EIA, International Energy Statistics.

Figure 1: Japan's Oil Consumption by Year (1980-2010)



Source: US Energy Information Administration Statistics

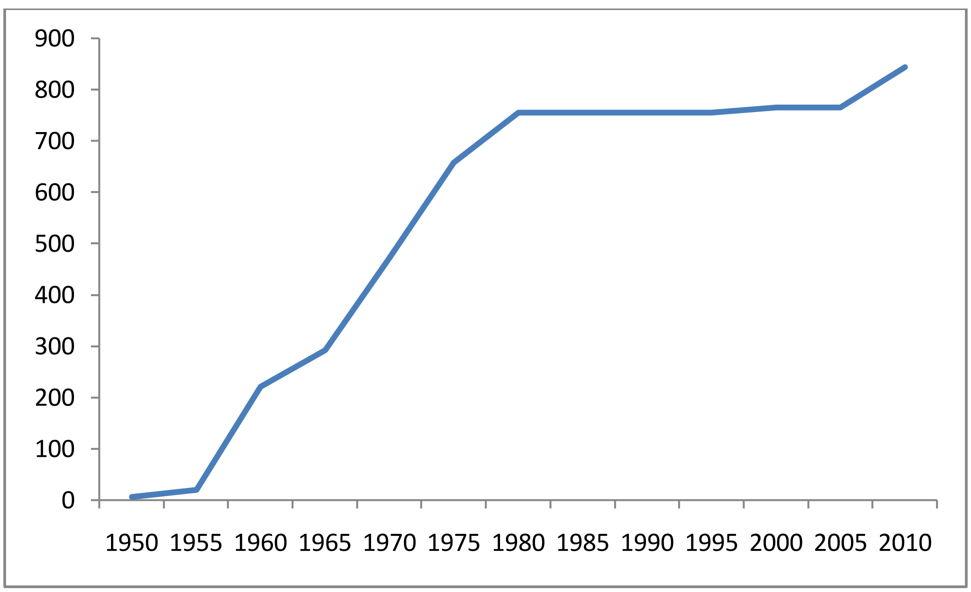
Figure 2: Japan's Total Energy Consumption by Type (2008)



Source: US Energy Information Administration

Besides, Japan is always among the top gold holders in the world, latest ranked at 9th place in 2011, with increasing gold holdings from 765.2 tons of gold as of January 2011 to 843.3 tons of gold as of early July 2011.[6] There are two reasons for this fact. First, it is the Japanese culture that people harbor gold to protect against unforeseen events and only sell it when they have urgent needs. Second, in an uncertain international economic crisis, the only certain thing is that countries are increasing their gold reserves and Japan is obviously not an exceptional case (Refer to Figure 3). Japan's gold reserves which are worth about US$43.17 billion on the open market constitutes, however, only 3.3% of the country's total foreign reserves.

Figure 3: Japan's Gold Reserves (1950-2011)



Source: IMF International Financial Statistics

Since Japan is a major oil-consuming and gold-holding country, the fluctuations of oil and gold prices would have significant economic implications for movements of macroeconomic variables in the economy. We select interest rate, exchange rate and stock price index as the

[6] Source: IMF International Financial Statistics.

representatives of financial variables in our empirical investigation of Japan. The reason is because interest rate is a variable that captures the monetary policy instrument, exchange rate is an important transmission channel in an open economy, and stock market is an indicator of the health of an economy. For Japan case, the nominal interest rates on yen assets have been forced toward zero during recent decades. The objective of a low nominal interest rate was to temporarily lower the banks' yen exposure at a time when confidence in the yen and the Japanese economy was very low. Hence, it is interesting to investigate, among others, how gold price and the Japanese interest rates are related. Despite this fact, to the best of our knowledge, there has not been any study conducted on this particular subject.

The rest of this paper is organized as follows. Section 2 discusses the background and reviews the related work in the area. Section 3 presents the data and methodology. Section 4 interprets the empirical results. Section 5 concludes with the principal findings and economic implications.

2. RELATIONS AMONG OIL PRICE, GOLD PRICE AND FINANCIAL VARIABLES

Oil prices had been fairly stable until 1973. Since then, the oil price has been quite fluctuating and the impact of oil price shocks on the world economy has also been larger. A considerable number of researches have been conducted on studying oil price-macroeconomy relationships. Examples of early and notable studies are Hamilton (1983), Burbridge and Harrison (1984), Gisser and Goodwin (1986), Loungani (1986), Mork (1989) which explore casual linkage between oil price and macroeconomic variables. Recent studies in the field are either time series data analyses on one country (Guo, 2005; Breitenfellner and Crespo, 2008) or cross-sectional data analyses across countries (Cunado and Gracia, 2003, 2005; Jimenez and Marcelo, 2005;

Cologni and Manera, 2008). For instance, on investigating the relationship between oil prices and the US dollar, Lizardo and Mollick (2010) find a significantly negative relationship between oil price and the value of US dollar against the currencies of several oil-exporting countries including Canada, Mexico and Russia. Further, they bring evidence that the relationship is positive for oil importers such as Japan. For those countries that are neither net oil exporters nor significant importers (e.g. the United Kingdom), an increase in oil price leads to a depreciation of the US dollar relative to their domestic currencies.

