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Full Length Research Paper

The interactive relationship among international gold indices, gold futures and the overall economy

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This study was devised to improve our understanding of the interactive relationship among the Amex gold BUGS index, the New York gold spot and the New York gold futures in the gold market, as well as the Commodity Research Bureau (CRB) futures price index, the Dow Jones industrial average, the OPEC crude oil spot, and the dollar index. To do so, this study adopted the Vector Error Correction Model (VECM), the Granger causality test, the state space model and several other time series research methods. The research results indicate that co-integration exists among gold futures, gold indices and the overall economy, meaning there is a long-term equilibrium relationship with gold futures. Moreover, by utilizing the vector error correction model, the Granger causality test, and the state space model in this study found that only the AMEX gold index, the CRB futures index, the New York gold spot and the Dow-Jones industrial average move ahead of the New York gold futures. Furthermore, the relationship between the New York gold spot and the New York gold futures as well as the CRB futures index and the New York gold futures show bi-directional causality.

Key words: Gold futures, co-integration, vector error correction model, Granger causality test, state space model.

INTRODUCTION

The stock, currency and banking markets of Asian-Pacific countries suffered a setback during the 1997 and 1998 Asian financial crisis. Nowadays, every country is aware of the importance of International Finance. Since the crisis, not only Asian countries, but also countries in Europe and the United States have concentrated their efforts on developing regional finance systems and inte-grated financial markets. Moreover, taken as a whole, the financial crisis also showed us that the overall economies of all countries are interdependent and mutually risk-sharing. The crisis made space for policymakers to take into account measures that would avoid the reappearance of another financial crisis in emerging countries.

As far as investment is concerned, in order to prevent a personal financial crisis, investors do not solely concentrate on stock markets any more, but also consider other investments, such as mutual funds, futures, options, bonds, foreign exchanges, arbitrage, hedging, and other financial derivatives. There are many financial instru-ments emerging quickly in the stock market, bond market and foreign exchange markets to provide more choices for investors. Taiwan is not lagging behind in this regard. As of 1998, when the first future commodity emerged, the era of financial derivatives began. In recent years, Taiwan has developed new derivatives from old ones, and so far, many futures that include option contracts have already been launched as investment instruments, such as the Taiwan stock futures, the financial futures, the electronic futures, the small Taiwan stock futures, the Taiwan index options, the stock options, the Taiwan 50 futures, the ten-year bond futures, the 30 day interest rate futures, the electronic options, the financial options, etc. In order to attract more foreign investment and to improve the inter-nationalization of the Taiwan futures market, Taiwan has launched three financial derivatives, which are valued in U.S. dollars, including the gold futures, the MSCI Taiwan

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index future and the MSCI Taiwan index options.

In addition, with the rising pressure of inflation and the upsurge of crude oil prices, investors are looking for a way to avoid risks when making investments. Gold is not only a good value- keeping commodity, but the importance of gold futures is also irreplaceable. The gold price is running at record levels in the international market. Therefore, whether in risk- diversion, or arbitrage and speculation, the gold futures are the best financial instru-ment, and they have gradually obtained the favor and acceptance from Taiwanese investors. Furthermore, in view of the future investment environment and financial instruments, Taiwan has been making great efforts to develop and launch gold futures. In particular, the “Gold Army” and other plans in 2006 played an active role in invigorating the gold market. Recently, in order to meet the trading habits of domestic investors, Taiwan launched the “NT Dollar-denominated Gold Futures” in 2008. This new product may attract domestic investors to participate in the market and provide a product that is different from the existing US Dollar-denominated Gold Futures. Taiw-anese investors can engage in hedging and arbitrage between the two products. From what has been said above, we know that the gold futures will be one of major financial instruments in Taiwan in the future, and it will undoubtedly become a main stream financial product. This means that the opportunity for Taiwanese to choose gold futures as a financial instrument in arbitrage, hed-ging and investment will be equal to or greater than other international gold futures, such as the New York futures, the Chicago futures, and the Japan futures.

However, as Taiwan is in a stage of initial development, many investors are still taking a wait and see attitude toward gold futures. Therefore, nowadays many investors still regard the New York, Chicago and Japan futures as the places for gold futures operations. Furthermore, many factors influence the change of gold futures. Such factors can be narrowed into the following categories: spot goods, inflation, the interest rate, the dollar, the oil price, and other economic variables. Roope and Zurbruegg (2002) discussed the Taiwan stock price futures index held by the Singapore stock exchange and the Taiwan stock exchange. They pointed out that the dollar has more potential as a trade currency in the Singapore stock exchange, so it is advantageous to count in dollars. Therefore, this study focuses on the New York gold futures which also are counted in dollars; the purpose is to investigate the relationship among gold indexes, gold futures, and overall economic variables, and to provide a main basic reference for those investors conducting gold futures operations in arbitrage, hedging and investment.

To sum up, this study was devised to examine the dynamic relationship among international gold indexes, gold futures and overall economic variables by adopting several time series methods. We utilize the Johansen co-integration test to analyze and verify if long-term equ ilibrium exists among international gold indexes, gold-futures and overall economic variables. And then, we investigate its short-term interaction as leading, lagging and feedback by using the Granger causality test and the state space model. However, if, in the series, there is long term equilibrium, we then use the vector error correction model, to compare, analyze and explain the results made from the Granger causality test and state space model.

