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DYNAMICS BETWEEN STRATEGIC COMMODITIES AND FINANCIAL VARIABLES

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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 (oil and gold) and the financial variables (interest rates, exchange rates and stock prices) of Japan – a major oil-consuming and gold-holding country. Our results suggest that the prices of gold and stock can help form expectations of higher inflation over time. In the short run, only gold prices impact the interest rate in Japan. Overall the findings of this study could help the Japanese monetary authority in conducting monetary policy and investors of Japanese yen in building their optimal portfolios. Specifically our findings suggest that the optimal choice in the long term for those who invest in yen-denominated assets would be to include gold in their portfolios.

Key words: strategic commodities, financial variables, bounds test to cointegration.

JEL Classifications: C32, E4, F31.

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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 have irreplaceable roles to the global economy. Oil is the most traded commodity in the world and its price fluctuations were observed not only associated with major developments in the world economy, but also a trigger for inflation and recession. The oil price hike in 1974 and 1979, for instance, 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.

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 linkages between oil prices 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). In sharp contrast to the large volume of studies on relationships between oil prices and macroeconomic variables, 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).

Gold, 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 domestic currency. Since the 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) find 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].

Literature on the relationships between gold prices and macroeconomic variables has been rather sparse and that on gold price-financial variable relationships is even sparser. Only gold price-exchange rate relationships have been empirically investigated by several studies (e.g., Capie et al., 2005; Levin and Wright, 2006; Sjaastad and Scacciallani, 1996; Sjaastad, 2008). Results from very few studies seem to ascertain the critical role of interest rates on the price of gold (e.g., Koutsoyiannis, 1983; Fortune, 1987; Cai et al., 2001). The logic is simply that during periods when nominal interest rates on short and safe financial assets are low, people tend to respond by purchasing commodities such as gold even though it does have some storage cost. To the best of our knowledge, no formal studies have been conducted on gold price-stock price relationship.

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

[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.

attempt to fill this gap, our paper examines the dynamic relationships between the price of oil, gold and financial variables taking Japan as a case country examined.

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). Still, according to the International Energy Statistics from U.S. Energy Information Administration (EIA), Japan is the third largest net oil importer in the world behind the US and China, as of March 2011. Japan is also the third biggest oil consumer with daily oil consumption of 4.4 million barrels in 2010. 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. Consequently, it had to rely heavily on oil imports to meet 45% of its energy consumption needs in 2009. 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.

[Please place Figure 1 and 2 here]

Besides, based on IMF International Financial Statistics, Japan is always among the top gold holders in the world, latest ranked at 9^{th} 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. 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.

[Please place Figure 3 here]

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 rates, exchange rates and stock price indices as the representatives of financial variables in our empirical investigation of Japan. The reason is that the interest rate is a variable that captures the monetary policy instrument, the exchange rate is an important transmission channel in an open economy, and the stock market is an indicator of the health of an economy. For the Japan case, the nominal interest rate on yen assets has 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 how the gold price and the Japanese interest rate 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 data and methodology. Section 3 presents and interprets the empirical results. Section 4 concludes with the principal findings and economic implications of this study.

2. DATA AND METHODS

2.1. Data

We collect 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 the world oil price. The original WTI crude oil spot price is acquired from the US's EIA. The monthly average of the London afternoon (pm) fix (quoted in US dollar) is selected as a representative of the world gold price and obtained from the World Gold Council. The data of Japanese macroeconomic variables including the consumer price index (CPI), the interest rate, the exchange rate (JPY/USD) and the 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 prices, oil prices 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 choice of oil price and gold price variables between the 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 prices have the highest volatility, followed by oil prices, stock prices, exchange rates and interest rates. After taking log transformation, however, the interest rate has the highest volatility, and the oil price is more volatile than the gold price. The logged interest rate 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 price 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 that of gold. The skewness, kurtosis and Jarque-Bera statistics indicate that both oil prices and gold prices are significantly non-normally distributed, especially comparedto the stock price.

[Please place Table 1 here]

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

[Please place Table 2 here]

2.2. 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 Ordinary Least Squares (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 due to the scarcity of related literature, 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 prices, gold prices, interest rates, stock prices and exchange rates 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. An augmented ARDL$(p, q_1, q_2, \dots q_k)$ 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, $p = 1,2, \dots m$ and q_i is the lag of the ith independent variable, $q_i = 1,2, \dots m$; $\Phi(L, p)$ 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, $i = 1,2, \dots k$; 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 AIC, Schwarz Bayesian Criterion (SBC), etc. 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:

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

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

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

Where $\hat{\Gamma}$ 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.

3. RESULTS AND INTERPRETATION

3.1. 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.