In sharp contrast to the large volume of studies on the relationships between oil price changes and macroeconomicvariables, the number of analyses on oil price-stock price relationships has been relatively few. The most recent and notable studies in this field include Basher and Sadorsky (2006), Park and Ratti (2008), Kilian and Park (2009) and Narayan and Narayan (2010). For instance, Park and Ratti (2008) employ multivariate VARs to investigate the interaction between oil price shocks and stock returns in the US and 13 European countries. They show that oil price has a crucial role in explaining the stock market performance in oil-importing countries. The impact, however, is less for oil-exporting countries. Furthermore, they point out that for most European countries, an increase of oil price volatility significantly depressed the real stock market returns. For the Unite States, shocks of oil price appear to explain more of fluctuations in real stock returns compared to those of interest rates. Narayan and Narayan (2010) examine the relationship between oil price and Vietnam's stock market and results indicate that a long-run relationship exists among oil price, the nominal exchange rate of Vietnamese dong vis-à-vis the US dollar (VND/USD exchange rate) and Vietnam's stock price. The study also indicates that both oil price and the VND/USD exchange rate have significantly positive effect on Vietnam's stock price.

The literature on gold price-macroeconomic variable relationships has been rather sparse. For our particular interest in this study, the next paragraphs will discuss relationships between gold price and the three financial variables: exchange rate, stock price and interest rate.

Inflation is one factor, among others, contributing to the depreciation of a domestic currency, which in turns reduces the nominal price of domestic assets. In such a case, as gold price can rapidly adjust to the inflation rate, gold has the value-preserving ability. However, under special economic conditions, gold price may not always do this, specifically due to unique market competition, transaction costs or country-specific characteristics. When the correlation between exchange rate and gold price rises, exchange rate shocks are likely to have more impact on domestic price level and domestic currency denominated wealth. Therefore, investors can buy more gold to avoid exchange rate shocks. Nevertheless, the price adjustment may be asymmetric due to the rigidities of gold price responding to exchange rate shocks, as a consequence of market imperfect competition or the existence of transaction costs caused by the monetary authority intervention (Wang and Lee, 2011).

Further, when the US dollar depreciates against the domestic currency of a country, the US dollar prices of commodities tend to rise (and the domestic prices fall) even though the fundamentals of markets and all relevant factors other than exchange rates and price levels remain unchanged. This statement is related to the law of one price applied to gold. If gold price is fixed with respect to some world numeraire, its price in a depreciating currency will rise and its prices in an appreciating currency will fall. The prices of gold expressed in the two currencies will move in opposite directions. Pukthuanthong and Roll (2011), however, bring evidence against this conclusion by showing that gold prices are strongly positively correlated across both depreciating and appreciating currencies.

The relationship between gold price and exchange rate has been empirically investigated by several studies. For instance, Capie et al. (2005) employ the exponential generalized autoregressive conditional heteroskedasticity (EGARCH) to examine the hedge ability of gold against exchange rate fluctuations and report a negative relationship between gold price and the yen-dollar exchange rates. The strength of this relationship, however, varies over time. Using the cointegration and VECM techniques for the time-series data over the 1976-2005 periods, Levin and Wright (2006) find a negative relationship among gold price movements and changes in the US dollar trade weighted exchange rate. Further, they also ascertain the role of gold as an effective long-term hedge against inflation in major gold consuming countries such as Saudi Arabia, China, India, Indonesia, and Turkey.

Sjaastad carries out two studies on the linkages between the gold price and major exchange rates. Both the studies find that since the dissolution of the Bretton Woods international monetary system, exchange rate fluctuations have been a major source of instable gold price. In his first study with Scacciallani (1996) on relationships between major exchange rates and internationally traded commodity prices, they opine that as the world gold market is denominated by the European currency bloc, appreciations or depreciations of European currencies have strong impacts on the gold prices denominated by other currencies. In the second study carried out recently of which he is the sole author (2008), he states that since the global gold market is now denominated in the US dollar bloc, appreciations or depreciations of the US dollar have strong impacts on the gold prices denominated by other currencies.

Studies on gold price-interest rate relationships are relatively fewer in number and seem to support a unidirectional causality running from interest rate to gold price. In other word, when nominal interest rates are low or even become negative, the price of gold tends to move higher and the gold mining equities appreciate. The logic is simple. During periods when nominal interest rates on short and safe financial assets are low, people tend to respond by purchasing commodities such as gold. They could always hold gold even though gold does have some storage cost. Thus, low nominal interest rates are likely to result in an increase in the demand for gold and hence gold price. The critical role of interest rates on the price of gold has been reported by several studies (e.g. Koutsoyiannis, 1983; Fortune, 1987). In a recent study, it was found that gold price changesare due to fluctuations in interest rates, among those of other variables (Cai et al, 2001).

