The International Journal of Business and Finance Research
Vol. 16, No. 1, 2022, pp. 35-46
ISSN: 1931-0269 (print)
ISSN: 2157-0698 (online)

IBFR
www.theIBFR.com

EVIDENCE ON RELATIONSHIPS BETWEEN OIL, GOLD, AND THE CHINA STOCK MARKET

Che-Ming Yang, Xiamen University Tan Kah Kee College
Shuo-Ming Xing, Xiamen University Tan Kah Kee College

ABSTRACT

Many studies exist on the relationship between capital markets, oil prices, and the gold price that provide many meaningful results. But the impact of oil and gold prices on the China market is rarely considered. We use variables such as the return of oil price, return of gold price, volatility index of Chicago Board Options Exchange, and exchange rate to explore their relationship with the Shanghai Securities Composite Index. Our results show the Shanghai Securities Composite Index is affected by these international factors. In addition, we calculated the threshold value for the threshold effect of oil price on the Shanghai Securities Composite Index but using the similar method, there is no threshold effect of gold price on the Shanghai Securities Composite Index.

JEL: G00, G10

KEYWORDS: Oil Price, Chinese Market, Threshold Effect

INTRODUCTION

A number of scholars have used various techniques to explore the relationship between multivariate factors and stock returns, including the return of oil price, return of gold price, Volatility Index (VIX), and exchange rate (Sadorsky, 1999, Gokmenoglu and Fazlollahi, 2015, Jain and Biswal, 2016, Singhal et al., 2019). This paper focuses on international factors that impact the Chinese stock market. The motivations and contributions of this paper are twofold: firstly, most of the extant literature on the Chinese stock market uses the Chinese oil market, the Chinese gold market, and the exchange rate market. However, Chinese oil and gold prices are not exactly equal to international oil and gold prices. One of the questions of this paper is whether international factors affect the Chinese stock market (Cong et al., 2008, Luo and Qin, 2017). Secondly, empirical research methods used on this topic use mostly linear models. Since oil prices experienced a panic increase due to the 2008 economic crisis during our study period, the linear model may be inaccurate. Therefore, in this paper, we try to use a nonlinear threshold model to test the relationship between these factors and SSEC (Gokmenoglu and Fazlollahi, 2015, Singhal et al., 2019).

The main objective of this study is to investigate whether there exists a relationship between the gold price, oil price, VIX, and the exchange rate (CNY/USD), on the Shanghai Securities Composite Index (SSEC). Second, we investigate the length of time that the above factors will affect the returns of the SSEC and their significance. Finally, we examine the threshold effect of oil prices on SSEC. The impact between the stock market and the exchange rate market is not direct but through the linkage reaction of the oil market. Therefore, we expect the impact will change over time. According to a study of the Mexican market by Singhal et al (2019), the reaction times of oil, gold and the exchange rate to the stock market are variable. Moreover, by adjusting for these factors lagging 1, 2, and 3 periods respectively, they concluded that the price of oil negatively impacts the exchange rate, however, the price of gold has an insignificant impact on the exchange rate. In this study, first, we find that the return of oil price has a weakening significant as time goes, possibly resulting from a momentum effect. Second, the return of gold price is significant with

SSEC in the current period and at two lags periods. We suspect this effect may be due to a reversal effect of overreaction. VIX is significant as usual, which is consistent with historical experience. The significance of the exchange rate to SSEC return is relatively weak. Finally, we find that there is a threshold effect of oil price returns on the return of SSEC. Moreover, when we use data from the post-2008 economic crisis, we can illustrate that high oil prices do not produce a significant positive effect on the stock market. We find the oil price works positively for the stock market when it is between 50.06 and 83.06. The rest of the paper is organized as follows: Section 2 is the literature review; Section 3 presents the data and methodology and Section 4 is the empirical result. Section 5 provides some concluding comments.

LITERATURE REVIEW

Crude oil is an important resource for industry and provides the basis for whether industrial producers can provide consumers with stable products. Drastic changes in oil prices can expose producers and consumers to market risks. Past research has found that oil prices have a correlation with the stock market. Sadorsky (1999) analyzes movements in oil price and how they explain the relationship with movements in stock returns. Another, the oil market also provides the opportunity to hedge, as well as hedging opportunities for the stock market, Arouri et al. (2011), provide evidence that the Gulf Cooperation Council (GCC) provides the best hedging ratio with the oil market in these markets, ranging from a low of 0.0782 (Saudi Arabia) to 0.4289 (Oman). However, other studies have shown that different countries and types of markets react to oil price to different degrees, which can be broken down into aspects such as emerging markets versus developed markets. For example, Hammoudeh et al. (2011) examined the South Korea market, which was an emerging market at the time. They find that the country's rapid industrialization led to an increase of more than 300% in energy consumption in its industrial sector. Their research points out that corporate profits will drop when oil prices experience an adverse shock and investors will sell their holdings. From this, we think that the China stock market, as an emerging market, will also be affected by the oil price. In addition, Degiannakis et al. (2018) found that correlation between the stock market and oil price is roughly the same in countries that are oil-importing or oil-exporting. But the correlation between the two markets is more likely to be affected by some unpredictable sudden changes in the demand side, such as the Asian crisis, the real estate boom, the global economic crisis, and the rapid growth of the Chinese economic market.

