MODELLING ASYMMETRY IN OIL, GOLD AND STOCK MARKETS BY A HIDDEN COINTEGRATION TECHNIQUE*

1. INTRODUCTION AND OVERVIEW

Although the central role of gold in the world economy has diminished since the demise of the gold standard in the 1970s, it is still an important item in the central bank reserves, it remains to be sought-after store of value, and its price is closely watched as an indicator of changing risk perceptions. Whereas gold was historically perceived to be a hedging mechanism against economic uncertainty, the current consensus is that gold has lost much of its role in the world’s financial markets. Indeed, several authors have concluded that the importance of gold has evolved over a period of time and is now considered just like any other traded commodity (Salant and Henderson, 1978; Solt and Swanson, 1981). This argument has, however, lost its significance due to the recent global financial crisis as gold is once again returned to center stage amid strong evidence that it is being used as a hedging device by investors. In the emerging market settings, the role of gold as precautionary savings is at least as important as its personal ornament aspect and its demand is negatively related to the development of private credit markets or stock markets (Starr and Tran, 2008). However, there is continuing interest in the role and impact that gold has on financial markets, investors and the modern day firm.

Surprisingly, as yet a very few studies have examined the role of gold in stock market performance. Rubio (1989) incorporates the return on gold as a potential hedging variable into his tests of the applicability of an intertemporal capital asset pricing model (ICAPM) in the Spanish market. The ICAPM assumes that investors can build portfolios to hedge against uncertainties. Davidson et al. *The first author would like to acknowledge the financial support that has been received from the UAE University in cooperation with the UAE National Fund that has partially funded this paper via an UPAR grant.
(2003) also examined the importance of gold in an international asset pricing context. They suggest that, with its long distinguished and prominent role in the financial markets, gold is an ideal candidate to be a factor in international extensions to asset pricing models such as Merton (1973) ICAPM.

Another important item that creates foreign earnings and determines aggregate demand is oil exports. An increase in oil prices creates additional income and wealth for oil producers (or governments). If this income is transmitted back to the economy, then higher oil prices would generate higher levels of economic activity. In other words, the aggregate demand affects corporate output and domestic price levels (through its effects on expected inflation which in turn influences the expected discount rate), which eventually influences corporate earnings and stock market share prices. More specifically, asset prices and stock prices in particular will be affected by the price of oil, through the cash flow of oil related firms. Asset prices may then affect consumption through: (i) investments via the Tobin-Q effect (wealth channel), and (ii) increase a firm’s ability to fund operations (credit channel). Hence, asset prices may be an important transmission channel of wealth in an oil exporting country. It is reasonable to expect that the stock market would absorb information about the consequences of an oil price shock and include it in stock prices very quickly (in efficient financial markets, the actors will anticipate these changes, therefore, the steps will occur almost simultaneously). Both the current and the future impacts of such a shock should be absorbed into prices and returns without waiting for those impacts to actually take place, due to the fact that asset prices are the present discounted value of the future net earnings of firms. Such a strong oil (as a main source of income) and gold (as a main investment object) impact on the national economy makes countries primarily targets for examining the links among oil prices, gold prices, and the performance of their stock markets.

There has been a large volume of work investigating the links among international financial markets. In contrast, little work has been done on the relationships among oil price growth, gold price movements, and stock market performance. Jones and Kaul (1996) investigate the impact of oil shocks on the equity prices in Canada, Japan, UK, and the US using quarterly data. They utilize a standard cash-flow dividend valuation model and find that only in the case of US and Canada the reaction of stock prices to oil price shocks can be accounted for entirely by the impact of the oil
shocks on real cash flows. Huang et al. (1996) study the relationship between daily returns of oil futures and US stock returns, using an unrestricted VAR model. They find that oil future returns affect some individual oil company stock returns but have negligible impact on the broad-based market indices such as the S&P 500. Sadorsky (1999) examines the link between the US oil prices and stock prices in an unrestricted VAR model using monthly data. The result shows that oil price fluctuations are important in explaining movements in broad-based stock returns. Papapetrou (2001) uses a VAR model to study the relationship between oil prices and stock prices in Greece using monthly data. The conclusion is that stock price movements are affected by oil prices.