[Please place Table 3 and 4 here]

3.2. Bounds test results and interpretation

We first test for the presence of long-run relationships among variables, described in the equation system in Section 2.2. 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 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 JPY/USD exchange rate are the forcing variables of the interest rate in Japan. This implies that when a common stochastic shock hits the system, all the variables move together but the four variables: oil prices, gold prices, stock prices and exchange rates move first and then the interest rates follow.

[Please place Table 5 here]

Table 6 reports the coefficient estimates of the long-run relationship but we will only consider the cointegrating equation detected from the previous procedure which is the LIR equation. The results indicate that gold prices and stock prices 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. Specifically, a 1% increase in the 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 Japanese stock price.

The results indicate there is a stable causality from the gold price to the interest rate and from the stock price to the interest rate in Japan. This finding is contradictory with prior studies (e.g., Koutsoyiannis, 1983; Fortune, 1987; Cai et al., 2001) and the common thought that low nominal interest rates are likely to result in an increase in the demand for gold and hence the gold price. Our findings imply 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 the interest rate in the long run.

In contrast, the oil price and the JPY/USD exchange rate fluctuations do not have significant effects on the Japanese interest rate. It could be explained due to the fact that Japan’s annual consumption of oil has been falling in recent periods. 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.

[Please place Table 6 here]

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 prices. The effects are positive for both. Thus, the stock price influences the interest rate in Japan in the long run but not in the short run. The error correction term (ECM(-1)) in the equation has the right sign, which is 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. The equilibrium correction is thus fairly slow.

[Please place Table 7 here]

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 statistics do not cross the critical value lines, this indicates that the coefficients are stable over the sample period.

4. CONCLUSION

Oil and gold are the two most strategic commodities in the world and may have significant implications for the movements of macroeconomic variables, including those of financial variables, of any economy. Despite this fact, to the best of our knowledge, very little research has been conducted on dynamics between strategic commodities and performance of financial variables. Thus, our paper, as a first kind of such study, aims to fill in this gap.

The focus of this paper is to investigate dynamic relationships between the price of oil and gold and the financial variables in Japan, namely, stock prices, exchange rates and interest rates. The choice of financial variables are made based on theoretical macroeconomic basis that the interest rate is a variable that captures the monetary policy instrument, the exchange rate is an important transmission channel in an open economy, and the 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 employ the bounds test to cointegration, which is a relatively new cointegration technique, as our methodology in this empirical study.

Our results suggest that in the long run, the 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 the 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 who hold yen-denominated assets in their portfolios. 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 choice for investors in a long term would be to include gold 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 rates to stabilize gold prices, among others. The results from error correction approach indicate that we may observe movements in gold prices to predict fluctuations in interest rates in Japan. In addition, since increases in gold prices 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.

Results show that, either in the long run or in the short run, the oil price does not have a significant and stable impact on any of Japanese financial variables. This finding seems to contradictory with the common thought for such a major net oil importer in the world like Japan. This seemingly strange result may be attributable to the continuous decrease in Japan's annual oil consumption during recent periods and/or special characteristics of the Japanese financial and monetary system.

The scarcity of existing literature on the subject matter would raise many opportunities for further researches. Specifically, further studies could be carried out to extend the scope of this study by investigating the subject with inclusions of more strategic commodities (e.g., precious metals, coal, and natural gas) or with panel data for cross-country analysis.