The literature on the gold price and stock price is even sparser. Theoretically, we may expect an inverse relationship between gold price and stock price. This is because when stock prices go up, investors make more money at the stock market and thus they do not need to hold so much gold and tend to sell their gold. This drives the price of gold down. In reality, whenever there is enough liquidity, gold and stock markets tend to run in tandem. During inflation, the gold market rises and the stock market falls, but the reaction of gold is slow. On examining the extra-market sensitivity of the Australian industry equity returns to the gold price factor, Chan and Faff (1998) find a widespread sensitivity of the industry equity returns to the gold price returns, over and above market returns. The sensitivity is positive for the resource and mining sectors, whereas negative for the industrial sector. Wang et al (2010), however, employ the Granger causality analysis and find that gold price and Taiwan's stock price are independent.

3. DATA AND METHODOLOGY

3.1. Data

We collected monthly data spanning from Jan-1986 to Feb-2011, which consists of 302 observations for each series. We chose the West Texas Intermediate (WTI) crude oil price (quoted in US dollar) as a representative of world oil price. The original WTI crude oil spot price is acquired from the US's Energy Information Administration (EIA).[7] The monthly average of the London afternoon (pm) fix (quoted in US dollar) is selected as a representative of world gold price and obtained from the World Gold Council.[8] The data of Japanese macroeconomic variables including consumer price index (CPI), interest rate, exchange rate (JPY/USD) and stock price index are obtained from CEIC data sources. The money market rate is chosen as a representative for the short term interest rate in Japan. Except the rates and stock price indices, the data on gold price, oil price and CPI are subject to seasonal adjustment to eliminate the influence of seasonal fluctuations. All the data series are transformed into natural logarithms to stabilize the variability in the data. Since all the variables are converted to natural logarithms, the estimated coefficients are interpreted as elasticities.

Considering the inflation factor, the prices of oil, gold and stock are entered into the model in real terms (adjusted to the base year 2005). In order to get rid of the effect of any exchange rate differences, the prices of oil and gold are converted from US dollar into the domestic currency of Japan, which is the Japanese yen. For instance, national real oil prices are obtained as products of WTI crude oil prices and exchange rates (Japanese yen per US dollar) deflated using the inflation indicator (monthly CPI with the base year of 2005) of Japan. It is important to note that the

[7] Source: http://www.eia.doe.gov/dnav/pet/pet_pri_spt_s1_m.htm
[8] Source: http://www.gold.org/investment/statistics/prices/average_monthly_gold_prices_since_1971/

choice of oil price and gold price variables betweenthe world price and the national price are difficult and relevant. In reality, national prices of gold and oil are influenced by many factors such as price-controls, high and varying taxes on petroleum products, exchange rate fluctuations and national price index variations. Such considerations justify our choice of using the world price in US dollars and converted into the Japanese yen by means of the market exchange rate.

Table 1 tabulates the descriptive statistics of the series in level, in log and first difference of log level. The coefficient of standard deviation indicates that in level, gold price has the highest volatility, followed by oil price, stock price, exchange rate and interest rate. After taking log transformation, however, interest rate has the highest volatility, and oil price is more volatile than gold price. Interest rate in log is the only variable that has negative mean; due to the fact that the Japanese nominal interest rate in recent periods (about 16 years) has been a way too low, less than 1%. For oil, gold and stock series, the mean of the first differences of the log of the variables implies annualized average return. Overall stock is the only asset that yields negative annualized average return whereas for gold and oil, the return is positive. However, oil offers higher average return with lower level of volatility as compared to gold. The skewness, kurtosis and Jarque-Bera statistics indicate that both oil price and gold price are significantly non-normally distributed, especially compared to the stock price.

Table 2 presents the correlation matrix between all the logged variables. Oil and gold prices have the highest and positive correlation (about 0.70). Gold price is negatively but not significantly correlated with stock price and exchange rate. In contrast, oil price is negatively, however, significantly correlated with stock price and exchange rate. Further, oil price and gold price are significantly correlated with interest rate but the sign is positive for gold whereas negative for oil. The correlations between the Japanese financial variables are all highly positive.