Hammoudeh and Aleisa (2004) examine the links between the stock market indices of five member countries of the Gulf Corporation Council (GCC) and oil futures prices using daily data. The countries in the sample are Bahrain, Kuwait, Oman, Saudi Arabia, and the UAE. Utilizing a vector error correction model (VECM), the findings suggest that there is a bi-directional causality between stock market and oil futures prices in Saudi Arabia only. They also conclude that other GCC markets are not directly linked to oil prices. El-Sharif et al. (2005) study the relationship between the price of crude oil and equity values in the oil and gas sector using daily data relating to the UK. The evidence indicates that the relationship is always positive, often highly significant and reflects the direct impact of volatility in the price of crude oil on share values within the sector. Hammoudeh and Li (2005) investigate the link between oil sensitivity and equity returns of Mexico and Norway using daily data. Utilizing Johansen’s cointegration approach and causality in the VECMs, the authors find that the oil price growth leads the stock returns of the oil exporting countries but only Norway has a lead relationship with the oil price. Malik and Hammoudeh (2007) study the volatility and shock transmission mechanisms between oil market and equity markets of Saudi Arabia, Kuwait, and Bahrain using daily data. Employing multivariate GARCH model, their results reveal that Gulf equity markets receive volatility from oil market but only in the case of Saudi Arabia. They find a significant volatility spillover from the Saudi market to the oil market. Nandha and Faff (2008) also investigate to what extent oil prices influence various global equity prices. They show that oil price rises have a negative impact on equity returns for all sectors except the mining and oil and gas industries.

Driesprong et al. (2008) examine whether changes in oil prices
predict stock returns using stock market data from 48 countries, a world market index, and price series of several types of oil. They find that stock returns tend to be lower after oil price increases and higher if the oil price falls in the previous month. This predictability was not only statistically significant but also economically significant in many countries, and in the world market index. Bhar and Nikolova (2009) investigate the link between the BRIC countries’ equity market and global oil price using weekly data. Utilizing EGARCH approach, they find that the level of impact of oil price returns on equity returns and volatility in the BRIC countries depends on the extent to which these countries are net importers or net exporters of oil. However, they show that there is a strong relationship between Russian equity and global oil price returns only. Both, equity returns and the conditional volatility of returns are largely determined by oil price return spillovers.

Finally, Bjornland (2009) analyses the impacts of oil price shocks on stock returns in Norway, highlighting the transmission channels of oil prices for macroeconomic behavior. To examine the interaction between the different variables, stock returns are included in structural VAR model. The author finds that following a 10% increase in oil prices, stock returns increase by 2.5%, after which the effect gradually dies out. However, all variables indicate that the Norwegian economy responds to higher oil prices by increasing aggregate wealth and demand.

However, no work has been done on the relationship between the stock markets of the GCC countries, and their links to the oil and gold markets simultaneously, despite the fact that the economy of these countries depends to a large extent on oil revenues and demand for gold. There is a common belief that stock market prices respond faster and larger in magnitude to oil price increases than decreases. In this paper, we suggest an alternative methodology to deal with asymmetry in oil, gold, and stock market price movements. Thus, the main objective of this study is to investigate the steady-state relationship between stock market index, oil price growth, and gold price movements by applying hidden cointegration technique (Granger and Yoon, 2002).

There is no consensus as to the existence, or nature, of the asymmetric relationship between gold price growth, oil price shocks, and stock market performance. Error correction models (ECM) or vector autoregressive models (VAR) used in the literature suffer from problems of low power in test statistics and bias issues stemming from misspecified exogenous thresholds for determining statistical
regimes. Furthermore, ECM or VAR models assume asymmetry as a short-run relationship between the series, i.e., asymmetry presents only in the adjustments process to the equilibrium and not in the cointegration relationship and there is no long-run asymmetry. Granger and Yoon (2002) introduce a hidden cointegration approach that allows for asymmetry in the long-run relationship between data components. The model specification allows for distinct cointegrating relationships between subcomponents of time series even when cointegration between two time series is not identified. Another approach that examines the possibility of asymmetric adjustment is threshold cointegration tests (Balke and Fomby, 1997; Dibooglu and Enders, 2001; Enders and Siklos, 2001). In the threshold autoregressive (TAR) model, asymmetry is a combination of short-run and long-run processes. While the literature of threshold cointegration is well developed and discussed over the last thirteen years, hidden cointegration methods are not applied or discussed frequently. The hidden cointegration is more flexible than threshold cointegration or the standard ECMs since they are not limited to two regimes and it is possible to explore all different combinations of cointegration between data components.

