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FULL PAPER

Using weighted Markov SCGM(1,1)$_c$ model to forecast gold/oil, DJIA/gold and USD/XAU ratios

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Abstract

Grey model can be counted as a potent approximation for extracting system dynamic information with only small amount of data. A weighted Markov model is appropriate for predicting the stochastic fluctuating dynamic by a transition probability matrix and normalizing autocorrelation coefficient as weighted and a single gene system cloud grey SCGM(1,1)$_c$ model. It is applied to regulate the development trend of time series. In this paper we employed a weighted Markov SCGM(1,1)$_c$ model for predicting the gold/oil ,DJIA/gold and USD/XAU ratios. By examining the forecasted results, it was concluded that the weighted Markov SCGM(1,1$_{)c}$ model is a reliable and effective modeling method.

Keywords: Weighted Markov chain , SCGM(1,1)$_c$ Model , gold, oil, DJIA, XAU

INTRODUCTION

Economic systems are convoluted and can be specified by deterministic or random models. Gold, oil, dollar and Dow Jones index are playing an important role in these systems. Over the long term gold keeps its value in real terms, but in short run factors such as financial stress, inflation, real interest rates, political turmoil, etc., can move gold away from its long run balance for extended times. Predicting and analyzing the movements of these draw much attention from policy makers now days. Gold and oil are critical not only in the assessing of derivatives and hedging plans, but also in larger financial market and the world economy; Moreover their degree of correlation is greatly positive (J. Simakova, 2011). The gold-to-oil ratio indicates the interrelationship between the commodity that makes the foundation of global economy and the commodity that has been the ultimate form of money. Dow Jones index is an indicator of aggregate stock market activity. Dow to gold ratio shows that how many ounces of gold it would take to buy the Dow on any given month. USD/XAU rate is another important indicator which some currency rankings demonstrate that it is the most popular gold exchange rate. The monthly fluctuations of gold/oil, DJIA/gold and USD/XAU ratios in recent years are shown in Figure 1 and Figure 2. The variations of these ratios are vital issues of macroeconomic.

By using various methods the relations between these variables have been analyzed in literature. (K. S. Sujit , B. Rajesh Kumar, 2011) established the dynamic relationship among gold price, Oil price with exchange rate and stock index using vector autoregressive technique.

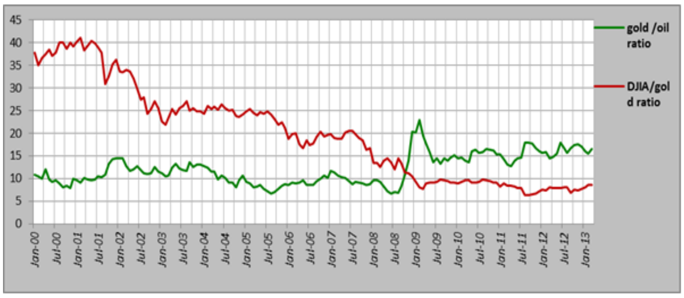

Figure 1. Monthly trend of Gold/Oil ad DJIA/Gold ratios from January 2000 to March 2013

