Forecasting Thai Gold Prices

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This paper addresses forecasting Thai gold price. Two forecasting models, namely, Multiple-Regression, and Auto-Regressive Integrated Moving Average (ARIMA), are applied to forecast the gold price. The research result suggests that ARIMA (1, 1, 1) is the most suitable model to be used for forecasting gold price in the short term. The second method, multiple-regression, shows that Australian Dollars, Japanese Yen, US dollars, Canadian Dollars, EU Ponds, Oil prices and Gold Future prices have effect on the change of Thai gold price. Closer examination suggests to me that simultaneously use Multiple-regression and ARIMA (1, 1, 1) to observe the future movement of Thai gold price in short term increasing accuracy.

Field of research: Thai gold prices, ARIMA, Multiple Regression

1. Introduction

Many researchers believed that gold is the best preserving purchasing power in the long run. Gold is also providing high liquidity; it can be exchanged for money anytime the holders want. Gold investment can also be used as a hedge against inflation and currency depreciation. However, in high volatility situation the change in gold price fluctuation is common. The investors hesitate to execute decision because only their intuition is not enough and can lead to loss. To provide better view of gold investment, forecasting models should be formed to support the decision.

2. Review of Literatures

Many researchers suggest that Box-Jenkins' ARIMA is the most accurate forecasting model. ARIMA wins over other models; Holt's Forecast model and a combination of Box-Jenkins' and Holt's in regression, by providing lowest MAPE (Mean Absolute Percent Error), (Wararit, 2006) The idea that Box and Jenkin's ARIMA model has predictability in Gold Price is accepted in many countries including Thailand. In Australia, the comparison between the forecasted London daily gold price resulted from the Economic Research Centre (ERCP) and ARIMA model has been done. The paper was claimed and proved that only simple ARIMA is very low cost and effectively enough to predict gold price. (Selvanathan, 2006)

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Additionally, Box-Jenkins' ARIMA is widely used to predict the future outcome for economic or financial purpose, but in agricultural field, ARIMA is also employed to forecast a shrimp productivity in global regions. Briefly, the world shrimp productivity can be forecasted by using ARIMA (0, 2, 1). (Agricultural Research Center, Chiangmai University, 2000)

However, ARIMA model can predict the future price from historical data. It does not provide any theoretical backgrounds. Multiple Regression with simple linear regression method can be used to find which factors in economy can affect the movement of Thai gold price. Jitprapan (2006)'s paper studies the monthly prices data starting from Jan 1, 1998 to October 30, 2005. The result is found from Multiple Regression that fours factors significantly affect the change of Thai gold price are World gold price, US-Thai exchange rate, Consumer Price Index and (911) terrorism in the United States.

The papers concerning ARIMA research are supporting the idea that ARIMA is the effective model for finding accurate Thai gold price prediction. By the use of ARIMA model integrated with information obtained from multiple regression model, Thai gold price prediction could be better by including some economics variables.

3. Methodology and Research Frameworks

The research does two parts; Multiple Regression and Box-Jenkins' ARIMA, to provide information about gold forecast in term of "variables finding" and "price prediction".

Multiple Regression Framework

Multiple regression would start with creating independent variables to test. Many necessity tests are performed to identify any statistical problems. Then, solving the problem, some variables may be deleted from the model because of insignificance. Finally, the model becomes completed and ready for prediction.