In 2020, China's crude oil consumption reached 736 million tons, of which 542 million tons were imported accounting for 73.64% of the overall. This suggests that China's capital market will be shocked by changing international oil prices. However, China's domestic oil price is affected by the mark-up, which does not truly reflect its relationship with the capital market. Cong et al. (2008) conducted an evidence-based study of the Chinese market through a multivariate autoregressive approach (VAR model). They found the shock of oil price is limited for the composite class, such as the Shanghai and Shenzhen stock. However, the manufacturing index and some oil-related companies show a more significant statistical effect on changes in oil price. Some studies have different views. For instance, Luo and Qin (2017) use the VAR model to produce evidence that oil price shocks have a positive effect on the China stock market. They argue that higher oil prices are a sign of increased aggregate demand and represent a boom. At the same time, they apply the oil volatility index (OVX) and find the OVX has a negative impact on the China stock market. From past research, we have found that oil prices have an impact on the stock market, but the positive or negative impact is not consistent. Results may be driven y the selection of the data period or the research method.

In financial markets, many financial assets may have inconsistent positive and negative returns. As a result, some studies use asymmetric models for estimation. Escobari and Sharma (2020) use a variety of nonlinear models. They find that stock price shocks to crude oil is asymmetric. Because oil is a highly demanded energy commodity, when the economy is in a recession and encounters an increase in oil price, the financial

market reacts relatively quickly. Their research shows this reaction will be immediately reflected in consumers and the stock market. Other studies use threshold regression to identify mutation points. The threshold regression model (TR) describes a simple form of nonlinear regression with the special feature of using ordinary regression practices to identify mutation points for segmented regression (Hansen, 1999). In our study, we find a threshold effect of oil price changes on the return of the SSEC index, which is consistent with the model proposed by Barberis et al. (1998).

We know that precious metals are another important investment instrument in financial markets because of their good returns and low volatility and correlation properties. Metals are unlike the stock market, which can diversify away from increasing market risks. Batten et al. (2010) document the sensitivity of precious metal volatility to macroeconomic factors. Overall results suggest that precious metals cannot be considered a a single asset class and, in particular, that the volatility of gold can be explained empirically by monetary variables. Traditionally, gold has been used as a hedge against inflation and will show its usefulness in times of economic crisis. Gold creates a hedge to diversify increasing risks in the market, thanks to the different volatility and the low return correlation with equities that it offers at the sector and market level. It is an ideal asset class for portfolio diversification (Arouri and Nguyen, 2010, Daskalaki and Skiadopoulos, 2011). Some studies argue that gold should predominate in the optimal portfolio (Arouri and Nguyen, 2010, Hammoudeh et al., 2011, Baur, 2012). Therefore, investors can adjust their investment strategies to the stock market according to changes in the gold price, thereby affecting stock market prices. Zhang et al. (2021) used the DCC-GARCH model to investigate whether there would be a transmission of gold to the stock market due to hedging. They found the optimal hedging ratio of spot gold to the stock market was at 0.0952, but the spot gold to oil is the highest hedge ratio of 0.2271. They concluded that gold is a good hedge instrument against stock market risks.

Gokmenoglu and Fazlollahi (2015) used the ARDL model for the gold price, oil price, gold price volatility (GVZ), and oil price volatility (OVX) on the S&P500 stock market price index (GSPC). They found that all variables have an impact on the stock price index, but the gold price has more impact on the stock market. Jain and Biswal (2016) used the DCC-GARCH model to study the relationship between oil price, gold price, exchange rates, and the Indian stock market over the same period. They argue that crude oil price is a key determinant of future economic growth and is of great significance. Their results show that gold price, exchange rates, and the stock market have a short-term negative correlation. This means that investors may transfer their assets from high-risk assets to low-risk or stable-risk assets when macroeconomic risks increase. Arouri et al. (2015) studied the relationship between gold and other precious metal markets and the China stock market and found the price of gold had a significant volatility crossover effect on the Chinese stock market in 2004-2011. Their research shows that including gold in China's stock investment portfolio can effectively improve risk-adjusted performance.

Since oil and gold are settled in U.S. dollars, there may be a correlation between exchange rates and capital markets. Gavin (1989) argued that since monetary policy affects the foreign exchange market, the interest rate dominates the change with the exchange rate, which affects the price volatility of the stock market. In terms of spillover effects, Jebran and Iqbal (2016) indicated there are spillover effects in the stock market and the foreign exchange of some Asian countries. They found asymmetric volatility spillovers in the two markets, especially in China, where there is a two-way asymmetric volatility spillover between the foreign exchange market and the stock market. In other studies, they found that the oil price, gold price, and exchange rate are correlated. For example, Kumar et al. (2021) found that energy price has a significant impact on the Indian market. In theory, exchange rates, interest rates, and the securities market will have a certain degree of dependence on funds due to the relationship between the economic boom. Due to the Indian government's control measures on oil imports, the increase in oil price has a significant impact on the gas market. The impact of gold prices on the oil and gas markets is also significant. The exchange rate is not significant. Therefore, this article attempts to verify whether the same relationship exists on the Shanghai Securities Composite Index.