Table 1: Descriptive statistics of series

	Gold price	Oil price	Stock price	Exchange rate	Interest rate
Level					
Mean	54537.52	3938.171	115.3462	118.7690	1.846506
Std. dev.	21545.53	2397.475	34.46711	18.98073	2.415065
Skewness	0.981081	1.551602	0.780172	0.739332	1.176576
Kurtosis	3.047719	4.878465	3.443337	4.261368	3.141187
Jarque-Bera	48.47549	165.5778	33.10954	47.53349	69.92888
Probability	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	302	302	302	302	302
Log					
Mean	10.83652	8.131502	4.705064	4.764884	-1.358454
Std. dev.	0.367199	0.519025	0.292862	0.156310	2.874324
Skewness	0.449856	0.645148	0.063841	0.177786	-0.697807
Kurtosis	2.148535	2.584738	2.550319	3.290633	2.333622
Jarque-Bera	19.30881	23.11944	2.749650	2.653821	29.99711
Probability	0.000064	0.000010	0.252884	0.265296	0.000000
Observations	302	302	302	302	301
First difference of log					
Mean	0.001255	0.001818	-0.000289	-0.002943	-0.013366
Std. dev.	0.037407	0.086545	0.049947	0.027620	0.360691
Skewness	0.040842	-0.647030	-0.479338	-0.412149	1.369446
Kurtosis	4.013493	6.594339	4.683407	3.532176	17.92842
Jarque-Bera	12.96608	183.0314	47.06787	12.07358	2869.891
Probability	0.001529	0.000000	0.000000	0.002389	0.000000
Observations	301	301	301	301	299

Table 2: Correlation matrix (in log level)

	Gold price	Oil price	Stock price	Exchange rate	Interest rate
Gold price	1.000000				
Oil price	0.694998	1.000000			
Stock price	-0.021031	-0.239504	1.000000		
Exchange rate	-0.032640	-0.230694	0.473171	1.000000	
Interest rate	0.197579	-0.343101	0.597658	0.373778	1.000000

3.2. Methodology

We employ a relatively new method of the bounds testing to cointegration (or autoregressive distributed lag (ARDL)) procedure, developed by Pesaran et al (2001) to empirically analyze the long-run and short-term relationships and dynamic interactions among the variables. The ARDL approach is selected for several reasons. First, the bounds testing (ARDL) approach to cointegration is more appropriate for estimation in finite or small sample studies. Second, unlike other well-known cointegration methods, the cointegrating relationship can be estimated by OLS in the bounds test procedure once the lag order of the model is identified. Third, the bounds test does not require the pre-test for existence of unit root of the series as in the Johansen-Juselius and Engle-Granger cointegration approaches. The ARDL approach is applicable irrespective of whether the variables are purely I(0), purely I(1) or mutually cointegrated. Fourth, we can identify specific forcing relationships for regressors in the ARDL system. One issue, however, to note with the use of bounds testing is that although the integration order of the series is only needed to identify critical values for inferences,the system crashes in the presence of I(2) series.

First, we test for cointegrating relationship using the bounds testing procedure (Pesaran and Pesaran, 1997; Pesaran et al, 2001) which helps to identify the long-run relationship by posting a dependent variable followed subsequent by its forcing variables.Since we are uncertain about the directions of the long-run relationships, we estimate unrestricted regressions as follows:

$$\Delta LOP_t = \alpha_0 + \alpha_1 . LOP_{t-1} + \alpha_2 . LGOLDP_{t-1} + \alpha_3 . LIR_{t-1} + \alpha_4 . LSP_{t-1} + \alpha_5 . LER_{t-1}$$

$$+ \sum_{i=1}^{k} \alpha_{6i} \, . \Delta LOP_{t-i} + \sum_{i=1}^{k} \alpha_{7i} \, . \Delta LGOLDP_{t-i} + \sum_{i=1}^{k} \alpha_{8i} \, . \Delta LIR_{t-i}$$

$$+ \sum_{i=1}^{k} \alpha_{9i} \, . \Delta LSP_{t-i} + \sum_{i=1}^{k} \alpha_{10i} \, . \Delta LER_{t-i} + \varepsilon_{1t}$$

$$\Delta LGOLDP_t = \beta_0 + \beta_1 . LOP_{t-1} + \beta_2 . LGOLDP_{t-1} + \beta_3 . LIR_{t-1} + \beta_4 . LSP_{t-1} + \beta_5 . LER_{t-1}$$

$$+ \sum_{i=1}^{k} \beta_{6i} \, . \Delta LOP_{t-i} + \sum_{i=1}^{k} \beta_{7i} \, . \Delta LGOLDP_{t-i} + \sum_{i=1}^{k} \beta_{8i} \, . \Delta LIR_{t-i}$$

$$+ \sum_{i=1}^{k} \beta_{9i} \, . \Delta LSP_{t-i} + \sum_{i=1}^{k} \beta_{10i} \, . \Delta LER_{t-i} + \varepsilon_{2t}$$

$$\Delta LIR_t = \gamma_0 + \gamma_1 . LOP_{t-1} + \gamma_2 . LGOLDP_{t-1} + \gamma_3 . LIR_{t-1} + \gamma_4 . LSP_{t-1} + \gamma_5 . LER_{t-1}$$