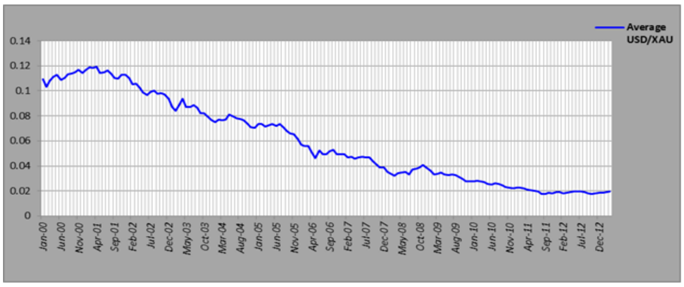

Figure 2. Monthly trend of USD/XAU ratio from January 2000 to March 2013

(H.F. Chang, L.C. Huang, M.C. Chin, 2013) examined the correlations of oil prices, gold prices and the NT Dollar versus US Dollar exchange rate by the vector auto-regression and variance decomposition method. (C. Toraman , C. Basarir , M. F. Bayramoglu, 2011) examined the effects of oil prices, USA exchange, inflation and interest rates on the gold prices with MGARCH model. (M.M. Baig, M. Imran, M. Jabbar, Q.U. Ain, 2013) studied the relationship between gold prices, oil prices and KSE100 return with augmented Dickey-Fuller, Phillip-Perron, Johannes and Jelseluis Co-integration and variance decomposition test. (J.C. Reboredo, 2013) used a method based on copulas to analyses the dependence structure between gold and oil price markets. (J. Barunik, E. Kocenda, L. Vacha, 2013) studied the dynamics of the price of gold, oil and S&P500 with methods of nonparametric realized volatility, a parametric DCCGARCH model and wavelet analysis. (J. Beckmann,R. Czudaj, 2013) analyzed the oil and gold price dynamics and their relation to US prices and the dollar exchange rate applying a cointegrated VAR model. (N. Apergis, D. Papoulakos, 2013) examined the association between the exchange rate between Australian Dollar against US Dollar and gold prices with the error correction model and the generalized autoregressive heteroskadistic method.

(A. Jain,S. Ghosh, 2013) investigated cointegration and causality and examined the generalized error variance decomposition of these variables among global oil prices, precious metal prices and Indian Rupee-US Dollar rate. (G.C. Nath, 2013) studied the long term relationship between crude oil and gold prices using granger causality test and regression with lags. (T. Ewing, F. Malik, 2013) applied univariate and bivariate GARCH models to analyze the volatility of gold and oil futures. (T.H. Le, Y. Chang, 2011) found that the oil price causes the gold price nonlinearly and can be applied to forecast the gold price. The grey system theory is the study of grey system modeling, analysis, decision making, prediction and control theory. The fuzzy mathematics copes with issues of phenomenon with cognitive uncertainty by experience and affiliation functions. Probability and statistics need specific distributions and large sample. When any necessary distribution cannot establish or we do not have any prior experience or large sample, the grey models can be used (Liu S., Lin Y., 2006). The grey model examines and detects the realistic laws of evolution of events through the works of sequence operators and information coverage (Liu S., Lin Y., Forrest J.Y.L., 2010). These characteristics make the grey models superior compared to probability, statistics and fuzzy mathematics models. The grey models have been used in many fields such as economics (C. Wang, Y. Chen, L. Li, 2007), (G. Kim, R.S. Yun, 2012), (C.C. Hsu, C.Y. Chen, 2003), energy issues (Z. Yunlong, L. Mao, 2011), (H. Mostafaei, Sh. Kordnoori, 2011), environment (Z. Yunlong, L. Mao, 2011), engineering (J. Gu, N.H. Viehare, B. Ayyub, M. Pecht, 2010), sociology (L. Juan, W.J. Liu, 2011), seismicity (J. Min, W. Shang-Xu, C. Shuang-quan, 2005).

The $SCGM(1,1)_c$ model is considered as the best extension of GM(1,1) model; Moreover the $SCGM(1,1)_c$ model has more theoretical basis and can more profoundly search practical information from its data series. Compared with other grey prediction models, this model has some advantages such as low calculation complexity, less information required and better prediction accuracy. The compound model of Markov chain and grey theory has been used in many domains. (W. Zeng-min, W. Kai-Jue, 2012) applied the grey weighted Markov chain model to predict mobile communications markets. (Y.M. Tian, H.L. Shen, L. Zhang, X.R. Lv, 2010) forecasted the utility water supply with the GM(1,1) weighted Markov chain. (F. Zhang, Z.P. Jia, H. Xia, *et al*., 2012) suggested the improved SCGM(1,1) model based on Markov theory and fuzzy identification to predict the node trust in mobile and hoc networks. (C. Zhang, C.B. Ma, J.D. Xau, 2006) predicted air disaster death toll with the grey Markov $SCGM(1,1)_c$ model . (G.Q. Xiang, Q.J. Gao, 2007) proposed an algorithm of similarity prospecting in time series data according to the grey Markov $SCGM(1.1)_c$ model. (X.C. Jiang, S.F. Chen, 2009) applied a combination of the weighted $SCGM(1.1)_c$ model and Markov chain to drought crop area. (Z. Ling, X. Hong Ke, 2014) used grey weighted Markov $SCGM(1.1)_c$ to predict the traffic accident times of Beijing. (Z. Gong, C. Chen, X. Ge, 2013) applied weighted Markov and grey weighted Markov method to predict the risk of low temperature in china.