THEORETICAL FRAMEWORK

Grubel (1968) investigated and analyzed the risks and benefits of international stock markets by using the research methods of the efficiency investment portfolio and the efficiency frontier to explore the feasibility of dispersing the risk of international investment portfolios; Grubel indicated that international investment portfolios may really disperse their risk and effectively increase the opportunities of obtaining benefits. Kolluri (1981) pointed out that an association does exist between the gold price and inflation rate, which can be utilized for hedging and other activities. Ghosh (1993) took the S and P 500 index spot, the S and P 500 index futures, the CRB futures index and the CRB spot index as subjects to investigate the relationship between futures and spot by the method of co-integration analysis. Ghosh’s study revealed that the S and P 500 index and the CRB index may have a separate long-term equilibrium when the error term is ignored. Abdalla and Murinde (1997) adopted co-integration and causality tests to investigate the relationship between stock price indexes and exchange rates in South Korea, the Philippines, India, Pakistan, etc. They showed that there is no long-term equilibrium in South Korea and Pakistan, but there is short-term interaction between exchange rates and stock price indexes in South Korea, India, and Pakistan. Ball and Torous (2000) employed the state space model to examine the stock markets in the Asia-Pacific region, Europe and America, and then it pointed out that the stock price of each country changes as time goes on, showing a stochastic and dynamic form. Graham (2001) discussed how there is short-term interaction and long-term equilibrium between the gold price and stock prices, and this illustrated that there is no obvious relationship in the long run, but in the short run, the gold price is affected by the stock price. Hondroyiannis and Papapetrou (2001) explored the relationship among the oil price, the stock market of Greece and the overall economy. They then exploited the industrial production index as their research subject, and found that a negative correlation exists between crude oil prices and the overall economy and the stock market. Cuñado and Gracia (2003) adopted co-integration analysis and the causality test and took the oil price as the target to find the relationship between oil price and inflation in the overall economy. They noticed that the impacts on the inflation of each country’s international oil price are not identical. Kim (2003) used co-integration analysis and VECM and investigated the relationship between the stock market and the overall economy in the United States. He indicated that the S and P stock price index only has a positive correlation with industrial production. Shamsuddin and Kim (2003) employed VAR, co-integration analysis and other time series methods to examined currency and the stock markets of Japan, Australia and the United States, and pointed out that in the prior Asian financial crisis period, long-term equilibrium and short-term interaction existed, but there was only long-term equilibrium in the later period. Guo and Kliesen (2005) found that the oil price has both a positive or negative influence on fixed investments, interest rates and other factors of the overall economy in the United States.

Grudniski and Osburn (1993) investigated the feasibility of utilizing neural networks to forecast standard and poor's 500 stock index and gold futures prices based on past price changes and historical open interest patterns. Batten and Lucey (2010) explored the volatility structure of gold, trading as a futures contract on the Chicago Board of Trade using intraday data from January, 1999 to December, 2005 and the results imply considerable discrepancy across the trading day and week consistent with microstructure theories.

Adam et al. (2007) looked into macroeconomic impacts on gold using the asymmetric power GARCH model (APGARCH) exploiting both cash and futures prices of gold and significant economic variables over the 1983 - 2003 period. The results proposed that APGARCH model presents the most adequate explanation for the data, with the inclusion of a GARCH term, free power term and unrestricted leverage effect- term. Ogden et al. (2005) utilized Transactions data supplied by the Montreal Stock Exchange and the New York commodity exchange and tested rational pricing conditions relevant to American gold spot and futures options. The results indicate a considerable number of violations of a condition appropriate to call options are found, and most of these violations are sufficient to cover the relevant transaction costs of arbitrage.

On the basis of the investigations discussed above, it is evident that many scholars have already investigated the relationship among financial markets by using multi-term time series. Such studies include the analysis of stock markets, exchange markets, futures markets and other topics; as for futures markets, most attention has been paid to the analysis of the causality between futures and spots, but little attention has been paid to the investigation of the relationship between futures market and the overall economy. However, according to the view-points previous studies, American markets have an influence on global financial markets, and there is an obvious association between gold, inflation and oil prices. Moreover, CRB Futures Indexes, the dollar index, and the Dow-Jones Industrial Average are important indexes in American financial markets. Thus, this study takes the American market's AMEX Gold Index, gold futures, the New York gold spot and the CRB Futures Index, the OPEC crude oil price, the dollar index and the Dow-Jones Average as subjects to investigate the relationship among them. The emphasis is on analyzing which kind of economic factors have an obvious correlation with gold futures.

STUDY DESIGN AND EMPIRICAL

ANALYSIS Source and selection of data

The Asian financial crisis made important changes in the structure of international financial systems. In order to avoid this change and their indirect affect on empirical results, this study takes the monthly data of variables from January, 1998 to September, 2006 as research data. There are about 105 sample data. Next, each variable is taken as a natural logarithm before analysis so as to avoid influence on all the empirical results by extreme data and to improve the accuracy of the tested data. The source of time series data selected and variable symbols is the AMEX Gold Index (HUI) as derived from Yahoo Finance; while the dollar index (DX), the CRB Futures Index (CRB) and the New York gold futures (GS) are derived from the NYMEX; and the Dow-Jones Industrial Average (DJIA), the OPEC crude oil spot (OPEC) and the New York gold spot (GS) are derived from the data-base of the Taiwan Economic Journal (TEJ).

Results of the stationarity test

However, if we only use time trend charts to carry out a stationarity test on a sequence, the results may be too subjective. Thus, in order to improve the precision and accuracy of the research process, this study further uses the ADF unit test method to make the stationarity test. Then, in the selection of the ADF unit root lagging phase, this study is based on the AIC rule, and takes the minimum value as each variable's lagging period to make the stationarity test of the three models, Model 1 (no intercept term and time trend term), Model 2 (intercept term and no time trend term) and Model 3 (intercept term and time trend term). If the sequence does not exclude the null hypothesis of unit root, it is non-stationary state, which means the numerical data is meaningless. And the sequence will be carried out with the first order difference value test or the second order difference value test, until it refuses the null hypothesis of the unit root. At this time, its state becomes a stationary state. In order to conduct the co- integration test on long-term equilibrium, analysis is carried out to see whether each sequence has the same integration order.