$$+ \sum_{i=1}^{k} \gamma_{6i} \, . \Delta LOP_{t-i} + \sum_{i=1}^{k} \gamma_{7i} \, . \Delta LGOLDP_{t-i} + \sum_{i=1}^{k} \gamma_{8i} \, . \Delta LIR_{t-i} + \sum_{i=1}^{k} \gamma_{9i} \, . \Delta LSP_{t-i}$$

$$+ \sum_{i=1}^{k} \gamma_{10i} \, . \Delta LER_{t-i} + \varepsilon_{3t}$$

$$\Delta LSP_t = \delta_0 + \delta_1 . LOP_{t-1} + \delta_2 . LGOLDP_{t-1} + \delta_3 . LIR_{t-1} + \delta_4 . LSP_{t-1} + \delta_5 . LER_{t-1}$$

$$+ \sum_{i=1}^{k} \delta_{6i} \, . \Delta LOP_{t-i} + \sum_{i=1}^{k} \delta_{7i} \, . \Delta LGOLDP_{t-i} + \sum_{i=1}^{k} \delta_{8i} \, . \Delta LIR_{t-i}$$

$$+ \sum_{i=1}^{k} \delta_{9i} \, . \Delta LSP_{t-i} + \sum_{i=1}^{k} \delta_{10i} \, . \Delta LER_{t-i} + \varepsilon_{4t}$$

$$\Delta LER_t = \mu_0 + \mu_1 . LOP_{t-1} + \mu_2 . LGOLDP_{t-1} + \mu_3 . LIR_{t-1} + \mu_4 . LSP_{t-1} + \mu_5 . LER_{t-1} + \sum_{i=1}^{k} \mu_{6i} . \Delta LOP_{t-i} + \sum_{i=1}^{k} \mu_{7i} . \Delta LGOLDP_{t-i} + \sum_{i=1}^{k} \mu_{8i} . \Delta LIR_{t-i} + \sum_{i=1}^{k} \mu_{9i} . \Delta LSP_{t-i} + \sum_{i=1}^{k} \mu_{10i} . \Delta LER_{t-i} + \varepsilon_{5t}$$

Where LOP, LGOLDP, LIR, LSP and LER are natural log transformation of oil price, gold price, interest rate, stock price and exchange rate respectively, Δ is the first difference operator, k is lag length, $\alpha_0, \beta_0, \gamma_0, \delta_0$ and μ_0 are the drift, $\alpha_i, \beta_i, \gamma_i, \delta_i$ and μ_i (i=1 to 5) are the long-run multipliers, $\alpha_i, \beta_i, \gamma_i, \delta_i$ and μ_i (i=6 to 10) are the short-run multipliers and ε_{it} (i=1 to 5) are white noise errors. The lag lengths are determined by the Akaike Information Criteria (AIC).

The null hypothesis of “no cointegration” in the long run in each equation:

$$F(LOP_t | LGOLDP_t, LIR_t, LSP_t, LER_t): \quad \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$$

$$F(LGOLDP_t | LOP_t, LIR_t, LSP_t, LER_t): \quad \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$$

$$F(LIR_t | LOP_t, LGOLDP_t, LSP_t, LER_t): \quad \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$$

$$F(LSP_t | LOP_t, LGOLDP_t, LIR_t, LER_t): \quad \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$$

$$F(LER_t | LOP_t, LGOLDP_t, LSP_t, LIR_t): \quad \mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = 0$$

The general F-statistics are used to test the hypotheses by computing the variables in levels. We compare the statistics with critical values obtained from Pesaran et al. (2001). There are two types of critical values, depending on the properties of the series. One type is for the purely stationary I(0) series (i.e. the lower level critical value), and the other type is for the purely I(1) series (i.e. the upper level critical value). If there is a mixed of I(0) and I(1) series, then the calculated F-statistics are compared with the upper and lower level critical values. We accept the null hypothesis of no cointegration if the test statistic is smaller than the lower critical value. On the other hand, we reject the null hypothesis if the computed test statistic is bigger than the upper critical value. The test result is inconclusive when the computed F-statistics lie between the lower and upper bounds of critical values.

Next step, we estimate the long-run and short-run parameters within a vector error representation model, which consists of a two-step procedure. First, we select the order of the lags and then estimate the ARDL model. According to Pesaran and Pesaran (1997), an augmented ARDL$(p, q_1, q_2, \ldots q_k)$ model can be expressed as:

$$\Phi(L,p)y_t = \alpha_0 + \sum_{i=1}^{k} \Theta_i\,(L,q_i)x_{it} + \delta' w_t + u_t$$

Where p is the order of the dependent variable, $p = 1,2, \ldots m$ and q_i is the lag of the ith independent variable, $q_i = 1,2, \ldots m$; $\Phi(L,p)$ and $\Theta_i(L,q_i)$ are polynomial lag operators of the maximum order equal to p and q, for the dependent and independent variables, respectively, and have following representations:

$$\Phi(L,p) = 1 - \sum_{j=1}^{p} \Phi_j L^j$$

$$\Theta_i(L,q_i) = \sum_{j=0}^{q_i} \Theta_{ij} L^j$$

L is a lag operator; y_t represents any of the variables in this group as a dependent variable; α_0 is a constant; x_{it} is the ith independent variable, $i = 1,2, \ldots k$; w_t is a sx1 vector of deterministic variables (i.e., intercept, time trend, dummies).