The goal of this paper is to introduce the new model by combining the benefits of $SCGM(1,1)_c$ model and Markov chain. We predict the ratios of gold/oil prices, DJIA/gold and USD/XAU by applying the weighted Markov $SCGM(1,1)_c$ model.

THE MATHEMATICAL MODEL

Suppose $X^{(0)}$ as the initial time series as follows:

$$X^{(0)} = \{X^{(0)}(1), X^{(0)}(2), \dots, X^{(0)}(n)\} \tag{1}$$

A new sequence $\bar{X}^{(1)}$ is obtained by the transformation of $X^{(0)}$ as

$$\bar{X}^{(1)}(k) = \sum_{m=2}^{k} \bar{X}^{(0)}(m), (k = 2,3,\dots,n) \tag{2}$$

where

$$\bar{X}^{(1)}(k+1) = \frac{X^{(0)}(k+1) + X^{(0)}(k)}{2} \tag{3}$$

which can be expressed as

$$\bar{X}^{(1)} = \{\bar{X}^{(1)}(2), \bar{X}^{(1)}(3), \dots, \bar{X}^{(1)}(n)\} \tag{4}$$

Provide that $f_r(k) = be^{a(k-1)} - c$ is a discrete exponential function of non-homogenous and time series $\{\bar{X}^{(1)}(k)\}$ is a trend relationship, the system cloud grey $SCGM(1,1)_c$ model is

$$\frac{dX^{(1)}(k)}{dk} = aX^{(1)}(k) + U, (k \geq 2) \tag{5}$$

The response function is presented as

$$\hat{X}^{(1)}(k) = \left(\hat{X}^{(1)}(k) + \frac{U}{a}\right)e^{ak} - \frac{U}{a} \tag{6}$$

where

$$a = \ln \frac{\sum_{k=3}^{n} \bar{X}^{(0)}(k-1)\bar{X}^{(0)}(k)}{\sum_{k=3}^{n} (\bar{X}^{(0)}(k-1))^2} \tag{7}$$

$$b = [(n-1)\sum_{k=2}^{n} e^{2a(k-1)} - (\sum_{k=2}^{n} e^{a(k-1)})^2]^{-1}.[(n-1)\sum_{k=2}^{n} e^{a(k-1)}\bar{X}^{(1)}(k) - (\sum_{k=2}^{n} e^{a(k-1)})(\sum_{k=2}^{n} \bar{X}^{(1)}(k))] \tag{8}$$

$$c = \frac{1}{n-1}[(\sum_{k=2}^{n} e^{a(k-1)})b - \sum_{k=2}^{n} \bar{X}^{(1)}(k)] \tag{9}$$

$$U = ac \tag{10}$$

$$\hat{X}^{(1)}(1) = b - c \tag{11}$$

The system cloud grey $SCGM(1,1)_c$ is achieved by replacing $\hat{X}^{(1)}(1)$ as

$$\hat{X}^{(0)}(k) = \frac{2b(1-e^{-a})}{(1+e^{-a})}.e^{a(k-1)} \tag{12}$$

The grey precision index which shows the departure degree between the raw data and the fitted value is calculated as follows:

$$Y(k) = \frac{X^{(0)}(k)}{\hat{X}^{(0)}(k)} \tag{13}$$

The $Y(k)$ series created a nonstationary random process.

Hence for evaluating the fluctuation rule of grey precision the Markov processes are applied in order to increase the prediction precision of $SCGM(1,1)_c$ model; Moreover more precise forecasting result can be obtained by the weighted Markov model when the data are a stochastic fluctuating dynamic process. A Markov chain is a stochastic process $\{X_n, n = 0,1,\dots\}$ in discrete time with infinite or finite state space S which satisfies: (Markov property). If E is an event relying only on any subset of $\{X_{n-1}, X_{n-2}, \dots, 0\}$ for each $n \geq 1$ then

$$P\{X_{n+1} = j | X_n = i, E\} = P\{X_{n+1} = i | X_n = i\} \qquad \forall\, i, j \in S$$

Markov theory predicts the future state of the system based on state transition probability. The transition probability reflects the influence degree of the stochastic factors.