As shown in Tables 1 and 2, all variables within the three constant models of the original level value could not refuse the null hypothesis as a non-stationary sequence, because the numerical data is meaningless. Next, after the fist difference, all of the variables within the three constant models changed to a constant sequence, meaning that the sequence's average, variance and auto- covariance have not varied with the change of time; as is the case with the sequence of I (1), so there is no need for a second difference. This study takes the AMEX Gold Index, the dollar index, the CRB Futures Index, the Dow-Jones Average, the OPEC crude oil spot, the New York gold spot, the New York gold futures and other variables that belong to the same sequence of I (1) as the investigated subjects to further analyze the long-term equilibrium among variables by applying the Johansen Co-integration Test.

Results of the Johansen co-integration test

For the stationarity test, the AMEX Gold Index, dollar index, CRB

Table 1. ADF unit root test result table of the original level value of each variable.

Variables	Unit root test of the original level value of the AIC rule					
	Intercept	Log	Trend and intercept	Log	None	Log
New York gold futures	1.319673	2	-2.039110	0	1.617970	0
New York gold spot	1.326417	2	-2.034788	0	1.621153	0
OPEC crude oil spot	-0.778970	0	-2.342782	0	1.346250	0
New York Do-Jones average	-2.598896	0	-2.651247	0	0.816670	0
CRB futures index	-0.529936	3	-2.607046	6	1.061211	2
Dollar index	-0.813216	1	-1.493309	0	-0.591663	1
AMEX gold index	-0.326434	3	-3.108936	3	0.725110	3

Notes: 1.* means that the value is under a level of significance of 5, and the null hypothesis on the existence unit root is refused.

Table 2. ADF unit root test result table of the first difference of each variable.

Variables	Unit root test of the first difference of the AIC rule					
	Intercept	Log	Trend and intercept	Log	None	Log
New York gold futures	-8.623620*	1	-9.164722*	1	-10.97166*	0
New York gold spot	-8.561452*	1	-5.247992*	5	-5.293307*	2
OPEC crude oil spot	-5.352919*	3	-5.306024*	3	-5.015755*	3
New York Do-Jones average	-10.57103*	0	-10.51223*	0	-10.57336*	0
CRB futures index	-7.892282*	1	-8.053934*	1	-4.730792*	2
Dollar index	-8.853799*	0	-8.887241*	0	-8.864975*	0
AMEX gold index	-5.256128*	2	-5.481987*	2	-5.214854*	2

Notes: Ditto.

Futures Index, Dow-Jones Average, OPEC crude oil spot, New York gold spot, New York gold futures and other variables all belong to the same sequence of integration order, that is, the sequence of State I (1); this also means that there is a possibility of the existence of long-term equilibrium among variables. Therefore, this study further analyzes the results using the Johansen Co-integration Test. Whereas this study is conducted on the basis of the vector autoregressive model, the variables' optimum lagging phase is determined before conducting the co-integration test and the analysis of the vector autoregressive model. Moreover, this study takes the AIC rule as the principal axis and combines the methods of LR, FPE, SC, and HQ to carry out simultaneous testing. However, if there is discrepancy among the empirical results, the AIC rule is taken as the main judgment rule. As shown in Table 3, using the methods of AIC, LR, FPE, SC and HQ, the optimum lagging phase shown in AIC and FPE is one; thus, a one-phase-lag is used as the optimum lagging phase of the Johansen Co-integration Test and vector autoregressive model. On this basis, estimations for each variable's number of co-integration vector are performed to see if there is a long-term equilibrium among variables. Next, in the Johansen co-integration Test, there are five test models, and in order to improve the accuracy of analysis results, this study takes these five co-integration models for analysis at the same time, and then selects the optimum model.

First, the selection of the optimized model is screened according to the time trend of graphical analysis, and then the determination rule of the order is selected from left to right and top to bottom in accordance with H_0 (0) H_1^* (0) H_1 (0) H_2^* (0) H_2 (0) H_0 (1) H_1^* (1) H_1 (1) H_2^* (1) H_2 (1) …

… H_0 (p-1) H_1^* (p-1) H_1 (p-1) H_2^* (p-1) H_2 (p-1), until the null hypothesis is not refused. Furthermore, in these five models, the test can be subdivided into a trace test and max-eigenvalue test; in this study, both tests are adopted and combined based on the points put forward by Johansen and Juselius (1990). In other words, during the analysis of the trace test and tax-eigenvalue test, if there is discrepancy among the empirical results, the max-eigenvalue test is taken as the main judgment rule for the better test outcome.

From Tables 4 and 5, among the five test models of the Johansen co-integration Test, no matter whether the trace test or max-eigenvalue test is selected, the analyzed results are all consistent. This means that there is a co-integration vector. That is to say a long-term equilibrium exists among variables. For the selection of the optimum model, according to the time trend chart, we know that the variables selected in this study all have time trend fluctuations.

Table 3. Test of the variables' optimum lagging phase.

	Judgment rules				
Lagging phase	**LR**	**FPE**	**AIC**	**SC**	**HQ**
Zero-phase-lag	NA	2.15e-21	-27.72165	-27.53467*	-27.64607*
One-phase-lag	106.3424	1.79e-21*	-27.90926*	-26.41339	-27.30460
Two-phase-lag	59.84670	2.41e-21	-27.62727	-24.82252	-26.49354
Three-phase-lag	70.04710	2.70e-21	-27.55302	-23.43938	-25.89022
Four-phase-lag	70.05649*	2.85e-21	-27.57781	-22.15528	-25.38593
Five-phase-lag	36.22930	4.94e-21	-27.16079	-20.42938	-24.43985
Six-phase-lag	62.82605	5.17e-21	-27.32536	-19.28506	-24.07534
Seven-phase-lag	45.58050	7.29e-21	-27.29541	-17.94622	-23.51631
Eight-phase-lag	59.59692	6.97e-21	-27.80270	-17.14463	-23.49453

Notes: 1.* represents that the optimum lagging phase of data are selected in accordance with the LR, FRE, AIC, and Scand HQ rule, respectively.