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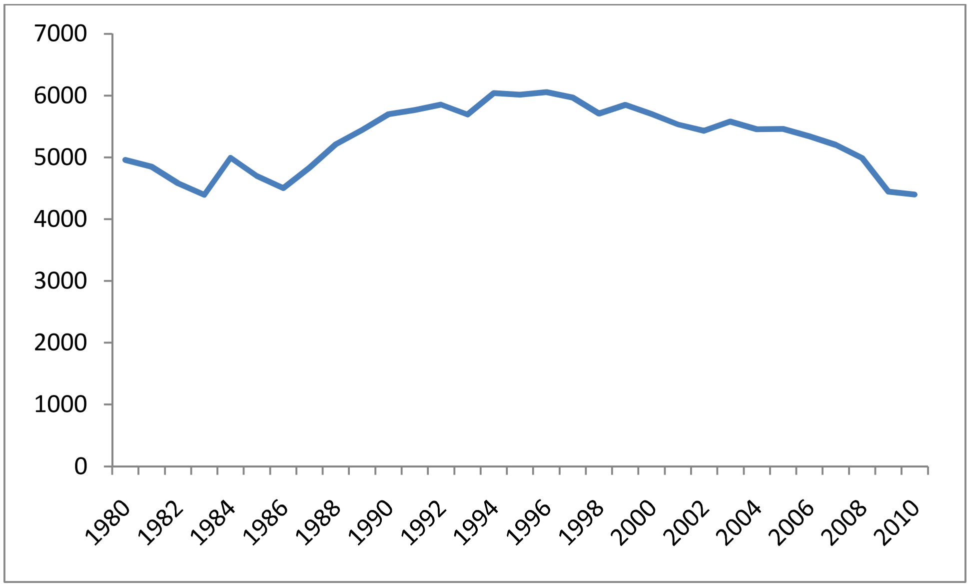
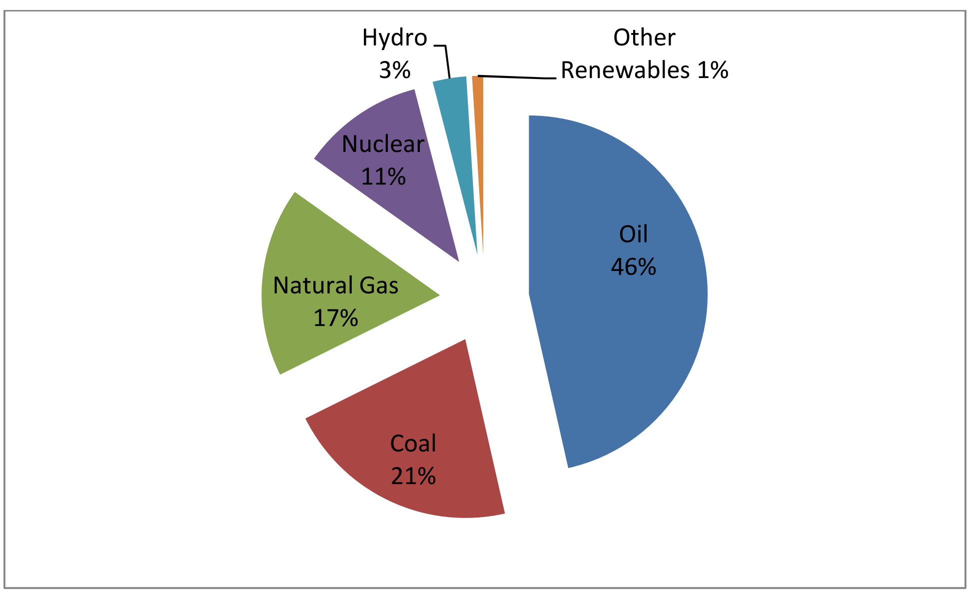
Figure 1: Japan's Oil Consumption by Year (1980-2010)



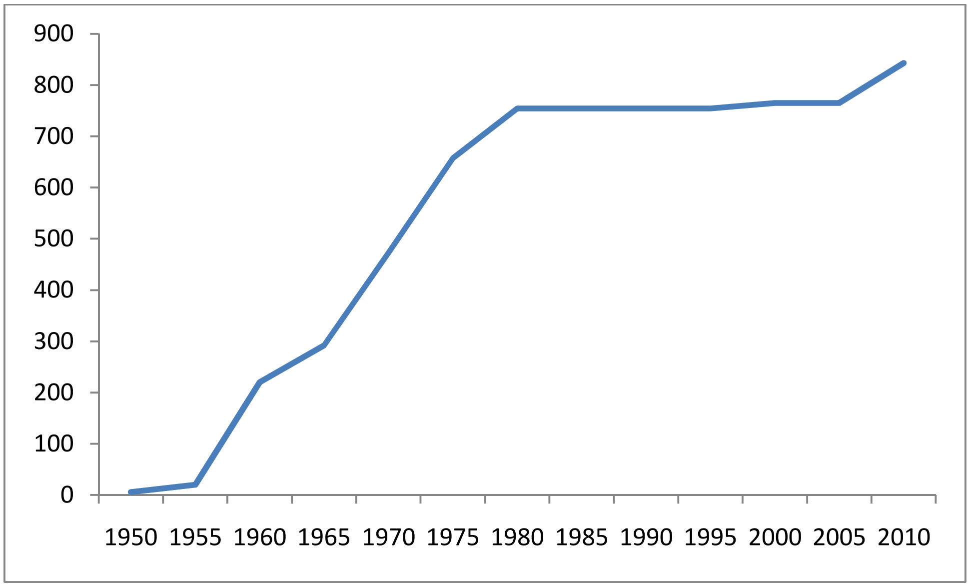
Source: US Energy Information Administration Statistics

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



Source: US Energy Information Administration

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



Source: IMF International Financial Statistics

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

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.

Table 5: Bounds test cointegration procedure results

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

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).