Most studies examine only the movements between oil price, gold price, and stock price indices of each country through models such as GARCH and ARDL (Gokmenoglu and Fazlollahi, 2015, Singhal et al., 2019). But, Sarwar (2012) analyzes the impact of VIX on the BRIC countries' stock markets. Because of the time difference, the opening time of the US stock market is displayed at different times in China, Indian and Russian markets and managers can adjust their investment strategies in time. Their research results show that VIX is not only a fear index for American investors, but also a fear index for investors in Brazil, China, and India. So, we consider the volatility index (VIX) in our paper. The VIX is the trading code of the Chicago Board Options Exchange market volatility index. It is commonly used to measure the implied volatility of S&P 500 index options. The VIX is a price-weighted index of a series of S&P 500 index options. It is often referred to as the " Panic Index" or "Panic Indicator". It is a measure to understand the market's expectations of future market volatility. We included VIX to test the impact of the three variables of oil price, gold price, and VIX on the securities market.

DATA AND METHODOLOGY

From past research, we understand that oil price, gold price, or VIX all have an impact on the securities market. However, the Chinese securities market has only gradually grown in the last thirty years. Coupled with the particularity of Chinese economic regulation, this article discusses whether the phenomena that exist in various international markets will also appear in the Chinese market. In this paper, we study the relationship between oil price returns, gold price returns, VIX, and the exchange rate to the return of Shanghai Securities Composite Index (SSEC). Data on the gold price, oil price, and VIX come from the FRED economic database. The SSEC and CNY/USD are provided by the Wind database. CNY/USD adopts the middle price. All data use daily observations. Our data period is from 1991/01/02 to 2020/12/30. We use the natural logarithm format for all variables. The returns of these variables are calculated using the following formula:

$$r_t = ln(X_t)/ln(X_{t-1})$$

X represents the variables used in this article. Cong et al. (2008) find the impact of international oil is significant in the China stock market. Among the various international oil price series, the best known are the prices of OPEC, Brent, and WTI. Most studies on oil price use WTI. In order to avoid differences caused by data, this article follows the use of Oil_WTI. Gold is an important investment commodity in the international financial market. However, since China is a net importer of gold, its domestic market usually has a premium to the international gold price. As a result, we use the closing price of the London bullion market at 15:00 in US dollars instead, and in this paper, we use $Gold\_1500$ instead. Chen and Yang (2019) find the VIX has a significant impact on most investments, and is very stable and sensitive, so we use the Chicago Board Options Exchange's VIX as our reference variable and replace it with Vix in this paper. Oil and gold price are quoted in U.S. dollars in the international market, and the exchange rate also affects the flow of funds. This article takes the exchange rate into consideration and represents it as US_CNY. The Shanghai Stock Exchange (SSE) develops the Shanghai Stock Exchange Composite Index (SSEC) is one of the two major exchanges in China. It has the significance of a weather vane for the China stock market. So, we use SSEC as the object for the test. The methodology is divided into two parts: "impact on the Return of the SSEC with GARCH Model" and "impact on the Return of the SSEC with Threshold Model".

Impact on the Return of the SSEC with GARCH Model First

We estimate the relationship between the SSEC index and the gold price, the oil price, the VIX, and the exchange rate. For this, we use three different time conditions for the model to be inferred. We observe the results of the current period, lagged one period and lagged two periods, Equation 1 and 2 show the formulas:

$$R\_SS_t = \beta_0 + \beta_1 Oil\_WTI\_r_t + \beta_2 Gold\_1500\_r_t + \beta_3 Vix_t + \beta_4 US\_CNY_t + \varepsilon_t \quad (1)$$

$$R\_SS_t = \beta_0 + \beta_1 Oil\_WTI\_r_{t-1} + \beta_2 Gold\_1500\_r_{t-1} + \beta_3 Vix_{t-1} + \beta_4 US\_CNY_{t-1} + \varepsilon_t \quad (2)$$

In these models, R_SS is the daily SSEC index return. R_SS_t state the daily return of the SSEC index at the end of day t. $Gold\_1500\_r_t$ represents the price return at the 15:00 in the London bullion market. $Oil\_WTI\_r_t$ is the return representing the price of oil at the end of day t. The Vix_t is the VIX at the end of day t. And US_CNY_t is the Dollar against the CNY (mid-price) at the end of day t. All variables in Equation 2 are the value lagged one period. Singhal et al. (2019) argued that if the relationship between variables is established in a long-term observation process when using the long-term error estimation equation, the error correction term in the error correction model may appear. Therefore, in this paper, the factors and number of backward periods is incorporated into an equation for long-term observation. Doing so facilitates observation of the variation of these factors in the subsequent study, and results from Equation (3) can be obtained.

$$\begin{aligned} R\_SS_t = {} & \beta_0 + \beta_1 Oil\_WTI\_r_t + \beta_2 Gold\_1500\_r_t + \beta_3 Vix_t + \beta_4 US\_CNY_t + \beta_5\, Oil\_WTI\_r_{t-1} \\ & + \beta_6 Gold\_1500\_r_{t-1} + \beta_7 Vix_{t-1} + \beta_8 US\_CNY_{t-1} + \beta_9 Oil\_WTI\_r_{t-2} \\ & + \beta_{10} Gold\_1500\_r_{t-2} + \beta_{11} Vix_{t-2} + \beta_{12} US\_CNY_{t-2} + \varepsilon_t \end{aligned} \quad (3)$$

There is sometimes an asymmetric effect of unknown returns in finance markets. The symmetric GARCH model is often used to handle such situations. However, this method has a major flaw in that it cannot determine the time point or price of the asymmetry. The threshold regression (TR) model can solve this problem. Applications of TR include sample split models, multiple equilibrium models, and the very popular threshold autoregressive (TAR) and self-excited threshold autoregressive (SETAR) specifications (Hansen, 1999, 2011). It can describe a simple form of nonlinear regression featuring piecewise linear specifications and regime-switching that occurs when an observed variable crosses unknown thresholds.