Table 4. Result table of the trace test.

	Trace test									
	Model 1 H_0 (R)		**Model 2 H_1 *(R)**		**Model 3 H_1 (R)**		**Model 4 H_2 *(R)**		**Model 5 H_2 (R)**	
Rank	**Trace test**	**Critical value 5%**	**Trace test**	**Critical value 5%**	**Trace test**	**Critical value 5%**	**Trace test**	**Critical value 5%**	**Trace test**	**Critical value 5%**
r=0	133.68*	111.78	153.24*	134.68	145.73*	125.62	167.52*	150.56	162.66*	139.28
r=1	70.05	83.94	89.27	103.85	**82.21**	**95.75**	103.72	117.71	99.03	107.35
r=2	47.02	60.06	64.48	76.97	57.63	69.82	73.78	88.80	69.25	79.34
r=3	25.26	40.17	42.55	54.08	36.80	47.86	51.62	63.88	48.38	55.25
r=4	11.71	24.28	23.53	35.19	18.57	29.80	30.83	42.92	28.28	35.01
r=5	3.32	12.32	10.39	20.26	6.78	15.49	16.19	25.87	13.64	18.40
r=6	0.99	4.13	2.22	9.16	0.09	3.84	5.08	12.52	2.63	3.84

Notes: 1. The boldface data and underlined data are obtained according to the time trend drawing and optimized model selected based on the point proposed by Nieh and Lee (2001). 2. *Means that the value is under the level of significance of 5 , and the null hypothesis is refused. 3. The values listed in the table are rounded off to two decimals. 4. Model 1 means that there are no time trend terms in the VAR model and no intercept terms in the co-integration equation. 5. Model 2 means that there are no time trend terms in the VAR model, but there are restricted intercept terms in the co-integration equation. 6. Model 3 means that there are time trend terms in the VAR model and intercept terms in the co-integration equation. 7. Model 4 means that there are time trend terms in the VAR model, and there are restricted intercept terms in the co-integration equation. 8. Model 5 means that there are two time trend terms in the VAR model, there are also time trend terms in the co-integration equation.

Table 5. Max eigenvalue test result table.

	Max eigenvalue test									
	Model 1 H_0 (R)		**Model 2 H_1 *(R)**		**Model 3 H_1 (R)**		**Model 4 H_2 *(R)**		**Model 5 H_2 (R)**	
Rank	**max test**	**Critical value 5%**	**max test**	**Critical value 5%**	**max test**	**Critical value 5%**	**max test**	**Critical value 5%**	**max test**	**Critical value 5%**
r = 0	**63.63***	**42.77**	63.97*	47.08	63.52*	46.23	63.80*	50.60	63.63*	49.59
r = 1	23.03	36.63	24.80	40.96	**24.58**	**40.08**	29.94	44.50	29.79	43.42
r = 2	21.76	30.44	21.93	34.81	20.83	33.88	22.16	38.33	20.87	37.16
r = 3	13.56	24.16	19.02	28.59	18.23	27.58	20.79	32.12	20.10	30.82
r = 4	8.39	17.80	13.14	22.30	11.79	21.13	14.64	25.82	14.64	24.25
r = 5	2.33	11.22	8.18	15.89	6.69	14.26	11.11	19.39	11.01	17.15
r = 6	0.99	4.13	2.22	9.16	0.09	3.84	5.08	12.52	2.63	3.84

Note: Ditto.

Therefore, models 3 and 4 may be the optimum models. Then, conducting a screening by using the method proposed by Nieh and Lee (2001), finally, the optimum model of the trace test or max-eigenvalue test can be selected. The results are all on model 3 and there is a co-integration vector and long-term equilibrium.

Results of the vector error correction model

From the co-integration test, we can know that there is long-term information implied within the model, and there are long-term equilibriums among variables and a co-integration vector within the model. At this point, an error correction term is added into the vector autoregressive model to establish a vector error correction model. Then the investigation into short-term relationships is carried out on this model. The vector error correction model can distinguish five testing models, while the selection of the optimized model is consistent with the optimized model of the co-integration test. Through the test of co-integration analysis, it is initially judged that Model 3 is the optimized model. Therefore, this study takes Model 3 as the optimized model of the vector correction model to analyze the long-term equilibrium and short-term interaction.

Long-term equilibrium of the error correction model

From the co-integration test, we know that there is a co-integration vector or long term equilibrium exists. The long- term equilibrium among variables can be explored further by the error correction model on the basis of the existence of long-term equilibrium. Then, by using the adjusted coefficient value of the long-term error correction term, a test is further executed to see if there is long-term equilibrium between this variable and other variables within the sequence, and to judge the speed and strength of the vector regression equilibrium value within the model by this value. So it is used to analyze the long-term equilibrium, deviation state, and correction direction within the sequence. The Empirical results are shown in Tables 6 and 7.

Firstly, from Table 6, as to the point of causality, the t value of the CRB Futures Index, OPEC oil spots, New York gold futures and New York gold spot shows an obvious phenomenon. This means that there is long-term causality. So OPEC oil spots and the New York gold spot have an obvious positive correlation with the AMEX Gold Index, while the CRB Futures Index and New York gold futures have an obvious negative correlation with the AMEX Gold Index.