The advantages of weighted Markov chain and the grey theory are identifying the state transition regularity and showing the variation trend of time series data, respectively which gathered in the weighted grey Markov SCGM(1,1)$_c$ model simultaneously, therefore the precision of high volatile time series data is increased. Any state of $Y(k)$ is expressed as

$$S_i \in [\otimes_{1i}, \otimes_{2i}], i = 1,2, \dots, m \tag{15}$$

where S_i is the $i\ th$ state , the lower and upper bounds of the i th state are $\otimes_{1i} = Y(k) + A_i$, $\otimes_{2i} = Y(k) + B_i$, respectively in which A_i and B_i are regarded as constant.

An element p_{ij} of the transition probability is calculated as

$$p_{ij}^{w} = \frac{M_{ij}^{(w)}}{M_i} , i, j = 1,2, \dots, m \tag{16}$$

where $M_{ij}^{(w)}$ is the number of occurrence that altering from states S_i to S_j with ω steps and M_i is the number of state S_i in the Markov chain of $Y(k)$ index. As a result the $m \times m$ step of transition probability matrix is achieved as

$$P^{(w)} = \begin{pmatrix} p_{11}{}^{(w)} & p_{12}{}^{(w)} & \cdots & p_{1m}{}^{(w)} \\ p_{21}{}^{(w)} & p_{22}{}^{(w)} & \cdots & p_{2m}{}^{(w)} \\ \vdots & \vdots & \vdots & \vdots \\ p_{m1}{}^{(w)} & p_{m2}{}^{(w)} & \cdots & p_{mm}{}^{(w)} \end{pmatrix} \tag{17}$$

The related importance of each transition probability is quantified with the ω order autocorrelation coefficient of data as

$$r_w = \frac{\sum_{l=1}^{n-w} (Y(l) - \bar{Y})(Y(l+w) - \bar{Y})}{\sum_{l=1}^{n} (Y(l) - \bar{Y})^2} \tag{18}$$

Then r_w is normalized to get

$$\theta_w = \frac{|r_w|}{\sum_{w=1}^{m} |r_w|} \quad , \omega \leq m \tag{19}$$

where m is the highest order by forecasting inquiry, frequently taken $|r_w| \geq 0.3$.

Associating the initial state as the relating state of grey precession index in the preceding one year with the row vector of its corresponding transition probability matrix leads to state transition probability vector in the year as

$$P_i^{(w)} = \left(p_{i1}{}^{(w)}, \quad p_{i2}{}^{(w)}, \quad \dots \quad p_{im}{}^{(w)}\right), i \in S \tag{20}$$

The m-order weighted state transition probability matrix is calculated as

$$\begin{pmatrix} p_{\alpha 1}{}^{(w)} & p_{\alpha 2}{}^{(w)} & \cdots & p_{\alpha m}{}^{(w)} \\ p_{\beta 1}{}^{(w)} & p_{\beta 2}{}^{(w)} & \cdots & p_{\beta m}{}^{(w)} \\ \vdots & \vdots & \vdots & \vdots \\ p_{\gamma 1}{}^{(w)} & p_{\gamma 2}{}^{(w)} & \cdots & p_{\gamma m}{}^{(w)} \end{pmatrix} \quad \alpha, \beta, \gamma \in S, \alpha, \beta, \gamma \leq m \tag{21}$$

Consequently state transition probability of grey precision index to forecasted year is

$$P_i = \sum_{w=1}^{m} \theta_w \,.\, P_{.i}^{(w)}, i \in S \tag{22}$$

We consider $\max\{P_i, i \in S\}$ as a forecasted state of grey precision index by the weighted Markov chain. By linear interpolation the predicted value $\hat{Y}(n+1)$ is calculated as

$$\hat{Y}(n+1) = \otimes_{1i} \times \frac{P_{i-1}}{P_{i-1} + P_{i+1}} + \otimes_{2i} \times \frac{P_{i+1}}{P_{i-1} + P_{i+1}} \tag{23}$$

At last the predicted value in the $(N+1)\ th$ year is obtained as follows:

$$\tilde{X}^{(0)}(n+1) = \hat{Y}(n+1).\hat{X}^{(0)}(n+1) \tag{24}$$

The mean absolute percentage error (MAPE) is used for evaluating the prediction precision of the model as

$$MAPE = \frac{1}{n} \sum_{k=1}^{n} \left| \frac{X^{(0)}(k) - \tilde{X}^{(0)}(k)}{X^{(0)}(k)} \right| 100\% \tag{25}$$

CASE STUDIES AND DISCUSSION

Gold has a thorough impact on the value of world currencies. This paper employed the weighted Markov SCGM(1,1)$_c$ model to monthly fluctuations of Gold/Oil, DJAI/Gold and average USD/XAU ratios. The data of these ratios from January 2011 to February 2013 are used for modeling and listed in Table 1.