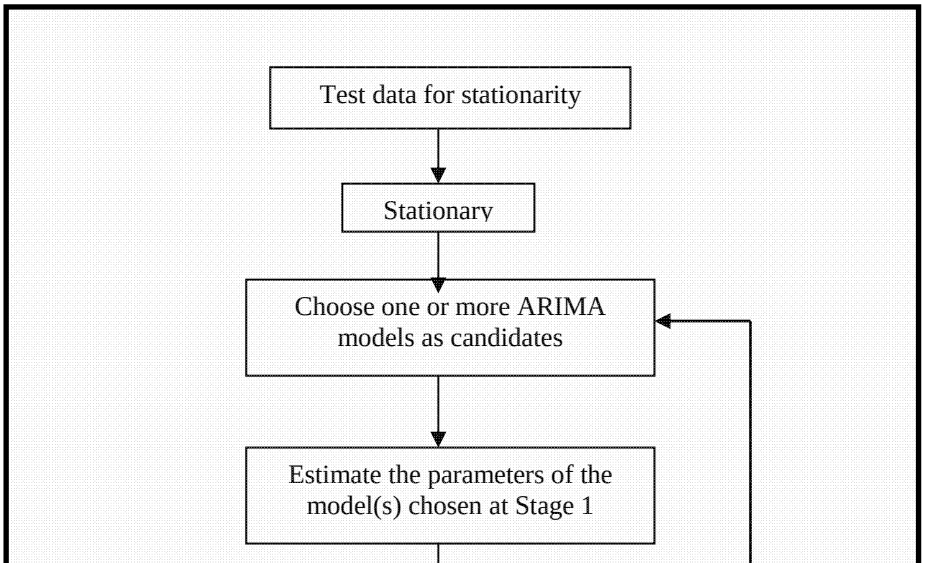
Currency Exchange Rate (Import & Export Function Theory): An appreciation of Thai baht provides the cheaper cost for Thai gold importers so Thai gold price will decrease. It also generates price competition among countries to supply gold to the market. These are the top ten gold exporting countries influencing and affecting the supply and trade of gold globally.

1. United States ... US$5.5 billion (23.2% of top ten gold exporters, up 25.2% from 2004)
2. Australia ... $4.4 billion (18.6%, up 7.1%)
3. Canada ... $3.7 billion (15.5%, up 28.4%)
4. Peru ... $3.1 billion (12.9%, up 30.1%)
5. Hong Kong ... $2.8 billion (11.8%, down 55.9%)
6. Japan ... $1.4 billion (6%, up 17.8%)
7. Germany ... $841.7 million (3.5%, up 22.7%)
8. Singapore ... $764.8 million (3.2%, up 14.2%)
9. Italy ... $628.7 million (2.6%, up 41%)
10. Colombia ... $627.2 million (2.6%, up 9%).

Oil Price (Inflation Theory): A change of gold price has direct affect to inflation. Higher inflation seems to generate more demand of holding gold. Indirectly, gold is a fundamental input of many products and gold is no exception for this. Generally and easily, transportation cost is computed and included cost of all goods.
SET Index (Portfolio Theory): A change of set index has impact on assets holding decision. If SET index is increasing, it is more attractive and more investors are attracted to buy stock. Gold, as a choice among other assets, seems to be dumped to the market since the investors go to stock market.
Interest Rates (Portfolio Theory): A change of interest rates has similar result as SET Index. If interest rate is increasing, it is more attractive and more investors are attracted to deposit money at a bank. Gold, as a choice among other assets, is less interesting and be left in the market since investors go to banks.
Gold Derivatives (Demand & Supply Theory): A change of gold derivative prices has impact on investors' expectation. If the derivative price is increasing, investors will have more demand to buy gold at the moment to speculate on price of the real gold asset price which is profited from the difference price of the derivatives and gold.
Chinese New Year (Demand & Supply Theory): In Thailand, Chinese New Year is considered culturally important day. Chinese-Thai People have belief that Gold represents prosperity, giving gold as a gift alike giving the prosperity to others. It is obviously seen that when Chinese New Year comes, there is more demand of gold and more volatile of Thai gold price.

ARIMA Framework

ARIMA is the model for predicting time series data. The model uses no other independent variables but the prediction will come out from historical gold price. If complete data of Thai gold price is collected, ARIMA model can be done successfully. The framework of ARIMA is shown on the following figure.