Impact on the Return of the SSEC with Threshold Model

The threshold model proposed by Hansen (1999) is commonly used to calculate the threshold and P-values of the threshold autoregressive (TAR) model, and its basic structure is as shown in Equation 4:

$$y_{it} = \mu_{it} + \beta_1 x_{it} \cdot \delta(q_{it} \le \gamma) + \beta_2 x_{it} \cdot \delta(q_{it} > \gamma) + \varepsilon_{it} \quad (4)$$

In Equation 4, y_{it} is the dependent variable, x_{it} is the independent variable, q_{it} is the threshold variable, γ is the threshold value, subscript i denotes individual, subscript t denotes time, and $\delta(\cdot)$ is the indicator function. In the Hansen model, the observed sample is divided into two stages, depending on the threshold variable, and the parameters β_1 and β_2 are allowed to vary between the two polities, here ($\beta = \beta_1, \beta_2$), ensuring that:

$$y_{it} = \mu_{it} + \beta x_{it}(\gamma) + \varepsilon_{it} \quad (5)$$

Chen and Yang (2019) use the hypothesis that Hansen's (1999) model predicts portfolio returns with a threshold value of oil price. They find a threshold effect of oil price on portfolio returns. Their research demonstrates that after reducing the relationship between the industry and oil through the portfolio, the characteristics of the portfolio will also be affected by changes in oil price. Since the SSEC index is compiled from a weighted composite stock price index that is calculated using all stocks listed on the SSEC, it is not difficult to introduce the threshold effect of oil price on corporate returns. It is also applicable to the SSEC index, which is also verified by the empirical results later in this paper. In this study, we specified the threshold equation by Equation 6:

$$R\_SS_t = \alpha_1 + \beta_2 Oil\_r_t + \omega_1 Oil\_r_t \cdot \delta(Oil\_WTI_t \leq \gamma) + \omega_2 Oil\_r_t \cdot \delta(Oil\_WTI_t > \gamma) + \varepsilon_t \quad (6)$$

In this specification, the current oil price is the threshold considered and Oil_WTI_t is the price of WTI. Oil_r_t are present the price return of WTI. This equation divides the result of the equation into two regimes depending on whether the threshold Oil_WTI_t will be smaller than γ. The coefficient ω_1 and ω_2 and the elements of Oil_r_t varies with time. Meanwhile, ε_t obeys an independent identical distribution. We calculate the threshold effect of gold price on the SSEC index by Equation (6), an equation that is achieved by replacing oil price and oil return equally with gold price and gold return. However, in our study, we find that there is no threshold effect of gold price on the SSEC index, which is consistent with the actual situation. In the Chinese market, gold usually exists not as an investment instrument, but as a collection instrument, so there is no threshold effect of gold in the Chinese financial market. So, we do not present the results of the gold price. To make it easier for readers to understand the variables used in this article, we summarized them in Table 1:

Table 1: Definition of Variables

Variable	Definition
Oil_WTI	The oil price of West Texas Intermediate
Oil_WTI_r	The oil price return of West Texas Intermediate
Oil_r	The oil price return of West Texas Intermediate is used in the threshold model
$Gold\_1500\_r$	London Bullion Market Gold Price at 15:00 hours
US_CNY	the Dollar against the currency of China (mid-price)
Vix	Volatility Index
SSEC	China Shanghai Securities Composite Index

This table summarizes all variables which we have used in the model, and we explain them.

This study firstly explores the impact of gold price, oil price, VIX and CNY/USD exchange rate on SSEC. Second, we discuss the threshold effect of oil price on SSEC.

EMPIRICAL RESULTS

In this section, we discuss the impact of the gold price, oil price, VIX, and the exchange rate between CNY and USD on the Shanghai Securities Composite Index (SSEC). Degiannakis et al. (2018) argue the fluctuation of oil price has a salutary impact on the stock market and the oil market provides hedging opportunities for the stock market. Therefore, the two markets are connected. In addition, Jawadi et al. (2016) demonstrated the price of crude oil shows a collinearity relationship with the return in the exchange rate market. This result implies that we can use the exchange rate as an indicator of monitor the stock market. Chen and Yang (2019) found that VIX returns are similarly significant for the stock market, with a negative correlation in most portfolios. Singhal et al. (2019) found the price of gold is likewise highly correlated with stock prices in an empirical demonstration of the Mexican stock market using the ARDL model. Results show the lag lengths of oil, gold, and exchange rates are different when the system is subject to shocks. Hong and Stein (1999) argue that investors in the market are divided into two categories, news watchers and momentum traders. News watchers have behavioral biases of news, resulting in the prices of the assets traded not reaching the equilibrium price instantaneously. When news watchers start trading and the price gradually rises, momentum traders start to enter the market. Since these investors do not enter the market at the same time, early momentum traders have a lower price than the long-term equilibrium price, so they can profit. When they push the price further up, and another group of momentum traders enter, the prices is driven higher implying stronger momentum. At that time, the trade prices are higher than the long-term equilibrium price, thus allowing an overreaction to form.