Table 1. The data of Gold/Oil, DJAI/Gold and USD/XAU ratios.

Date	Gold/Oil Ratio	DJAI/Gold Ratio	USD/XAU Ratio
Jan. 2011	15.29	8.29	0.022851
Feb. 2011	14.30	8.89	0.022656
March 2011	13.09	8.48	0.021873
April 2011	12.72	8.44	0.021054
May 2011	13.99	8.33	0.020544
June 2011	14.55	7.91	0.020347
July 2011	14.71	7.94	0.019816
Aug. 2011	17.96	6.45	0.017716
Sep. 2011	17.87	6.31	0.017573
Oct. 2011	17.81	6.60	0.018662
Nov. 2011	19.73	6.79	0.017887
Dec. 2011	16.04	7.31	0.018925
Jan. 2012	15.70	7.58	0.018844
Feb. 2012	15.79	7.38	0.017848
March 2012	14.45	8.17	0.018583
April 2012	14.78	7.88	0.018852
May 2012	15.47	7.99	0.019625
June 2012	18.00	7.86	0.019423
July 2012	16.73	8.04	0.019515
Aug. 2012	15.67	8.08	0.019109
Sep. 2012	16.82	6.96	0.017864
Oct. 2012	17.37	7.66	0.017809
Nov. 2012	17.60	7.49	0.018056
Dec. 2012	17.11	7.78	0.018452
Jan. 2013	16.09	8.15	0.018606
Feb. 2013	15.46	8.58	0.019092

We obtain:

Gold/Oil ratio: $\hat{X}^{(0)}(k) = 15.924\, e^{a(k-1)}$
$a = 0.001046$, $b = 15224.33123$

DJAI/Gold ratio: $\hat{X}^{(0)}(k) = 7.7676\, e^{a(k-1)}$
$a = -0.00224$, $b = -3467.681652$

USD/XAU ratio: $\hat{X}^{(0)}(k) = 0.0213\, e^{a(k-1)}$
$a = -0.00956$, $b = -2.228465$

The grey precision indices are calculated according to Equation (13) which demonstrates the trend of these ratios in Table 2.

Table 2. Grey precision indices for Gold/Oil ,DJAI/Gold and USD/XAU ratios.

Date	Gold/Oil ratio	DJAI/Gold ratio	USD/XAU ratio
Jan. 2011	0.960147	1.067253	1.072617
Feb. 2011	0.89704	1.147064	1.073679
March 2011	0.820278	1.096616	1.04653
April 2011	0.796259	1.09389	1.017021
May 2011	0.874844	1.082055	1.001918
June 2011	0.908912	1.029802	1.001842
July 2011	0.917946	1.036025	0.985069
Aug. 2011	1.119584	0.843495	0.889136
Sep. 2011	1.112809	0.827037	0.890431
Oct. 2011	1.107913	0.866986	0.954695
Nov. 2011	1.039641	0.893945	0.923838
Dec. 2011	0.995721	0.964565	0.986838
Jan. 2012	0.973595	1.002434	0.992053
Feb. 2012	0.978153	0.978174	0.948644
March 2012	0.894207	1.085312	0.997198
April 2012	0.913672	1.049135	1.021351
May 2012	0.995327	1.066166	1.073443
June 2012	1.110401	1.051171	1.072899
July 2012	1.030977	1.077655	1.088032
Aug. 2012	0.964646	1.085445	1.07563
Sep. 2012	1.034358	0.937084	1.015209
Oct. 2012	1.067063	1.033644	1.021805
Nov. 2012	1.080062	1.01297	1.045928
Dec. 2012	1.048895	1.054551	1.079135
Jan. 2013	0.985334	1.10718	1.098594
Feb. 2013	0.945764	1.168209	1.138118

The grey precision indices are partitioned into states with equal ranges (Table 3) for applying the weighted Markov chain.