Data Source

Thai gold prices are from the website of Thai Gold Traders Association (*http://www.goldtrader.or.th/price.php*). Ten currencies exchange rates, oil price, SET index, Interest Rates and Chinese New Year are from Reuters Database, Bank of Thailand (*http://www.bot.or.th/BOTHHomepage/DataBank/).* Time Range are from 4 February 2002 – 11 April 2008 (for ARIMA model), and 22 November 2005 – 25 April 2008 (for Multiple Regression model)

4. Result and discussion

Box-Jenkins' ARIMA model

1. Stationarity Test

Before the use of data to create ARIMA model, the data needed to be tested for stationarity. The test is done to prove that the data is stationary. It means if Thai gold prices are stationary meaning they are not affected by other factors, such as seasonality, trends.
In this research, stationarity test will be done by "Augmented Dickey-Fuller Regression's Unit Root Test" by setting hypothesis as;

Ho: $\gamma = 0$ (Non-Stationary)
H_1: $\gamma \neq 0$ (Stationary)

	t-statistic	Prob.
Augmented Dickey-Fuller test	-2.440709	0.3581
Test critical values 1% level	-3.964248	
5% level	-3.412845	
10% level	-3.128408	

Thai gold prices series is non-stationary at price level which is test at 0.05 critical value. The series need to be transformed to 1st difference data and tested again.

	t-statistic	Prob.*
Augmented Dickey-Fuller test	-25.49056	0.0000
Test critical values 1% level	-2.568697	
5% level	-1.941335	
10% level	-1.616356	

*MacKinnon (1996) one-sided p-values.

Thai gold prices become stationary at 1st difference since the null hypothesis is rejected at 0.05 critical value.

Data Transformation

After the test of stationarity, it is found that the data will be stationary at 1st difference. So, Thai gold price of each day will be transformed by the following formula.

$$Y'_t = Y_t - Y_{t-1}$$

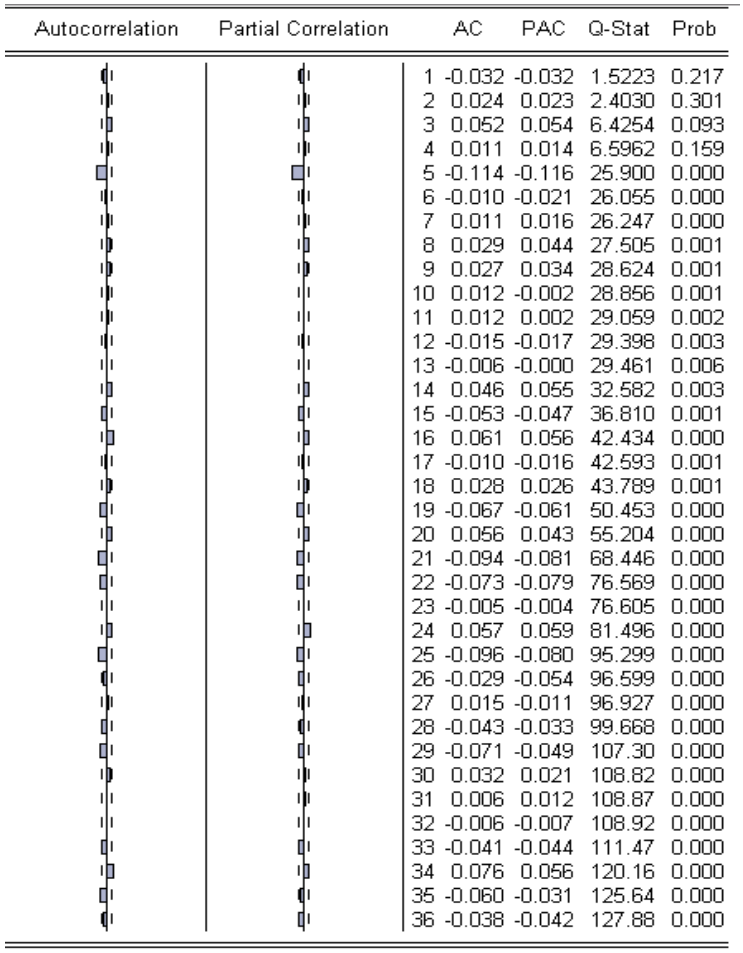
Where; Y'_t = A result of first differencing at time t
Y_t = Data at time t
Y_{t-} = Data at tme t-1 or the data before time t for 1 unit

1. Model Identification

The regressor that would be chosen to form the model will be selected from various lag of time of AR (p) and MA (q). The selection will be done by observing the ACF (Autocorrelation Function) and PACF (Partial Autocorrelation Function).