In this paper, investors have different reaction times to the SSEC when they get news about gold and oil prices. Table 2 shows the momentum of these assets is different, as we can see from the table, oil returns create a momentum effect that gradually decreases against the return of SSEC as the lag periods changes. The return of gold price to return of SSEC shows significance in the current period. The coefficient reverses and is not significant in the lag one period, but in the lag two periods, gold returns are coefficients reversed again and significant. This pattern is consistent with the reversal effect due to overreaction proposed by Chopra et al. (1992). We first consider the relationship between Oil_WTI_r, $Gold\_1500\_r$, Vix, and US_CNY with SSEC return in the current period. We use Equation (1) for testing. From Table 2, we find that US_RMB is statistically significant at the 5% significance level and other variables are statistically significant at the 1% significance level. Among the three variables of Oil_WTI_r, $Gold\_1500\_r$, and Vix, only the Vix is significantly negative, which is consistent with the results of past research. Take Oil_WTI_r as an example in Table 2. When Oil_WTI_r increases by 1%, SSEC return will increase by 0.0203% and other conditions remain unchanged.

Table 2: The Results for all Variables in the Current Period

Variable	Coefficient	Prob.
$Oil\_WTI\_r_t$	0.0203	0.0003***
$Gold\_1500\_r_t$	0.0576	0.0000***
Vix_t	-0.0001	0.0002***
US_CNY_t	0.0004	0.0263**

Table 2 shows the relationship of Oil_WTI_r, $Gold\_1500\_r$, Vix, and US_CNY. We use equation (1) for testing. Table 2 presents the P-value of Oil_WTI_r, $Gold\_1500\_r_t$, and Vix are 0.0003, 0.0000, and 0.0002 respectively. These factors are statistically significant at the 1% level. US_CNY is 0.0263, it is statistically significant at the 5% significance level. Equation (1) as: $R\_SS_t = \beta_0 + \beta_1 Oil\_WTI\_r_t + \beta_2 Gold\_1500\_r_t + \beta_3 Vix_t + \beta_4 US\_CNY_t + \varepsilon_t$. R_SS_t represent the daily return of the Shanghai Securities Composite Index (SSEC) in the current period. $Gold\_1500\_r_t$ denotes the gold price return at 15:00 in London bullion market. $Oil\_WTI\_r_t$ is the return of WTI price at the end of day t. The Vix_t is the VIX at the end of day t. US_CNY_t is the Dollar against the CNY (mid-price) at the end of day t.

Next, we test the relationship between Oil_WTI_r, $Gold\_1500\_r$, Vix, and US_CNY with SSEC return in the lag one period. We use Equation (2) for testing. In this test, only Oil_WTI_r and Vix have a 1% significant impact on SSEC return, US_RMB shows a 5% significance level. The Vix is still significantly negative at a 1% significance level. The results are shown in Table 3.

Table 3: The Results for all Variables in the Lag One Period

Variable	Coefficient	Prob.
$Oil\_WTI\_r_{t-1}$	0.0184	0.0013***
$Gold\_1500\_r_{t-1}$	-0.0226	0.1900
Vix_{t-1}	-0.0001	0.0006***
US_CNY_{t-1}	0.0004	0.0446**

Table 3 shows the relationship of Oil_WTI_r, $Gold\_1500$, Vix, and US_CNY. We use equation (2) for testing. Table 3 presents the P-value of Oil_WTI_r and Vix are 0.0013, 0.0006 respectively, $Gold\_1500$ is 0.0446. From the results of the table, we can see only Oil_WTI_r and Vix have a 1% significant impact on SSEC return, US_RMB shows a 5% significance level impact on the return of SSEC. Equation (2) as: $R\_SS_t = \beta_0 + \beta_1 Oil\_WTI\_r_{t-1} + \beta_2 Gold\_1500\_r_{t-1} + \beta_3 Vix_{t-1} + \beta_4 US\_CNY_{t-1} + \varepsilon_t$. R_SS_t state the daily return of the Shanghai Securities Composite Index (SSEC) at the current period. $Gold\_1500\_r_{t-1}$ denotes the gold price return of London bullion market at lag one period. $Oil\_WTI\_r_{t-1}$ is the return of WTI price at lag one period. The Vix_{t-1} is the VIX at lag one period. US_CNY_{t-1} is the Dollar against the CNY (mid-price) at lag one period.

We then aggregated all the factors and added the lag two periods. This method is based on Singhal et al. (2019). We use Equation (3) for testing. We find that no matter which backward period is considered, Vix will always show statistically significance at the 1% level. We find that due to momentum, Oil_WTI_r shows a gradually weakening momentum from 1% significance in the current period to non-significance in

the lag two periods. This finding is consistent with historical experience. Chopra et al. (1992) argue that in the reversal effect, losers have strong momentum to becoming better in the subsequent time period, while winners also tend to decline and fall in the subsequent time. We also find that $Gold\_1500\_r$ exhibit a reversal effect due to the overreaction, which $Gold\_1500\_r$ exhibiting a 1% significance only in the current period and lag two periods, and the coefficient with opposite coefficients in lag one period. The Vix also has a reversal phenomenon. However, in the case of Equation (3), the exchange rate is not significant. Table 4 shows the results.