Thus, we test the possible asymmetric links between our variables by applying hidden cointegration analysis. This enables us to identify asymmetry of the cointegrating vectors between components (cumulative positive and negative changes) of the series. A novel contribution of this paper compared to previous papers is to allow for asymmetric behaviour between the underlying variables by applying hidden cointegration analysis. To our best knowledge, this approach has not been used in the previous literature.

The reminder of the paper is organised as follows. Section 2 presents the data description and econometric methodology. Section 3 provides the empirical findings. The last section offers conclusions.

2. Data and Econometric Methodology

The dataset used in this study consists of daily observations of the Standard & Poor’s (S&P) Emerging Market Indexes for the Gulf Cooperation Council (GCC) countries for the period April 03,
2006 through March 28, 2008. The GCC includes the United Arab Emirates, the State of Bahrain, the Kingdom of Saudi Arabia, the Sultanate of Oman, the State of Qatar, and the State of Kuwait. All value-weighted stock markets indexes and oil prices are in USD terms and are based on the closing price of the day with the exception of gold which is based on the last bid price of the day. The database time-series are drawn from Thomson Database. The justification for using the time period mentioned above stems from the availability of the data.

As we indicated in the introduction, several papers have tested and estimated long-run co-integration relationships between oil price shocks and stock prices. These studies use different specifications and identifying restrictions and have met with varying degrees of success in uncovering the relationship at test. However, almost all these models use linear long-run relationships in which the adjustment of stock prices to shocks to oil prices is assumed to be independent of whether shocks are positive or negative. However, if stock prices respond faster and larger in magnitude to oil price increases than decreases then this relationship is asymmetric. This phenomenon is evident, for example, in the case of gasoline prices and oil prices, i.e., gasoline prices shoot up like rockets in response to oil price increases but they fall slowly like feathers as the price of crude oil declines (Bacon, 1991).

Modeling this asymmetric relationship, one common approach has been to add nonlinear dynamics to the standard linear vector error correction model (VECM). The most popular approach within this literature is to specify that the error-correction term shows threshold or switching behavior among multiple regimes. As noted by de Jong (2002), nonlinear VECMs cannot rely on the Granger representation theorem, because it applies only to linear processes. The Granger representation theorem has been critical to the development of linear cointegration analysis in two ways. First, it supports the decomposition of a system of cointegrated I(1) processes into long-run and short-run dynamics. Second, it maps the linear VECM into a moving-average representation. This mapping indicated that all cointegrated systems with only linear dynamics – both long run and short run – can be modeled as linear VECMs due to the Wold decomposition.

Escribano and Mira (2002), Bec and Rahbek (2004), and Saikkonen and Choi (2004) develop the Granger representation theorem for nonlinear processes. They face several difficulties: first,
in each extension the connection to the definition of integration can break down as the nonlinear VECM is not necessarily $I(1)$, second, nonlinear VECMs cannot always be decomposed into long-run and short-run dynamics. Third, the generality of the nonlinear VECM representation within the broad class of nonlinear dynamic processes is not known.

To overcome the problems related to threshold autoregressive ECMs, we adopt a recent approach suggested by Granger and Yoon (2002) that deals effectively with these issues. They investigate the presence of a co-integrating relationship not between the aggregate series but between their components, which they call “hidden co-integration”. That is, they allow for the possibility that, even if no linear co-integration exists, there may be a long-run relation between the positive and negative non-stationary components of some series. This technique allows us to analyze not only if stock market responds to shocks, but also if this response depends on the sign of the shocks. Granger and Yoon also show that the non-linear adjustment mechanism to long-run equilibrium can be easily reduced to a linear one without any loss of information. The mathematical discussion of the model has been presented in the Appendix.