As shown in Table 7, for the error correction of the term's adjusted coefficient value of variables within the model, the t value of its variable is significantly different from zero. This means that there is a long-term equilibrium among variables, and this variable can be corrected from the deviation state to a long-term equ-ilibrium value in a short time. Moreover, all adjusted coefficient values of the correction term are less than 1. Thus, the speeds at which they are corrected in the model to long-term equilibrium are slow, and their intensities are not strong.

Next, for the deviation state, the dollar index sequence is higher than the equilibrium value. This is corrected downwards to the long-term equilibrium value at the speed and intensity of 0.000719. Both the CRB Futures Index sequence and the New York gold futures sequence are below equilibrium value, thus, they are corrected upwards to their long-term equilibrium value at the speed and intensity of 0.001574 and 0.001102, respectively. However, the state of the AMEX Gold Index sequence, the Dow-Jones Average sequence, the OPEC crude oil spot sequence and the New York gold spot are not obvious, which means that they can be corrected to the long-term equilibrium value in a short time.

In all, the adjustment ability of the above mentioned factors are ordered as follows: the AMEX Gold Index, the CRB futures Index, the New York gold futures, the Dow-Jones Average, the dollar index, the New York gold spot and the OPEC crude oil spot.

Short-term inter-phase interaction of the error correction model

The short-term inter-phase interaction can be realized by Tables 6 and 7.

A). The AMEX Gold Index is not only influenced by its previous stage but also the previous stage of the CRB Futures Index's and the New York gold spot.
B) . The dollar index is influenced by its previous effect. Moreover, it is also influenced by the previous stage of the AMEX Gold Index, the CRB futures, the Dow-Jones Average, the New York gold futures and the New York gold spot.
C). The CRB Futures Index is not influenced by its previous stage. But it is influenced by the previous stage of the Dow-Jones Average, the OPEC crude oil spot, the New York gold futures and the New York gold spot.
D). The Dow- Jones Average is only influenced by its previous stage and it has no obvious correlation with the rest of the variables.
E). The OPEC crude oil spot is not only influenced by its previous stage but also by the previous stage of the CRB Futures Index.
F). The New York gold spot is influenced by its previous stage. Among all variables, only the AMEX Gold Index, the dollar index, the CRB Futures Index and the Dow-Jones Average are correlated with and are influenced by the New York gold spot.
G) . The sequence of the New York gold futures, it is not influenced by its previous stage. But it is still influenced by the AMEX Gold Index, the CRB Futures Index, the Dow-Jones Average, and the previous stage of the New York gold spot.

Results of the Granger causality test

In the Granger causality test, if the sequence has a long-term equilibrium, it is easy for the empirical results to be biased since long-term information is ignored when using the Granger causality test directly deduced by the Vector Autoregressive Model to make an analysis. In other words, if there is a long- term equilibrium, the Granger causality is conducted by the use of the vector error correction model. From the analysis of the co-integration test, a long-term equilibrium among variables can be observed. Therefore, this study takes the vector error correction model as the basic model first, and then investigates the short-term interaction among variables in coordination with the Granger causality test. In this way, we test the lead-lag relationship between every two variables. According to the judgment rule, χ^2 test statistics and the level of significance of a p value are taken as the agreed criteria, and if the value is greater than the critical value, then it is considered that there causality exists. The empirical results are shown in Table 8.

The short-term interaction can be deduced from Table 8, which means that either unidirectional causality or two-way causality exist, that is leading, lagging, feedback and other short-term interactive causalities.

A). The AMEX Gold Index is ahead of the dollar index and the New York gold futures respectively, but it lags behind the CRB Futures Index, in which case the relationship between the AMEX and the New York gold spot shows a feedback.
B). The relationship between the dollar index and the New York gold spot shows a feedback, but the dollar index lags behind the AMEX Gold Index, CRB Futures Index, Dow-Jones Average, and New York gold futures.
C). The CRB Futures Index is ahead of the AMEX Gold Index and

Table 6. Analysis table of the error correction term's model.

Model of error correction term								
Variable	hui_{t-1}	dx_{t-1}	crb_{t-1}	$djia_{t-1}$	$opec_{t-1}$	gs_{t-1}	gc_{t-1}	c
Coefficient value	1	11.6788	-119.0194	-16.1181	26.6153	2617.276	-2614.448	0.0775
t value	n/a	0.2057	-2.5167**	-0.6165	1.7389*	11.2203**	-11.0095**	n/a

Equation of the error correction term's model

$$z_{t-1} = hui_{t-1} + 11.6788dx_{t-1} - 119.0194crb_{t-1} - 16.1181djia_{t-1} + 26.6153opec_{t-1}$$
$$+ 2617.276gs_{t-1} - 2614.448gc_{t-1} + 0.0775$$

Notes: The data were collected by this study.

Table 7. Analysis table of the error correction model.