Table 4: Summary Test Results for all Variables and Lagging Periods

Variable	Coefficient	Prob.
$Oil\_WTI\_r_t$	0.0194	0.0010***
$Oil\_WTI\_r_{t-1}$	0.0126	0.0433**
$Oil\_WTI\_r_{t-2}$	0.0080	0.2268
$Gold\_1500\_r_t$	0.0493	0.0004***
$Gold\_1500\_r_{t-1}$	-0.0212	0.2097
$Gold\_1500\_r_{t-2}$	0.0476	0.0057***
Vix_t	-0.0004	0.0000***
Vix_{t-1}	-0.0005	0.0000***
Vix_{t-2}	0.0009	0.0000***
US_CNY_t	-0.0157	0.2793
US_CNY_{t-1}	0.0251	0.2448
US_CNY_{t-2}	-0.0091	0.6167

Table 4 shows the summary test results for the variable definitions are consistent with Table 2 and Table 3 and added the lag two periods. Results show that no matter which backward period if considered Vix show a 1% significance level. Due to momentum, Oil_WTI_r show a gradual weakening momentum from a 1% significance in the current period to the return of SSEC and show non-significance in the lag two periods. The $Gold\_1500\_r$ exhibits 1% significance only in the current period and lag two period, and opposite coefficients in lag one period. The US_CNY is not significant in all periods. Equation(3) as: $R\_SS_t = \beta_0 + \beta_1 Oil\_WTI\_r_t + \beta_2 Gold\_1500\_r_t + \beta_3 vix_t + \beta_4 US\_CNY_t + \beta_5 Oil\_WTI\_r_{t-1} + \beta_6 Gold\_1500\_r_{t-1} + \beta_7 vix_{t-1} + \beta_8 Us\_CNY_{t-1} + \beta_9 Oil\_WTI\_r_{t-2} + \beta_{10} Gold\_1500\_r_{t-2} + \beta_{11} vix_{t-2} + \beta_{12} US\_CNY_{t-2} + \varepsilon_t$. R_SS_t state the daily return of the Shanghai Securities Composite Index (SSEC) at the current period. $Gold\_1500\_r_{t-2}$ denotes the gold price return of London bullion market at lag two period. $Oil\_WTI\_r_{t-2}$ is the return of WTI price at lag two period. The Vix_{t-2} is the VIX at lag two period. US_CNY_{t-2} is the Dollar against the CNY (mid-price) at lag two period.

We want to understand the impact of oil prices on the stock price index. Are high oil prices really bad for the stock market? Chen and Yang (2019) pointed out that "reasonable" high oil prices are not bad for the stock market. Does this condition also exist in China's stock market? We use the threshold model for this experiment, as in Equation (6). In order to distinguish it from the GARCH model in the previous section, we have made some adjustments to the variables. In Equation (6), Oil_WTI is the price of WTI. Oil_r are present the price return of WTI. The result of threshold effect has presented in Table 5 and 6. Table 5 reports the estimation results of the threshold effect. In our result, we find two threshold values respectively 30.25 and 77.18. Using the threshold regression model shows that the return on the SSEC is non-significant at an oil price below 30.25, but the Oil_WTI between 30.25 and 77.18, and the Oil_WTI above 77.18 all have 1% significance on SSEC returns. When the Oil_WTI is between 30.25 and 77.18, the SSEC return will increase by about 0.04 percentage points on average for Oil_r increase of 1 percentage point. Similarly, when the Oil_WTI is above 77.18, for a 1% increase in Oil_r, the return on the SSEC will increase by about 0.15 %.

Table 5: The Threshold Effect of Oil Price

Dependent Variable	Coefficient	Prob.
threshold value	Oil_WTI_t <30.25	
Oil_r_t	-0.0139	0.3110
threshold value	30.25≤ Oil_WTI_t <77.18	
Oil_r_t	0.0412	0.0002***
threshold value	77.18≤ Oil_WTI_t	
Oil_r_t	0.1524	0.0000***

This table reports the results of the threshold model. Results show the Oil_WTI threshold is 30.25 and 77.18. The Oil_WTI between 30.25 and 77.18, and the Oil_WTI above 77.18 all have 1% significance on SSEC returns. In terms of the correlation coefficient, when the Oil_WTI is between 30.25 and 77.18, the SSEC return increases by about 0.04 % on average for Oil_r increase of 1 %. Similarly, when the Oil_WTI is above 77.18, for a 1 % increase in Oil_r, the return on the SSEC increases by about 0.15 percentage points on average. Equation (6) as : $R\_SS_t = \alpha_1 + \beta_2 Oil\_r_t + \omega_1 Oil\_r_t \cdot \delta(Oil\_WTI_t \le \gamma) + \omega_2 Oil\_r_t \cdot \delta(Oil\_WTI_t > \gamma) + \varepsilon_t$. *$Oil\_r_t$ are present the price return of WTI at t. Oil_WTI_t is the price of WTI at the end of t.*