3. Empirical findings

We generated positive and negative values for the stock market indexes (S), oil prices (O), gold prices (G) as described by equations (1)-(7). The first step is to determine the order of integration of each series. The results, presented in Table 1, show that each variable is integrated of the first degree. Next we test for existence of the hidden cointegration which is done by taking into account all possible cointegration regressions for the positive and negative components. This method, unlike the standard error correction model, allows for a potential difference between the impacts of positive shocks compared to negative ones. Separating the impact of positive shocks from negative ones is important, especially in the financial markets, because people react more to negative shocks than to positive ones even in cases when the magnitude of the shock is the

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It should be mentioned that the series were decomposed into their positive and negative values by using a statistical software component written in GAUSS by Hatemi-J (2014).
Table 1 - Unit Root Test Results

<table>
<thead>
<tr>
<th>Variables</th>
<th>$H_0$: I(1), $H_1$: I(0)</th>
<th>$H_0$: I(2), $H_1$: I(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$G^+$</td>
<td>0.586507</td>
<td>-24.05158</td>
</tr>
<tr>
<td>$G^-$</td>
<td>-2.291876</td>
<td>-20.71140</td>
</tr>
<tr>
<td>$O^+$</td>
<td>0.659714</td>
<td>-26.03819</td>
</tr>
<tr>
<td>$O^-$</td>
<td>-2.151618</td>
<td>-24.58073</td>
</tr>
<tr>
<td>UAE $S^+$</td>
<td>-0.990878</td>
<td>-21.86207</td>
</tr>
<tr>
<td>UAE $S^-$</td>
<td>-1.319025</td>
<td>-19.34920</td>
</tr>
<tr>
<td>Saudi Arabia $S^+$</td>
<td>-0.864385</td>
<td>-24.75427</td>
</tr>
<tr>
<td>Saudi Arabia $S^-$</td>
<td>-2.812587</td>
<td>-19.93741</td>
</tr>
<tr>
<td>Oman $S^+$</td>
<td>-0.028370</td>
<td>-20.57864</td>
</tr>
<tr>
<td>Oman $S^-$</td>
<td>-0.709029</td>
<td>-21.94263</td>
</tr>
<tr>
<td>Kuwait $S^+$</td>
<td>0.637592</td>
<td>-20.08475</td>
</tr>
<tr>
<td>Bahrain $S^+$</td>
<td>1.988134</td>
<td>-23.48762</td>
</tr>
<tr>
<td>Bahrain $S^-$</td>
<td>-0.573913</td>
<td>-22.86218</td>
</tr>
<tr>
<td>Qatar $S^+$</td>
<td>1.163964</td>
<td>-20.99034</td>
</tr>
<tr>
<td>Qatar $S^-$</td>
<td>-2.258152</td>
<td>-19.77026</td>
</tr>
</tbody>
</table>

Notes:
1. The Phillips-Perron unit root test is used, which rebuts autocorrelation and heteroskedasticity.
2. The Andrews (1991) bandwidth is applied to select the optimal length of the kernel.
3. The critical values are -3.443415 and -2.867195 at the 1% and 5%, respectively.
4. G., O., and S represent gold prices, oil prices, and stock market indexes, respectively.

same in absolute terms. The results of Granger-Yoon cointegration tests are presented in Table 2 which indicates that there is no hidden cointegration between the underlying variables in any of the six countries in the GCC region, even if we allow for asymmetric relationship by separating the effect of positive shocks from negative ones. This is based on the fact that the null hypothesis (there is
no cointegration between negative components as well as positive components of the underlying variables) cannot be rejected at any conventional significance levels.

Thus, systematic long run positive or negative shocks on gold and oil prices cannot affect the stock price indexes of these six countries. We interpret these results as empirical support for the
efficient market hypothesis that states that changes on the stock markets cannot be predicted based on public information. However, based on these results, we can conclude that neither gold nor oil prices causes the stock price index in each market. The economic implication of this empirical finding is that the financial markets are informationally efficient in the six GCC equity markets. Thus, the information contained in oil and gold price indexes cannot be used to predict the future values of the equity indexes in these six countries.