The ARDL procedure estimates $(m+1)^{k+1}$ number of regressions in order to obtain the optimal lag length for each variable, where m is the maximum lag length and k is the number of variables. The appropriate model could be selected based on any known selection criteria such as Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC), among others. The long-run coefficients for the response of a dependent variable to a change in an independent variable can be computed based on the selected appropriate model, as follow:

$$\hat{\vartheta}_i = \frac{\widehat{\Theta}_i(1,\hat{q}_i)}{\widehat{\Phi}(1,\hat{p})} = \frac{\sum_{j=0}^{\hat{q}_i}\widehat{\Theta}_{ij}}{1-\sum_{j=1}^{\hat{p}}\widehat{\Phi}_j}$$

Where $\hat{p}$ and $\hat{q}_i$ are the estimated values of p and q_i

The error correction model associated with the selected ARDL $(\hat{p},\hat{q}_1,\hat{q}_2,\dots\hat{q}_k)$ could be represented as follow:

$$\Delta y_t = -\Phi(1,\hat{p})EC_{t-1} + \sum_{i=1}^{k}\Theta_{i0}\Delta x_{it} + \delta^{'}\Delta w_t - \sum_{j=1}^{\hat{p}-1}\varphi_j\,\Delta y_{t-j} - \sum_{i=1}^{k}\sum\nolimits_{j=1}^{\hat{q}_i-1}\theta_{ij}\,\Delta x_{i,t-j} + u_t$$

Where $\Phi(1,\hat{p}) = 1-\sum_{j=1}^{\hat{p}}\widehat{\Phi}_j$ and EC_t is the error correction term defined by:

$$EC_t = y_t - \sum_{i=1}^{k}\hat{\vartheta}_i x_{it} - \widehat{\Gamma}^{'} w_t$$

Where $\widehat{\Gamma}$ is the long-run coefficient associated with the deterministic variables with fixed lags. The parameters φ_j and θ_{ij} are the short-run dynamic coefficients.

4. EMPIRICAL RESULTS AND INTERPRETATION

4.1. Stationarity test

This section examines the integrated order of all the variables by applying several unit root tests. Note here that the bounds test is based on the assumption that all variables could be I(0) or I(1) or some I(0) and I(1). When the variables are integrated of order 2 (i.e. I(2) series) or beyond, the computed F-statistics by Pesaran et al (2001) are no longer valid. Therefore, the tests are used to ensure that the regressors in the system are not I(2) stationary so as to avoid spurious results. For this purpose, we employ four unit root tests. Out of which, three tests, namely Dickey and Fuller (1979) (ADF), Phillips and Perron (1988) (PP), and Kwiatkowski et al (1992) (KPSS) do not account for a structural break and one test, namely Zivot and Andrews, accounts for one endogenous structural break.

The ADF and PP tests have common suggestion that all the five logged variables are non-stationary in level and stationary in their first differences. The KPSS and Zivot-Andrews tests have slightly different conclusions. Specifically, the KPSS tests (with trend) show that, at 5% level, the logged stock price is stationary in level and the Zivot-Andrews test suggests that we cannot reject the null hypothesis for the log series of interest rate in level at 10% levels of significance. Hence, the results after performing a range of unit roots test with and without structural breaks show a mixed conclusion between I(0) and I(1) series. We may conclude, however, that there is no risk of existence of I(2) variables. The findings justify the use of bounds testing to cointegration methodology.

Table 3: Results of unit root tests without accounting for a structural break:

1986:01 – 2011:02

		ADF	PP	KPSS
Log levels				
Intercept				
Japan	Gold price	-0.1232 (1)	-0.0836	0.5824
	Oil price	-1.3338 (1)	-1.3113	1.2947
	Stock price	-1.9497 (1)	-1.9112	1.0962
	Exchange rate	-2.3890 (1)	-2.7334	1.0719
	Interest rate	-2.0974 (2)	-1.6447	1.3301
Intercept and trend				
Japan	Gold price	-0.6951 (0)	-0.7453	0.4999
	Oil price	-2.5320 (1)	-2.9407	0.4031
	Stock price	-3.5233 (1)	-3.4635	**0.0729**
	Exchange rate	-3.0550 (1)	-3.1970	0.1666
	Interest rate	-2.2810 (2)	-1.7653	0.2435
First differences				
Intercept				
Japan	Gold price	-14.6507 (0)	-14.5848	**0.9809**
	Oil price	-14.1236 (0)	-13.9954	0.1893
	Stock price	-12.4855 (0)	-12.5550	0.1488
	Exchange rate	-13.0844 (0)	-12.7827	0.1551
	Interest rate	-10.1120 (1)	-16.7349	0.1084
Intercept and trend				
Japan	Gold price	-15.0289 (0)	-14.8891	0.0465
	Oil price	-14.1206 (0)	-13.9852	0.0349
	Stock price	-12.5169 (0)	-12.5802	0.0800
	Exchange rate	-13.0618 (0)	-12.7564	0.1272
	Interest rate	-10.1237 (1)	-16.7232	0.0730