We find that when the Oil_WTI is above 77.18 the coefficient is higher than the Oil_WTI is between 30.25 and 77.18. Although high oil prices do not necessarily have an adverse effect on the economy (Chen and Yang, 2019). Our results show that higher oil prices are better for SSEC returns. The result is inconsistent with historical experience. We analyze the changes in oil prices from 2006 to 2009 and found that oil prices fluctuated sharply because of the financial crisis. In 2008, the oil price increased by 36.04% compared with 2007 and increased by 44.18% compared with 2006. In 2009, the oil price dropped by 51.21% compared with that in 2008. The economy was still at a low point in 2009, but the oil price dropped significantly. The economic downturn in 2008-2009 was not caused by the oil price. We reasoned that this may be the reason why our results had a significant positive effect on the return of SSEC at high oil prices. To prove this inference, we use the sub-period of 2009/01/02 to 2020 /12/30. The results are presented in Table 6. Table 6 shows when the Oil_WTI is between 50.06 and 83.06 there is 1% significance, and when the Oil_WTI is above 83.06 there is 5% significance. When the Oil_WTI is between 50.06 and 83.06, the return of SSEC increases by about 0.14 % on average for a 1% increase in the Oil_r. Although when Oil_WTI is higher than 83.06 there still exists a smaller significant positive impact at 0.0477%.

Table 6: The Threshold Effect of Oil Price From 2009 to 2020

Dependent Variable	Coefficient	Prob.
threshold value	Oil_WTI_t<50.06	
Oil_r_t	0.0172	0.1125
threshold value	50.06≤ Oil_WTI_t<83.06	
Oil_r_t	0.1350	0.0000***
threshold value	83.06≤ Oil_WTI_t	
Oil_r_t	0.0477	0.0403**

This table reports the estimation results of the threshold model for Oil_WTI on the SSEC from 2009 to 2020. Results show Oil_WTI has the best effect on the stock market returns are when prices are between 50.06 and 83.06. When the Oil_WTI is above 83.06, the coefficient of Oil_WTI on stock market returns decreases, indicating that high oil prices do not have an incentive effect on stock market returns. Equation (6) as : $R\_SS_t = \alpha_1 + \beta_2 Oil\_r_t + \omega_1 Oil\_r_t \cdot \delta(Oil\_WTI_t \le \gamma) + \omega_2 Oil\_r_t \cdot \delta(Oil\_WTI_t > \gamma) + \varepsilon_t$. *$Oil\_r_t$ are present the price return of WTI at t. Oil_WTI_t is the price of WTI at the end of t.*

CONCLUSION

Stock markets of many countries are sensitive to oil prices, gold prices or the VIX. China is currently the second largest economy with little evidence on this relationship. This article tests whether these factors have the same effect on China. We use daily data from 1990/01/02 to 2020/12/30 for all variables. This paper analyzes the correlation between the oil price return, the gold price return, the exchange rate, the volatility index, and the return of the Shanghai Securities Composite Index. The uniqueness of this paper is to observe the relationship between these international factors with Shanghai Securities Composite Index.

We adjust the lag periods and use a threshold model to test the relationship of oil price and stock market returns.

We find high oil prices are advantage for the economy. Empirical results show the effect of exchange rate on the stock market is reflected in the lag two periods. This contrasts the case of no effect as found by Kumar et al. (2021) for the Indian market. The VIX is always significant, indicating that the VIX is also valid and significant in China. By adjusting for different lagged periods, we obtain the return of oil price, return of the gold price, VIX, and exchange rate are highly significant in the current period. But when lagged one period, only return of oil price, VIX, and exchange rate are statistically significant. We find that the impact of oil returns on SSEC gradually diminishes until it shows no significance at lag two periods. This is due to the inconsistent speed with which market investors react to news in the market, and the information is gradually reflected in the price. Thus, the price moves in the initial direction in the short run, implying a momentum effect. This is consistent with the findings presented by Hong and Stein (1999). Conversely, the reversal of the coefficients in the lag one period for the SSEC and is not significant. But in the case of lag two periods, the gold return is significant again, which is consistent with the reversal effect due to overreaction proposed by Chopra et al. (1992). Finally, we use a threshold regression to test the threshold effect of oil price. We find a threshold effect of oil price on the return of the SSEC, which is consistent with the model proposed by Barberis et al. (1998). But our result found the gold price has no threshold effect on the return of SSEC. In addition, the threshold of oil price exhibits several characteristics. For example, when the oil price is below the first statistically significant threshold, there is a negative relationship between oil price and SSEC return, but the result is insignificant. There is a positive relationship between oil price and SSEC return when the oil price is between the first and second thresholds. Next, when the oil price is above the second threshold value, the oil price is also positively correlated with SSEC return. We deduce that this situation was affected by the financial crisis. Further research might explore other financial crises in China and elsewhere to gain additional insights.

REFERENCES

Arouri, M.E.H., Lahiani, A., and Nguyen, D.K. (2011) "Return and volatility transmission between world oil prices and stock markets of the GCC countries," *Economic Modelling*, vol. 28(4), July, p. 1815-1825.

Arouri, M.E.H., Lahiani, A., and Nguyen, D.K. (2015) "World gold prices and stock returns in China: Insights for hedging and diversification strategies," *Economic Modelling*, vol. 44, January, p. 273-282.

Arouri, M.E.H., and Nguyen, D.K (2010) "Oil prices, stock markets and portfolio investment: Evidence from sector analysis in Europe over the last decade," *Energy Policy*, vol. 38(8), August, p. 4528-4539.