Our findings are in line with the results of Al Janabi et al. (2010) who explore whether the Gulf Cooperation Council equity markets are informationally efficient with regard to oil and gold price shocks using a robust bootstrap simulation technique. The empirical findings reveal that the GCC equity markets are informationally efficient with regard to gold and oil price indexes. Their results entail that short-term arbitrage profit opportunities in the equity markets of these countries might not prevail. Their findings can also reconcile previously contradictory results regarding the weak and semi-strong forms of efficiency of the GCC stock markets and its relation vis-à-vis petrol and gold prices. Furthermore, Hammoudeh and Aleisa (2004), albeit the authors did not include all of the six GCC equity markets in their testing sample and, therefore, their testing was carried out on GCC markets by excluding Qatar equity markets, also conclude that the GCC markets are not directly linked to oil prices except in the case of Saudi Arabia, where there are bidirectional causality between oil prices and stock prices.

Our findings can aid institutional investors and portfolio managers operating in the Gulf region in the structuring of coherent trading portfolios. The latter can be attained by devising rational asset allocation strategies between the six GCC equity markets and by utilizing oil and gold as a defensive hedging strategy in case of equity markets’ turmoil.

4. Summary and conclusions

Historically, investors have sought financial shelter from inflation and political instability through investing in gold. As such, a gold price factor is a strong factor to play a hedging role in the financial market. We also discussed that asset prices and stock prices in particular will be affected by the price of oil, through the cash flow of oil related firms. Asset prices may then affect consumption through:
(i) investments via the Tobin-Q effect (wealth channel), and (ii) increase a firm’s ability to fund operations (credit channel). Hence, asset prices may be an important transmission channel of wealth in an oil exporting country. Thus, the main focus of the analysis is to examine if and how oil price shocks and gold price growth influence stock returns in the GCC countries. A novel contribution of this paper compared to previous papers is to allow for asymmetric behaviour (by separating positive and negative shocks) between the underlying variables by applying hidden cointegration analysis. To our best knowledge, this approach has not been used in the previous literature.

However, we find that there is no cointegration between the stock prices and gold and oil prices in the six GCC countries. Overall, the results show that neither the oil price index nor the gold price index causes the equity price indexes of the six GCC markets. This implies that the information contained in the gold and oil price indexes cannot improve the forecast of the equity market index in each of the six GCC states. Thus, the possibility of arbitrage is ruled out and the six GCC equity markets can be considered as informationally efficient with respect to oil and gold prices. This has important policy implications for domestic and foreign institutional investors and portfolio managers operating in the Gulf region since the above finding can aid in the structuring of coherent trading portfolios. This can be achieved by developing rational asset allocation strategies between the six GCC equity markets and by utilizing oil and gold as a defensive hedging strategy in case of equity markets’ turmoil.

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Modelling asymmetry in oil, gold and stock markets by a hidden cointegration technique


**ABSTRACT**

This paper investigates the relationship between gold price growth, oil price shocks, and stock price index in the GCC countries over the period 2006-2008 using daily data. We apply hidden cointegration technique which identifies asymmetry of the cointegrating vectors between components (cumulative positive and negative changes) of the series. The results suggest that there is no link between stock price, gold price growth and oil price shocks. Our findings imply that stock market performance cannot forecast and be forecasted by oil and gold prices. Thus, the possibility of arbitrage is ruled out and the six GCC equity markets can be considered as informationally efficient with respect to oil and gold prices. This has important policy implications for domestic and foreign institutional investors and portfolio managers operating in the Gulf region since our finding can aid in the structuring of coherent trading portfolios in case of equity markets’ turmoil.

Keywords: Stock Market, Oil and Gold, Asymmetry, Hidden cointegration, GCC

JEL Classification: C20, F41, G1

**RIASSUNTO**

*Modelli di asimmetria nel mercato del petrolio, dell’oro e nei mercati azionari attraverso una tecnica di cointegrazione nascosta*

Questo lavoro esamina la relazione tra l’aumento del prezzo dell’oro, gli shock del prezzo del petrolio e gli indici azionari nei paesi del Golfo nel periodo 2006-2008 attraverso l’utilizzo di dati giornalieri. Viene applicata una tecnica di cointegrazione nascosta che identifica le asimmetrie dei vettori di cointegrazione tra le componenti (sia di segno positivo che negativo) della serie. I risultati suggeriscono che non c’è relazione tra indici azionari, crescita del prezzo dell’oro e shock nel prezzo del petrolio. Così la possibilità di arbitraggio è esclusa e i sei mercati azionari dei paesi del Golfo possono essere considerati informativamente efficienti in rapporto ai prezzi del petrolio e dell’oro. Ciò comporta implicazioni importanti sia per gli investitori nazionali che per quelli stranieri e per gli operatori di borsa che operano nella regione del Golfo, in quanto le evidenze riscontrate in questo studio possono aiutare a strutturare coerenti portafogli di trading in caso di volatilità nei mercati azionari.
APPENDIX