Note: Lag lengths are in parentheses. Without trend, critical values for ADF, PP and KPSS tests are respectively: at 1% = -3.45, -3.45 and 0.74; at 5% = -2.87, -2.87 and 0.46; at 10% = -2.57, -2.5 and 0.35. With trend, critical values for ADF, PP and KPSS tests are respectively: at 1% = -3.99, -3.99 and 0.22; at 5% = -3.42, -3.43 and 0.15; at 10% = -3.14, -3.14 and 0.12.

Table 4: Results of Zivot-Andrews unit root test with accounting for one structural break: 1986:01 – 2011:02

	[k]	t-statistics	Break point
Log levels			
Gold price	2	-4.448	Sep – 1998
Oil price	1	-4.379	Apr – 1993
Stock price	1	-4.798	Jun – 2005
Exchange rate	1	-3.919	Aug – 1995
Interest rate	3	-5.158	May – 2006
First differences			
Gold price	1	-12.889	Jun – 2005
Oil price	0	-14.236	Jan – 1999
Stock price	0	-13.038	May – 1992
Exchange rate	4	-9.861	May – 1995
Interest rate	4	-7.563	Mar – 2006

Note: The critical values for Zivot and Andrews test are -5.57,-5.30, -5.08 and -4.82 at 1%, 2.5%, 5% and10% levels of significance respectively.

4.2. Bounds tests and results

We first test for the presence of long-run relationships among variables, defined respectively in the above equation system. We use a general-to-specific modeling approach guided by the short run data span and AIC respectively to select a maximum lag of 3 for the conditional ARDL-VECM. Following the procedure in Pesaran and Pesaran (1997, pp.305) we first estimate OLS regressions for the first difference part of the system and then test for the joint significance of the parameters of the lagged level variables when added to the first regression. According to Pesaran and Pesaran, "this OLS regression in first differences are of no direct interest" to the bounds cointegration test. The F-test examines the null hypothesis that the coefficients of the lagged level variables are zero (i.e. no long-run relationship exists).

The calculated F-statistics for the cointegrating relationships among the five variables in the system are presented in Table 5. Optimal lag length is selected based on the Akaike Information

Criterion (AIC). Overall, the ARDL models pass the three diagnostic tests on serial correlation, functional form and heteroskedasticity. Except for only one case, the LIR equation, which does not pass the heteroskedasticity test. Given the fact the variables in the estimation model have different lag order, this result is, however, not so surprising. Critical values are taken from pp.301 of Pesaran, Shin and Smith (2001). The results suggest that we can reject the null hypothesis of no cointegration when the regressions are normalized on LIR variables. There is thus only one cointegrating vector among the group of five variables. The cointegrating vector indicates that the price of oil, gold and stock and the exchange rate are the forcing variables of the interest rate.This implies that when a common stochastic shock hits the system, all the variables move together but the four variables: oil price, gold price, stock price and exchange rate move first and then the interest rate follows.

Table 5: Bounds test cointegration procedure results

Cointegration hypothesis	Lag structure	F-statistics	Outcome
$F(LGOLDP_t \| LOP_t, LSP_t, LER_t, LIR_t)$	3-1-2-1-0	3.753223	Inconclusive
$F(LOP_t \| LGOLDP_t, LSP_t, LER_t, LIR_t)$	2-1-0-1-0	3.338920	No cointegration
$F(LSP_t \| LGOLDP_t, LOP_t, LER_t, LIR_t)$	2-0-1-0-0	2.557143	No cointegration
$F(LER_t \| LGOLDP_t, LOP_t, LSP_t, LIR_t)$	2-3-2-0-0	3.380853	No cointegration
$F(LIR_t \| LGOLDP_t, LOP_t, LSP_t, LER_t)$	3-0-0-1-0	5.898244	Cointegration

Note: Asymptotic critical value bounds are obtained from Table F in Appendix C, Case II: intercept and no trend for k=5 (Pesaran and Pesaran, 1997, pp. 478). Lower bound I(0)=3.516 and upper bound I(1) = 4.781 at 1% significance level.