2. Model Selection

After observing the lags, there are several possible models can be used for prediction includes ARIMA (5, 1, 5), ARIMA (3, 1, 5), ARIMA (1, 1, 1). However, the best model to forecast Thai gold price is ARIMA (1, 1, 1) since it contains the least MAPE value (Mean Absolute Percent Error) compared among the three.



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.032	-0.032	1.5223	0.217
		2	0.024	0.023	2.4030	0.301
		3	0.052	0.054	6.4254	0.093
		4	0.011	0.014	6.5962	0.159
		5	-0.114	-0.116	25.900	0.000
		6	-0.010	-0.021	26.055	0.000
		7	0.011	0.016	26.247	0.000
		8	0.029	0.044	27.505	0.001
		9	0.027	0.034	28.624	0.001
		10	0.012	-0.002	28.856	0.001
		11	0.012	0.002	29.059	0.002
		12	-0.015	-0.017	29.398	0.003
		13	-0.006	-0.000	29.461	0.006
		14	0.046	0.055	32.582	0.003
		15	-0.053	-0.047	36.810	0.001
		16	0.061	0.056	42.434	0.000
		17	-0.010	-0.016	42.593	0.001
		18	0.028	0.026	43.789	0.001
		19	-0.067	-0.061	50.453	0.000
		20	0.056	0.043	55.204	0.000
		21	-0.094	-0.081	68.446	0.000
		22	-0.073	-0.079	76.569	0.000
		23	-0.005	-0.004	76.605	0.000
		24	0.057	0.059	81.496	0.000
		25	-0.096	-0.080	95.299	0.000
		26	-0.029	-0.054	96.599	0.000
		27	0.015	-0.011	96.927	0.000
		28	-0.043	-0.033	99.668	0.000
		29	-0.071	-0.049	107.30	0.000
		30	0.032	0.021	108.82	0.000
		31	0.006	0.012	108.87	0.000
		32	-0.006	-0.007	108.92	0.000
		33	-0.041	-0.044	111.47	0.000
		34	0.076	0.056	120.16	0.000
		35	-0.060	-0.031	125.64	0.000
		36	-0.038	-0.042	127.88	0.000

3. Model Estimation

After AR and MA are chosen and defined, there will be a process of intercept and coefficient estimation. Generally, OLS or Ordinary Least Square Method would be used;

Forecasted Result = Intercept + AR (n) +MA (n) + ε

Where; n = number of lag(s) which has been chosen

The result of ARIMA (1, 1, 1) is

1st Diff of GOLD = 5.031026 + AR(1)*(-0.978225) + MA(1)*(0.961025)

Multiple Regression model

1. Model Forming and Checking

This stage will be done to satisfy the purpose of finding factors affecting Thai gold price. To answer this, the simple linear regression is used here. The model to be test is on the following;

GOLD = β1US+ β2AUS+ β3CAN+ β4PER+ β5HK+ β6JAP+ β7EU+ β8SIN+β9COL+β10OIL+ β11SET+ β12INT+ β13FUTURE + β14GIFT

Where:

Thai Gold Price	:	GOLD
Oil Price	:	OIL
SET Index	:	SET
Interest Rates	:	INT
Gold Derivative	:	FUTURE
Chinese New Year	:	GIFT (Dummy Variable)
United States	:	US
Australia	:	AUS
Canada	:	CAN
Peru	:	PER
Hong Kong	:	HK
Japan	:	JAP
Germany and Italy	:	EU
Singapore	:	SIN
Colombia	:	COL

All the variables to be run here are transformed to be all stationary 1st difference or return data by

$$\frac{(\text{Gold price}_T - \text{Gold price}_{T-1}) * 100}{\text{Gold price}_{T-1}}$$

To satisfy the purposes;

1. To simply lessen Autocorrelation Problem.
2. To lessen the effect from seasonality, trend and other unrelated factors.

Then, the running process comes. The research will separately run the data;

Firstly, all the nine currencies are to be in the regression analysis to find the currencies that have really significant impact on Thai gold price.
Secondly, the significant currencies will be brought to the analysis again but this time they will be processed with other variables; OIL, SET, INT, FUTURE, GIFT.