Barberis, N., Shleifer, A., and Vishny, R. (1998). "A model of investor sentiment," *Journal of Financial Economics*, vol. 49(3), September, p. 307–343.

Batten, J.A., Ciner, C., and Lucey, B.M. (2010) "The macroeconomic determinants of volatility in precious metals markets," *Resources Policy*, vol. 35(2), June, p. 65-71.

Baur, D.G. (2012) "Asymmetric Volatility in the Gold Market," *The Journal of Alternative Investments*, vol. 14(4), January, p. 26-38.

Chen, A.-S., and Yang, C.-M. (2019) "Oil price thresholds and stock returns," *Investment Analysts Journal*, vol. 48(2), April, p. 125-145.

Chopra, N., Lakonishok, J., and Ritter, J.R. (1992) "Measuring abnormal performance: Do stocks overreact?" *Journal of Financial Economics*, vol. 31(2), April, p. 235-268.

Cong, R.-G., Wei, Y.-M, Jiao, J,-L., and Fan, Ying(2008) "Relationships between oil price shocks and stock market: An empirical analysis from China", *Energy Policy*, vol. 36(9), September, p. 3544-3553.

Daskalaki, C., and Skiadopoulos, G. (2011) "Should investors include commodities in their portfolios after all? New evidence," *Journal of Banking & Finance*, vol. 35(10), October, p. 2606-2626.

Degiannakis, S., Filis, G., and Arora, V. (2018) "Oil Prices and Stock Markets: A Review of the Theory and Empirical Evidence," *The Energy Journal*, vol. 5(39), September, p. 85-130.

Escobari, D., and Sharma, S. (2020) "Explaining the nonlinear response of stock markets to oil price shocks," *Energy*, vol. 213, December, p. 118778.

Gavin, M. (1989) "The stock market and exchange rate dynamics," *Journal of International Money and Finance*, vol. 8(2), June, p. 181-200.

Gokmenoglu, K.K., and Fazlollahi, N. (2015) "The Interactions among Gold, Oil, and Stock Market: Evidence from S&P500," *Procedia Economics and Finance*, 25, May, p. 478-488.

Hammoudeh, S., Malik, F., and McAleer, M. (2011) "Risk management of precious metals," *The Quarterly Review of Economics and Finance*, vol. 51(4), November, p. 435-441.

Hansen, B. E. (1999). "Threshold effects in non-dynamic panels: Estimation, testing, and inference," *Journal of Econometrics*, vol. 93(2), December, p. 345-368.

Hansen, B. E. (2011). "Threshold autoregression in economics," *Statistics and its Interface*, vol. 4(2), January, p.123-127.

Hong, H., and Stein, J.C. (1999) "A Unified Theory of Underreaction, Momentum Trading, and Overreaction in Asset Markets," *The Journal of Finance*, vol. 54(6), December, p. 2143-2184.

Jain, A., and Biswal, P.C. (2016) "Dynamic linkages among oil price, gold price, exchange rate, and stock market in India," *Resources Policy*, vol. 49, September, p. 179-185.

Jawadi, F., Louhichi, W., Ameur, H. B., and Cheffou, A. I. (2016) "On oil-US exchange rate volatility relationships: An intraday analysis," *Economic Modelling*, vol. 59, December, p. 329–334.

Jebran, K., and Iqbal, A. (2016) "Dynamics of volatility spillover between stock market and foreign exchange market: evidence from Asian Countries," *Financial Innovation*, vol. 2(3), December, p. 1-20.

Kumar, S., Choudhary, S., Singh, G., and Singhal, S. (2021) "Crude oil, gold, natural gas, exchange rate and indian stock market: Evidence from the asymmetric nonlinear ARDL model," *Resources Policy*, vol. 73, October, p. 102-194.

Luo, X., and Qin, S. (2017) "Oil price uncertainty and Chinese stock returns: New evidence from the oil volatility index," *Finance Research Letters*, vol. 20, February, p. 29-34.

Sadorsky, P. (1999) "Oil price shocks and stock market activity," *Energy Economics*, vol. 21(5), October, p. 449-469.

Sarwar, G. (2012) "Is VIX an investor fear gauge in BRIC equity markets?" *Journal of Multinational Financial Management*, vol. 22(3), July, p. 55-65.

Singhal, S., Choudhary, S., and Biswal, P.C. (2019) "Return and volatility linkages among International crude oil price, gold price, exchange rate and stock markets: Evidence from Mexico," *Resources Policy*, vol. 60, March, p. 255-261.

Zhang, Y., Wang, M., Xiong, X., and Zou, G. (2021) "Volatility spillovers between stock, bond, oil, and gold with portfolio implications: Evidence from China", *Finance Research Letters*, vol. 40, May, p. 101786.

BIOGRAPHY

Dr. Che-Ming Yang is Assistant Professor of the School of Accounting and Finance at Xiamen University Tan Kah Kee College, China. His research appears in Investment Analysts Journal and PLOSONE. His research on oil price behavior with Dr. An-Sing Chen was cited by marketwatch.com.

Shuo-Ming Xing is the student of the School of Accounting and Finance at Xiamen University Tan Kah Kee College, China. He majored in finance and is a member of Dr. Yang's research team. Recently, he is working on a research project focusing on building quantitative models.