	HUI	**DX**	**CRB**	**DJIA**	**OPEC**	**GS**	**GC**
E	**0.001634**	**-0.000719**	**0.001574**	**0.000796**	**-3.81E-05**	**0.000393**	**0.001102**
	[1.13354]	**[-3.08044]****	**[4.56163]****	[1.39459]	[-0.03488]	[0.80170]	**[2.26573]****
HUI (-1)	-0.350882	-0.042404	0.001975	-0.081354	0.033689	0.085007	0.091465
	[-2.47868]**	**[-1.85171]***	[0.05828]	[-1.45089]	[0.31408]	**[1.76852]***	**[1.91545]***
DX (-1)	0.607644	-0.492154	0.192471	-0.235886	0.419192	0.336013	0.283014
	[1.04005]	**[-5.20737]****	[1.37619]	[-1.01931]	[0.94694]	**[1.69379]***	[1.43606]
CRB (-1)	0.832083	-0.261165	-0.067198	0.142397	0.895384	0.455664	0.534573
	[1.88557]*	**[-3.65848]****	[-0.63612]	[0.81465]	**[2.67785]****	**[3.04100]****	**[3.59121]****
DJIA (-1)	-0.311666	0.109528	-0.105644	-0.442785	-0.238249	-0.207610	-0.223426
	[-1.24831]	**[2.71188]****	**[-1.76761]***	**[-4.47740]****	[-1.25941]	**[-2.44895]****	**[-2.65294]****
OPEC (-1)	-0.090758	0.034666	-0.070741	-0.054276	-0.483267	-0.002939	-0.004519
	[-0.67951]	[1.60442]	**[-2.21255]****	[-1.02592]	**[-4.77527]****	[-0.06481]	[-0.10030]
GS (-1)	-3.580732	0.905210	-2.652906	-0.657472	-1.577973	-1.753141	-1.913357
	[-1.69900]*	**[2.65511]****	**[-5.25839]****	[-0.78759]	[-0.98815]	**[-2.44983]****	**[-2.69139]****
GC(-1)	2.877204	-0.868931	2.562559	0.769514	1.176123	1.059647	1.176110
	[1.34238]	**[-2.50611]****	**[4.99444]****	[0.90640]	[0.72420]	[1.45600]	[1.62671]
C	-0.001990	-7.87E-05	-0.000739	-0.000165	-0.000280	-0.000437	-0.000412
	[-0.13745]	[-0.03361]	[-0.21311]	[-0.02883]	[-0.02548]	[-0.08880]	[-0.08441]

Notes: 1. E: error correction term; C: constant term; HUI: AMEX Gold Index; DX: dollar index; CRB: CRB Futures Index; DJIA: Dow-Jones Average; OPEC: OPEC crude oil spot; GS: New York gold spot; GC: New York gold futures. 2. **, * means that the values are under the level of significance of 5 or 10 respectively, and the coefficient is significantly different from zero. 3. The value of [ ] is its t value.

Table 8. Res ults from t he Granger causality tests.

Null hypothesis (H_0)	χ^2 value	p value	Causality	Strength
HUI has no causality to DX	3.428823	0.0641*	Lead	Weak
HUI has no causality to CRB	0.003396	0.9535	No effect	None
HUI has no causality to DJIA	2.105089	0.1468	No effect	None
HUI has no causality to OPEC	0.098648	0.7535	No effect	None
HUI has no causality to GS	3.127674	0.0770*	Lead	Weak
HUI has no causality to GC	3.668961	0.0554*	Lead	weak
DX has no causality to HUI	1.081713	0.2983	No effect	None
DX has no causality to CRB	1.893913	0.1688	No effect	None
DX has no causality to DJIA	1.038993	0.3081	No effect	None
DX has no causality to OPEC	0.896688	0.3437	No effect	None
DX has no causality to GS	2.868921	0.0903*	Lead	weak
DX has no causality to GC	2.062276	0.1510	No effect	None
CRB has no causality to HUI	3.555365	0.0594*	Lead	weak
CRB has no causality to DX	13.38448	0.0003***	Lead	Strong
CRB has no causality to DJIA	0.663661	0.4153	No effect	None
CRB has no causality to OPEC	7.170876	0.0074***	Lead	Strong
CRB has no causality to GS	9.247706	0.0024***	Lead	Strong
CRB has no causality to GC	12.89679	0.0003***	Lead	Strong
DJIA has no causality to HUI	1.558284	0.2119	No effect	None
DJIA has no causality to DX	7.354299	0.0067***	Lead	Strong
DJIA has no causality to CRB	3.124440	0.0771*	Lead	weak
DJIA has no causality to OPEC	1.586114	0.2079	No effect	None
DJIA has no causality to GS	5.997368	0.0143**	Lead	Middle
DJIA has no causality to GC	7.038086	0.0080***	Lead	Strong
OPEC has no causality to HUI	0.461728	0.4968	No effect	None
OPEC has no causality to DX	2.574174	0.1086	No effect	None
OPEC has no causality to CRB	4.895359	0.0269**	Lead	Middle
OPEC has no causality to DJIA	1.052509	0.3049	No effect	None
OPEC has no causality to GS	0.004201	0.9483	No effect	None
OPEC has no causality to GC	0.010061	0.9201	No effect	None
GS has no causality to HUI	2.886618	0.0893*	Lead	weak
GS has no causality to DX	7.049619	0.0079***	Lead	Strong
GS has no causality to CRB	27.65071	0.0000***	Lead	Strong
GS has no causality to DJIA	0.620293	0.4309	No effect	None
GS has no causality to OPEC	0.976445	0.3231	No effect	None
GS has no causality to GC	7.243602	0.0071***	Lead	Strong
GC has no causality to HUI	1.801977	0.1795	No effect	None
GC has no causality to DX	6.280579	0.0122**	Lead	Middle
GC has no causality to CRB	24.94438	0.0000***	Lead	Strong
GC has no causality to DJIA	0.821557	0.3647	No effect	None

Table 8. Contd.

GC has no causality to OPEC	0.524464	0.4689	No effect	None
GC has no causality to GS	2.119940	0.1454	No effect	None

Notes: 1. ***, **, * means that the values are under the significance levels of 1, 5 or 10%, respectively and the coefficients are significantly different from zero.

Table 9. Typical Correlation analysis of the state space model.