Separating the impact of positive shocks from negative ones is essential, particularly in financial markets, since people seem to respond more to negative shocks than to positive ones even in situations in which the size of the underlying shock is identical in absolute terms. Previously published work by Longin and Solnik (2001), Ang and Chen (2002), Hong and Zhou (2008), as well as Alvarez-Ramirez et al. (2009) indicate that the returns and the underlying correlations in financial markets are characterized by an asymmetric structure.

Granger and Yoon (2002) develop a hidden cointegration technique to identify the dynamics between data components. The data components include both cumulative positive and negative changes of time series. If the components of two data series (negative or positive) are cointegrated, then the data has a hidden cointegration. This is an example of nonlinear cointegration that ordinary linear cointegration fails to identify. Suppose $X_t$ and $Y_t$ are two random walk time series:

\[ X_t = X_{t-1} + \epsilon_t = X_0 + \sum_{i=1}^{t} \epsilon_i, \]

\[ Y_t = Y_{t-1} + \eta_t = Y_0 + \sum_{i=1}^{t} \eta_i, \]

where $t = 1, 2, \ldots, T$ and $X_0, Y_0$ are initial values, $\epsilon_i$ and $\eta_i$ denote mean zero white noise disturbance terms. A standard cointegration exists if \{X, Y\} are cointegrated by one cointegrating vector. When movements of $X_t$ and $Y_t$ are asymmetric, it is possible to detect hidden cointegration between them. Granger and Yoon (2002) define positive and negative shocks as follows:

\[ \epsilon^+_i = \max(\epsilon_i, 0), \quad \epsilon^-_i = \min(\epsilon_i, 0), \quad \eta^+_i = \max(\eta_i, 0), \text{ and } \eta^-_i = \min(\eta_i, 0) \]

\[ \epsilon_i = \epsilon^+_i + \epsilon^-_i \text{ and } \eta_i = \eta^+_i + \eta^-_i. \]

Thus,

\[ X_t = X_{t-1} + \epsilon_t = X_0 + \sum_i^t \epsilon^+_i + \sum_i^t \epsilon^-_i, \text{ and } Y_t = Y_{t-1} + \eta_t = Y_0 + \sum_i^t \eta^+_i + \sum_i^t \eta^-_i. \]

Then the notations can be simplified with:

\[ X_t^+ = \sum_i^t \epsilon^+_i, \quad X_t^- = \sum_i^t \epsilon^-_i, \quad Y_t^+ = \sum_i^t \eta^+_i, \text{ and } Y_t^- = \sum_i^t \eta^-_i, \]
Thus,

\[ X = X_O + X_t^+ + X_t^-, \text{ and } Y_t = Y_O + Y_t^+ + Y_t^- . \]  

(6)

Consequently,

\[ \Delta X_t^+ = \varepsilon_t^+, \Delta X_t^- = \varepsilon_t^-, \Delta Y_t^+ = \eta_t^+, \text{ and } \Delta Y_t^- = \eta_t^- . \]  

(7)

We calculate the first difference (\( \Delta X_t = X_t - X_{t-1} \)) for both of the time series and sort observations to positive and negative movements (\( \Delta X_t^+ \) and \( \Delta X_t^- \)). We also calculate the cumulative sum of positive (negative) changes, at a given time, for all variables (\( X_t^+ = \sum \Delta X_t^+ \) and \( X_t^- = \sum \Delta X_t^- \)) via equations that are presented above. The same procedure also applies for \( Y \) variable. It should be mentioned that Granger and Yoon (2002) assumed that there were not deterministic trend components. Hatemi-J (2014b) shows how integrated variables with deterministic trend components can be transformed into cumulative sums of positive and negative parts.