Table 6 reports the coefficient estimates of the long-run relationship but we will only consider the cointegrating equation detected from the previous section which is the LIR equation. The results indicate that gold price and stock price have a positive and significant effect on the Japanese interest rate. Notice that the real stock price is more pronounced than the real gold price in determining the Japanese interest rate. For instance, a 1% increase in gold price causes the Japanese interest rate to increase by only 5.39% while the interest rate increases by 8.79% given a 1% increase in the Japanesestock price.This result contradicts to the theoretical relationship between interest rate and gold price discussed in the second section. Overall, the finding implies that increases in the price of gold and stock can help form expectations of higher inflation over time, which eventually leads to a rise in interest rate in the long run.

Table 6: Estimated long-run coefficients using the ARDL approach

	LIR equation
LGOLDP	**5.3861**
t-stat [p-value]	3.1567 [.002]
LOP	-1.9153
t-stat [p-value]	-1.3396[.181]
LSP	**8.7905**
t-stat [p-value]	3.9879 [.000]
LER	-1.7182
t-stat [p-value]	-.49225[.623]
LIR	---
t-stat [p-value]	---
CONST	**-77.6342**
t-stat [p-value]	-3.6255 [.000]

Note: Figures in bold are statistically significant at 5% level. Figures in parentheses are p-values.

The results of testing short-run dynamics are provided in Table 7. It clearly shows that most of the impact on the Japanese interest rate in the short run comes from its own past growth rates (lag 2 months) as well as gold price. The effects are positive. Thus, the stock price influences the interest rate in the long run but not in the short run.The error correction term (ECM(-1)) in the equation has the right sign (negative) and statistically significant, indicating that a given variable returns to equilibrium after deviation from it. Despite the statistical significance, the absolute value of estimated ECM(-1) is small, indicating the very slow speed of adjustment to equilibrium following short-run shocks. That is, only about 4.6% of the disequilibrium caused by previous period shocks converges back to the long run equilibrium in the LIR equation. In other words, it takes more than 15 months (1/0.046=21.74 months) to correct the disequilibrium.

Table 7: Error correction representation for the selected ARDL model

	LIR equation
ΔLGOLDP	**.24729**
t-stat [p-value]	2.3636 [.019]
ΔLOP	-.087934
t-stat [p-value]	-1.1115 [.267]
ΔLSP	-.38894
t-stat [p-value]	-.94326 [.346]
ΔLER	-.078884
t-stat [p-value]	-.49538 [.621]
ΔLIR	---
t-stat [p-value]	---
ΔLIR1	.0027310
t-stat [p-value]	.048044 [.962]
ΔLIR2	**.15315**
t-stat [p-value]	2.6922 [.008]
ΔCONST	**-3.5644**
t-stat [p-value]	-3.3333 [.001]
ECM(-1)	**-.045912**
t-stat [p-value]	-3.7502 [.000]

Note: Figures in bold are statistically significant at 10% level. Figures in parentheses are p-values.
ΔLIR1 = LIR(-1) – LIR(-2); ΔLIR2 = LIR(-2) – LIR(-3).

As a final test for structural stability, we apply the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) tests proposed by Brown, Dublin and Evans (1975). Since the plots of CUSUM and CUSUMSQ statisticsdo not cross the critical value lines, this indicates that the coefficients are stable over the sample period.

5. CONCLUSION

The focus of this paper is to investigate the relationship between the price of oil and gold and the financial variables, namely, stock price, exchange rate and interest rate. The choice of financial variables are made based on the theoretical macroeconomic basis that interest rate is a variable that captures the monetary policy instrument, exchange rate is an important transmission channel in an open economy, and stock market is an indicator of the health of an economy. We choose

Japan for our empirical investigation as it is a major oil-consuming and gold-holding country. Further, since the Japanese yen is a major currency, the findings of this study would benefit not only the Japanese monetary authority but also investors who hold the Japanese yen in their portfolios. We employed the bounds test to cointegration, which is a relatively new cointegration technique, as our methodology in this study.

Our results suggest that in the long run, gold price and the Japanese stock price have significantly positive impacts on the Japanese interest rate. This implies that rises in the price of gold and stock could help form expectations of increasing inflation over time, which eventually leads to an increase in interest rate in the long run. In the meantime, higher inflation is often thought to associate with the depreciation of the domestic currency (i.e. the Japanese yen) against major currencies. When the Japanese yen depreciates, it will adversely affect the asset portfolio return of those investors for which the Japanese yen is one of their assets. In order to reduce the wealth loss denominated in the yen and to maintain their purchasing power, the investors may find those assets whose values fluctuate against the Japanese yen value. In such cases, our results suggest that the optimal choices forinvestors in a long term would be to include goldor stock or both of them in their portfolios. Further, the finding has implications for monetary authority on how to conduct monetary policy that can use the derived information to adjust future interest rate to stabilize gold price, among others.

The results from error correction approach indicate that we may observe movements in gold price to predict fluctuations in interest rates in Japan.In addition, since increases in gold price have a depreciating impact on the Japanese yen versus major currencies (not only the US dollar), this may also suggest that in the short run, investors should sell the Japanese yen when the price of gold goes up. The equilibrium correction is fairly slow.

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