State vectors	**AIC value**	χ^2 **Value**	**DF**
hui(T;T), dx(T;T), crb(T;T), djia(T;T), opec(T;T), gs(T;T), gc(T;T), crb(T+1;T)	-11.6457	2.275063	7
hui(T;T) dx(T;T) crb(T;T) djia(T;T) opec(T;T), gs(T;T) gc(T;T) dx(T+1;T)	-1.36182	12.21286	7
hui(T;T) dx(T;T) crb(T;T) djia(T;T) opec(T;T), gs(T;T), gc(T;T), gc(T+1;T)	-0.76031	12.79413	7
hui(T;T), dx(T;T), crb(T;T), djia(T;T), opec(T;T), gs(T;T), gc(T;T), gs(T+1;T)	-6.92714	6.83483	7
hui(T;T), dx(T;T), crb(T;T), djia(T;T), opec(T;T), gs(T;T), gc(T;T), opec(T+1;T)	-7.26623	6.507151	7
hui(T;T), dx(T;T), crb(T;T), djia(T;T), opec(T;T), gs(T;T), gc(T;T), hui(T+1;T)	-5.94557	7.78336	7
hui(T;T), dx(T;T), crb(T;T), djia(T;T), opec(T;T), gs(T;T), gc(T;T), djia(T+1;T)	-3.01291	10.61734	7
Most suitable state vectors			
hui(T;T) dx(T;T) crb(T;T) djia(T;T) opec(T;T) gs(T;T) gc(T;T)			

Notes: 1. Information Source: The data were collected by this study.

dollar index respectively, and it only falls behind the Dow- Jones Average; in which case, all relationships between the OPEC crude oil spot, New York gold spot and New York gold futures show a feedback.

D). The Dow-Jones Average is in ahead of the CRB Futures Index, New York gold spot and New York gold futures respectively. The relationship between the Dow-Jones and the dollar index is a feedback relationship.

E). The OPEC crude oil spot only takes the lead on the dollar index, and it has no obvious correlation with the rest of the variables.

F). The New York gold spot stays one step ahead of the New York gold futures and falls behind the Dow-Jones Average; in which case, it has an interactive feedback with the AMEX Gold Index, the dollar index and the CRB Futures Index.

G). The New York gold futures is ahead of the dollar index and falls behind the AMEX Gold Index, Dow-Jones Average and New York gold spot; and it has an interactive feedback with the CRB Futures Index.

Next, from the analysis of Granger causality, the influence of the above mentioned factors are ordered from the highest to lowest as follows: the New York gold spot, the New York gold futures, the CRB Futures Index, the Dow-Jones Average, the OPEC crude oil spot, the AMEX Gold Index, and the dollar index.

Results of the state space model

The tests and analyses of the state space model can be carried out as follows:

The most suitable lagging period

First set up a basic model by application of the vector autoregressive model, and make a decision about the most suitable lagging period of the state space model based on the AIC principle. If the most suitable lagging period derived from the state space model and AIC rule is the same period, that period is the most explanatory lagging phase.

The most suitable state vector

Secondly, conduct typical correlation analysis by application of past vectors and future vectors, and test the χ^2 value by putting the most suitable lagging period in the model. If the value is greater than the critical value, then it can be determined as an acceptable state vector. Should the empirical results turn out to be insignificant, then the previous significant state vector is the most suitable state vector, that is, the most explanatory variable set. W e can acquir e the most suitabl e stat e vect ors from Tabl e 9, they ar e hui(T;T), dx(T;T), crb(T;T), djia(T;T), opec(T;T), gs(T;T), and gc(T;T).

Most suitable state model

However, in light of the variable set generated by the most suitable lagging period and the most suitable state vector, the parameters are not necessarily significant; therefore, it is necessary to further conduct a t test. In this study, t = 1.96 is set as the limitation, to set the values of the variables F and G as zero. Delete the insignificant conversion matrix AR and input matrix MA so that it rebuilds the model. That model coincides with the initial model. Then, continuously repeat estimating and testing the parameters until all parameters are significant and they are the final models. The empirical results are described in Table 10 and 11.

We can observe from Table 10 that the most suitable state models are $F(5,3)$, $F(6,6)$ and $F(6,7)$. Moreover, this study converts the empirical results to matrices and equations, by which, it detects whether there is a one-way or a feedback relationship, as well as the strength of their influences.

However, from Table 11, it can be seen that, among the variables, two groups of variables show cause-effect relationships, that is, the

Table 10. Parametric test table of the State space model.

Most suitable state model			
Parameters	**Estimated value**	**Standard difference**	**t Test value**
$F(5,3)$	0.636038	0.222542	2.86
$F(6,6)$	-0.65526	0.166385	-3.94
$F(6,7)$	0.708769	0.164699	4.30

Notes: 1. Information source: The data were collected by this study.

Table 11. Empiric al r esults of t he matrix and equation of the most suitable state space model.

Empirical results of the matrix of the most suitable State space model

$$\begin{bmatrix} HUI_{t+1} \\ DX_{t+1} \\ CRB_{t+1} \\ DJIA_{t+1} \\ OPEC_{t+1} \\ GS_{t+1} \\ GC_{t+1} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.636038 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -0.65526 & 0.708769 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \times \begin{bmatrix} HUI_{t} \\ DX_{t} \\ CRB_{t} \\ DJIA_{t} \\ OPEC_{t} \\ GS_{t} \\ GC_{t} \end{bmatrix} + \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} \varepsilon_{t+1} \\ \nu_{t+1} \\ \mu_{t+1} \\ \lambda_{t+1} \\ \gamma_{t+1} \\ \omega_{t+1} \\ \vartheta_{t+1} \end{bmatrix}$$

Empirical results of the Equation State space model

1. $OPEC_{t+1} = 0.636038\, crb_t + \gamma_{t+1}$ 2. $GS_{t+1} = (-0.65526)gs_t + 0.708769\, gc_t + \omega_{t+1}$

Notes: 1. Information source: The data were collected by this study.