The first stage's result shows that there are only five currencies significantly affecting Thai gold price at 0.05 critical value which are AUS, US, JAP, EU and CAN. These five currency variables will be taken to the regression analysis with the rest variables in the next stage.

The final stage for this part is the regression analysis for all the variables left. The outcome of testing at 0.05 critical value is shown in the form of the model below;

1st Difference of GOLD = 0.02203931137 + 0.6624022662***AUS** + 0.419961539***CAN** + 0.4368121817***JAP** + 0.1504451898***EU** - 0.8546501878***US** + 0.121974604***FUTURE** + 0.04365593688***OIL**

Dependent Variable: GOLD
Method: Least Squares
Sample (adjusted): 2 622
Included observations: 621 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.022039	0.038983	0.565357	0.5720
AUS	0.662402	0.075369	8.788809	0.0000
CAN	0.419962	0.091580	4.585752	0.0000
JAP	0.436812	0.071559	6.104245	0.0000
EU	0.150445	0.052845	2.846931	0.0046
US	-0.854650	0.154679	-5.525320	0.0000
FUTURE	0.121975	0.030663	3.977950	0.0001
OIL	0.043656	0.020048	2.177616	0.0298

R-squared	0.309976	Mean dependent var	0.061626
Adjusted R-squared	0.302097	S.D. dependent var	1.144179
S.E. of regression	0.955854	Akaike info criterion	2.760375
Sum squared residual	560.0715	Schwarz criterion	2.817462
Log likelihood	-849.0965	F-statistic	39.33935
Durbin-Watson stat	2.254450	Prob(F-statistic)	0.000000

2. Statistical Problems Checking

The research focuses on three general statistical problems; Autocorrelation, Multicollinearity and Heteroskedasticity. This part covers the problems diagnosis and solving.

Multicollinearity

To diagnose the problem of multicollinearity, the simplest way to use in this research is checking “Simple Correlation Coefficients”. In statistics, if the independent variables have the correlation value among them lower than 0.8, it is considered as no Multicollinearity problem.

The result, there is also a provision of Simple Correlation Coefficients table. The table is shown below.

	GOLD	AUS	CAN	JAP	EU	US	FUTURE	OIL
GOLD	1.000	0.427	0.317	0.123	0.147	-0.045	0.218	0.136
AUS	0.427	1.000	0.553	-0.191	0.023	0.148	0.129	0.085
CAN	0.317	0.553	1.000	-0.076	-0.007	0.384	0.060	0.082
JAP	0.123	-0.191	-0.076	1.000	0.201	0.195	0.067	-0.033
EU	0.147	0.023	-0.007	0.201	1.000	-0.007	-0.068	0.066
US	-0.045	0.148	0.384	0.195	-0.007	1.000	-0.049	-0.037
FUTURE	0.218	0.129	0.060	0.067	-0.068	-0.049	1.000	0.056
OIL	0.136	0.085	0.082	-0.033	0.066	-0.037	0.056	1.000

It is found that there is no pair of independent variables having correlation value larger than 0.8 so this model is considered no multicollinearity.

Heteroskedasticity

The problem of Heteroskedasticity can be firstly checked by setting hypothesis;

Ho : Homoscedasticity
H1 : Heteroskedasticity

The hypothesis is tested at 95% confident level

The value which is used to be a reference for the test is Obs*R-squared. This test is comfortably done White Heteroskedasticity Test function

White Heteroskedasticity Test:

F-statistic	17.59808	Prob. F(14,606)	0.000000
Obs*R-squared	160.0886	Prob. Chi-Square(14)	0.000000

Obs*R-squared, 160.0086 is brought to compare with the X^2 distribution table at 0.05 significance level; the table is shown 21.03 for the value. The model's Obs*R-squared value is greater than the value in the table which means the null hypothesis is to be rejected. The model is considered having Heteroskedasticity problem.

The problem should be lessened by "White Heteroskedasticity-Corrected Standard Errors" provided in E-Views. The method will change the value of t-Statistic and P value for re-deciding whether which variable(s) should be taken out of the model to lessen the problem of Heteroskedasticity by not changing the value of intercept and co-efficient. This method is the way out of lessening the problem which may not get rid of the problem. Still, this can be simply done in time limit constraint and when no variables should be taken out of the model.

The following tables show a comparison between before and after the problem is lessened.

Before

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.022039	0.038983	0.565357	0.5720
AUS	0.662402	0.075369	8.788809	0.0000
CAN	0.419962	0.091580	4.585752	0.0000
JAP	0.436812	0.071559	6.104245	0.0000
EU	0.150445	0.052845	2.846931	0.0046
US	-0.854650	0.154679	-5.525320	0.0000
FUTURE	0.121975	0.030663	3.977950	0.0001
OIL	0.043656	0.020048	2.177616	0.0298

After

White Heteroskedasticity-Consistent Standard Errors & Covariance

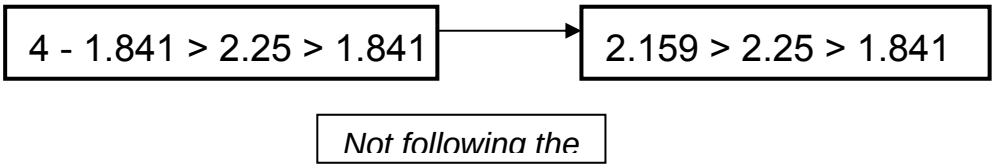
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.022039	0.041316	0.533437	0.5939
AUS	0.662402	0.086589	7.649973	0.0000
CAN	0.419962	0.114512	3.667403	0.0003
JAP	0.436812	0.081001	5.392682	0.0000
EU	0.150445	0.055771	2.697532	0.0072
US	-0.854650	0.172752	-4.947268	0.0000
FUTURE	0.121975	0.056870	2.144792	0.0324
OIL	0.043656	0.018191	2.399901	0.0167

All the judgment values shows that all the variables are still significant at 0.05 significant, so the problem is considered lessened and the current model is still to be used.

Autocorrelation

There are several methods for autocorrelation diagnosis. However, the simplest and well-known method is Durbin Watson Statistical value measurement which is used in this research. Durbin Watson Statistical value for the model equals to 2.25. Durbin Watson critical value (du) is 1.841.

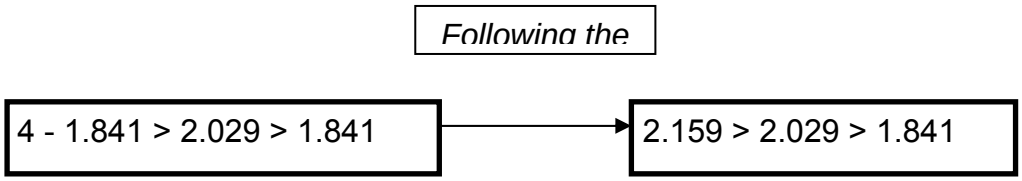
4- du > Durbin Watson Value > du



Thus, the model is having Autocorrelation problem.

The method to solve the problem in this research is “The Cochrane-Orcutt Iterative Method”. The model’s co-efficient and all statistical values will be recalculated again and again for finding the best possible ρ that reflects No Autocorrelation problem.

After Autocorrelation problem is solved, the new Durbin Watson value is 2.02957. The number is more so close to 2 and follows the rule;



This is the final proof shows No Autocorrelation problem since it has been solved. The new model is;

1st Difference of GOLD = 0.01821465662 + 0.5969828963***AUS**+
0.4095856383***CAN** +0.3915543885***JAP**+
0.1607288828***EU** - 0.7478841222***US** +
0.1942943066***FUTURE** + 0.04340635398***OIL**

3. Model Presentation

Finally, the model becomes successfully created. The factors expected to have impact on the price changes of Thai gold price are Australian Dollars, Japanese Yen, US dollars, Canadian Dollars, EU Ponds Gold Futures and Oil price

1st Difference of GOLD = 0.01821465662+0.5969828963***AUS**+
0.4095856383***CAN** + 0.3915543885***JAP** +
0.1607288828***EU** - 0.7478841222***US** +
0.1942943066***FUTURE** + 0.04340635398***OIL**

Prediction Results Analysis

Box-Jenkins' ARIMA model

1st Difference of GOLD = 5.031026736 + AR(1)*(-0.9782254545) +
MA(1)*(0.9610251236)

First, the ARIMA (1, 1, 1), is used to predict Thai gold prices from 18 April 2008 to 30 April 2008.