OPEC crude oil spot and the CRB Futures Index as well as the New York gold spot and the New York gold futures. This means that the CRB Futures Index is ahead of the OPEC crude oil spot and it is of a positive unilateral relationship. In which case, the CRB Futures Index exerts an impact on the OPEC crude oil spot of 0.636038%. Moreover, the New York gold futures in ahead of the New York gold spot, and it also has a positive unilateral relationship in which the fluctuation that the New York gold futures makes on the New York gold spot is 0.708769%. In addition, the New York gold spot is influenced by the negative relationship of its own previous period, and the fluctuation is 0.65526%.

In summary, the empirical results of the short-term interaction from the vector error correction model applied in e-views, the Granger causality test, and the state space model from the SAS statistical software are shown in Table 12.

CONCLUSION AND SUGGESTIONS

The purpose of the study is to take 105 observations of the monthly data from January 1998 to September 2006to investigate the dynamic interactive relationship among the variables. The study was devised to improve our understanding of the dynamic relationship between the gold market and the Amex Gold BUGS Index, the New York gold spot and the Gold Futures in the gold market, as well as the relationship between the Commodity Research Bureau Futures Price Index, the Dow Jones Industrial Average, and OPEC crude oil spot in the dollar market. This study also takes into account the

Table 12. Table of empirical results of e-views and the SAS short-term interaction relationship.

Table of the empirical results of the vector error correction, Granger causality test and State space model					
Cause vs. effect		**E-views**		**SAS**	**Collected and distributed empirical results**
		VECM	**Granger**	**SSM**	
Gold index	HUICRB				
	HUIDX				
	HUIGC				
	HUIGS				
	HUIOPEC				
	HUIDJIA				
Dollar	DX CRB				
	DX GC				
	DX GS				
	DX OPEC				
	DX HUI				
	DX DJIA				
Inflation	CRB DX				
	CRB GC				
	CRB GS				
	CRB OPEC				
	CRB HUI				
	CRB DJIA				
Gold price	GS CRB				
	GS DX				
	GS GC				
	GS OPEC				
	GS HUI				
	GS DJIA				
Gold futures	GC CRB				
	GC DX				
	GC GS				
	GC OPEC				
	GC HUI				
	GC DJIA				
Stock market	DJIA CRB				
	DJIA DX				
	DJIA GC				
	DJIA GS				
	DJIA OPEC				

Table 12. Contd.

	DJIAHUI
	OPECCRB
Oil price	OPECDX
	OPECGC
	OPECGS
	OPECHUI
	OPECDJIA

Note: 1. indicates that there is some relationship among variables. 2. Information Source: The data were collected by this study.

the effect of the above relationships on the overall economy.

FINDINGS

From the above empirical analysis, we derive the following findings:

(1) As for the long-term equilibrium relationship, at first, the results of the Johansen Co-integration Test show that there is a long-term consistency or linear combination. Test results further prove that there is a long-term equilibrium relationship among gold futures, gold indexes and economic variables. Moreover, the Error Correction Model shows that there is a long-term equilibrium relationship among the dollar index, the CRE Futures Index and the New York gold futures. Moreover, it is apparent that a positive correlation exists among the OPEC crude oil spot and the New York gold spot and the AMEX Gold Index while a negative correlation appears among the CRE Futures Index and the New York gold futures.

(2) As for short-term interaction on a whole, the New York gold futures is subject to the impact of the AMEX Gold Index, the CRB Futures Index, the Dow-Jones Industrial Average, and the New York gold spot. Moreover, they are all ahead of the dollar index, the CRB Futures Index and the previous period of the New York gold spot. Among them, the relationship between the New York gold spot and the New York gold futures is a feedback causality.

(3) From the Vector Error Correction Model, we know that the New York gold futures is not subject to the impact of its own previous period but is subject to the AMEX Gold Index, the CRB Futures Index, the Dow-Jones Industrial Average and the previous period of the New York gold spot.

(4) The results of the Granger Causality test illustrate that the strength of the impact factors can be ranked from highest to lowest as follows: the New York gold spot, the New York gold futures, the CRB Futures Index, the Dow-Jones Industrial Average, the OPEC crude oil spot, the AMEX Gold Index and the dollar index in sequence.

(5) The state space model reveals that there is a significant difference between the Vector Error Correction Model and the Granger Causality analysis. We can only detect the impact of the CRB Futures Index on the OPEC crude oil spot and the relationship between the New York gold futures and the New York gold spot. The reason might be because there are differences between the statistical software, statistical methods and theories applied in the Vector Error Correction Model and the Granger Causality Test. However, results still point out that oil price leads the CRB Futures Index in inflation, while the New York gold futures are ahead of the New York gold spot.

IMPLICATIONS

The above findings demonstrate that when investors conduct some relevant investment activities, if they anticipate fluctuation trends by analyzing the information of the previous period, investment is not practicable because the suitability is not obvious. However, the fluctuation trend of the gold futures can be anticipated with some relevant information of the dollar index, the CRB Futures Index and the previous period of the New York gold spot, since it is ahead of the dollar index. In addition, relevant anticipation and analysis on the AMEX Gold Index, the CRB Futures Index, the Dow-Jones Industrial Average and the New York gold spot can be further made with relevant information gold futures, since the New York gold futures are subject to their impact.

Summary

Finally, we suggest that in addition to the measurements taken by this study, investors might be able to predict the gold futures by the dollar index and inflation index and also predict the gold price, inflation index, gold index and the fluctuated trend of the stock market. Since there is no noticeable relationship among oil prices, the gold index in the gold market and gold futures, thus, if the prediction of gold futures is not notable, the investors can still anticipate the inflation index by the oil price and then further deduct the fluctuation trend of the gold futures. Therefore, based on the above discussion, gold futures investors may proceed with some operations including arbitraging, hedging, and other investment strategies.

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