The results in the table below shows that ARIMA (1, 1, 1) is quite having predictability, noticing the first half of the prediction, the errors seems acceptable in small range around less than 10 baht. However, later in the second half, the errors gain more value about 40 – 50 baht and show an increasing trend of error in the future.

Date	Real Data	ARIMA's Resulted Data	Error
18-Apr-08	13950	13738.34	*211.66*
19-Apr-08	13700	13962.80	*-262.80*
21-Apr-08	13700	13697.03	*2.97*
22-Apr-08	13700	13707.88	*-7.88*
23-Apr-08	13700	13697.45	*2.55*
24-Apr-08	13500	13707.48	*-207.48*
25-Apr-08	13300	13501.28	*-201.28*
26-Apr-08	13350	13307.24	*42.76*
28-Apr-08	13400	13347.21	*52.79*
29-Apr-08	13350	13406.85	*-56.85*
30-Apr-08	13100	13349.31	*-249.31*

1st half

2nd half

This is another similar proof to many papers supporting that Box-Jenkins' ARIMA model has predictability in many fields. Still, its drawback is that the accurate result is seen only in short term.

Thus only quantitative result may be not enough; some information needed to be used for noticing the movement of Thai gold price. The information referred here can be obtained from multiple regression process as mentioned before.

Multiple Regression model

1st Difference of GOLD = 0.01821465662 + 0.5969828963***AUS** +
0.4095856383***CAN** + 0.3915543885***JAP** +
0.1607288828***EU** - 0.7478841222***US** +
0.1942943066***FUTURE** + 0.04340635398***OIL**

As represented by the model, the multiple regression tells some information of what factors that have an impact on Thai gold price change. The significant variables or factors affect Thai gold price change are Australian Dollars, Japanese Yen, US dollars, Canadian Dollars, EU Ponds, Gold Future prices, Oil price. These factors can be summarized in detail in the table;

Variables	Relationship	Explanation
Australian Dollars	Positive	If the exchange rate of Thai Baht to Australian dollars rises by 1 baht, Thai gold price's return seems to rise by 0.6 baht or inverse incident.
Japanese Yen	Positive	If the exchange rate of Thai Baht to Japanese Yen rises by 1 baht, Thai gold price's return seems to rise by 0.4 baht
US dollars	Negative	If the exchange rate of Thai Baht to US dollars rises by 1 baht, Thai gold price's return seems to lessen by 0.75 baht
Canadian Dollars	Positive	If the exchange rate of Thai Baht to Canadian dollars rises by 1 baht, Thai gold price's return seems to rise by 0.4 baht
EU Ponds	Positive	If the exchange rate of Thai Baht to EU Ponds rises by 1 baht, Thai gold price's return seems to rise by 0.16 baht
Gold Futures	Positive	If the gold future prices rise by 1 unit, Thai gold price's return seems to rise by 0.19 baht
Oil price	Positive	If the oil price rises by 1 baht, Thai gold price's return seems to rise by 0.04 baht

The predictability of the multiple regression can be measured by R-squared and adjusted R-squared. The result shows both values

R-squared	0.325973
Adjusted R-squared	0.317148

The Adjusted R-squared can explain 31.71% of gold price change.

Conclusion

Thai gold investors can use ARIMA (1, 1, 1) for predicting the gold price. Though, ARIMA seems to be the best model for forecasting Thai gold price, it contains some errors. For more insightful, the investors should know which factors can have effect on the change of the gold price. This would help lessen the risk of loss because the investors can have more information when generating gold trading decision. The factor that the investors should take a close look is US dollars currency, since it has the highest co-efficient value among all the factors, if the US dollars exchange rate declines meaning that Thai gold prices seem to rise.

The rest factors are also usable as indicators to predict Thai gold prices movement. If Australian Dollars, Japanese Yen, Canadian Dollars, EU Ponds and Oil price have an increasing trend, it means Thai gold price should rise since they all have positive relationship.

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