An autocorrelation curve (Figure 3) shows that which order of the autocorrelation coefficients of grey precision indices satisfies in$|r_w| \geq 0.3$.

(a)

(b)

(c)

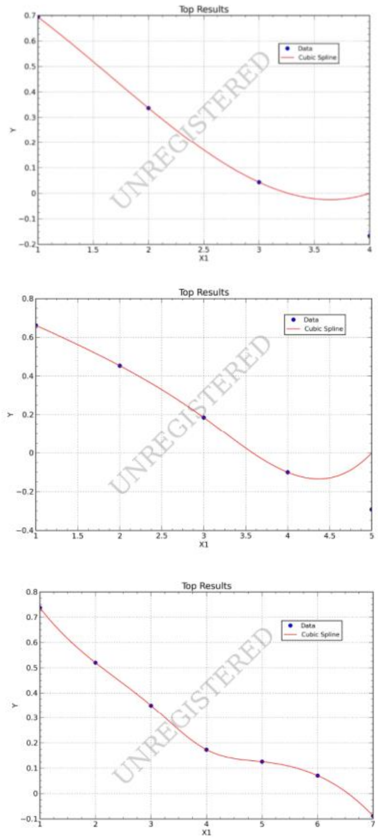

Figure 3. The autocorrelation curve of (a) Gold/Oil ratios, (b) DJAI/Gold ratios and (c) USD/XAU ratios.

The maximum order weighted state transition probability of Markov chain, normalized autocorrelation coefficients and weighted values of Markov chain and weighted Markov chain prediction probability p for all ratios are presented in Table 4.

Table 3. The state partitions of grey precision indices of SCGM(1,1)$_c$ model

Gold/Oil ratio	E_1:0.796259-0.8501465 E_2:0.8501465-0.904034 E_3:0.904034-0.9579215 E_4:0.9579215-1.011809 E_5:1.011809-1.0656965 E_6:1.0656965-1.119584	**DJAI/Gold ratio**	E1:0.827037-0.883899 E2:0.883899-0.940761 E3:0.940761-0.997623 E4:0.997623-1.054485 E5:1.054485-1.111347 E6:1.111347-1.168209	**USD/XAU ratio**	E1:0.889136-0.883899 E2:0.930633-0.97213 E3:0.97213-1.013627 E4:1.013627-1.055124 E5:1.055124-1.096621 E6:1.096624-1.138118

Table 4. Summary results of probability prediction by the weighted Markov chain.

Ratio	state	E_1	E_2	E_3	E_4	E_5	E_6	r_ω	θ_ω
Gold/Oil	$P_3^{(1)}$	0	0	0.333333333	0.333333333	0	0.333333333	0.693354	0.67324485
	$P_4^{(2)}$	0.095238095	0.081632653	0.278911565	0.236394558	0.112244898	0.195578231	0.336515	0.32675515
	P_i	0.031119538	0.02667389	0.31555074	0.301658089	0.036676599	0.288321144		
GJIA/Gold	$P_6^{(1)}$	0	0	0	0	0	1	0.661454	0.5936689
	$P_5^{(2)}$	0.042857143	0.04	0.092857	0.255714	0.288571	0.28	0.452726	0.4063311
	P_i	0.01741419006	0.016253244	0.03773068695	0.109045509	0.1172553714	0.707441608		
USD/XAU	$P_6^{(1)}$	0	0	0	0	0	1	0.737228	0.45880839
	$P_6^{(2)}$	0	0	0	0	0	1	0.519877	0.3235416
	$P_5^{(3)}$	0.007936508	0.007936508	0.074829932	0.281503077	0.343051506	0.284742468		
	P_i	0.001727381	0.001727381	0.016286735	0.061269147	0.74665164	0.844324191	0.349727	0.21765001

According to max p: for each of above ratios, it is inferred that the state of grey precision index of SCGM$(1,1)_c$ model in March 2013 for Gold/Oil is state E_3, for DJAI/Gold is state E_6 and for average USD/XAU is state E_6. Determining the nearness states of the plausible state and with formula (23),we obtain:

$$\text{Gold/Oil ratio: } \hat{Y}(March\ 2013) = 0.95354$$
$$\text{DJAI/Gold ratio: } \hat{Y}(March\ 2013) = 1.111347$$
$$\text{USD/XAU ratio: } \hat{Y}(March\ 2013) = 1.096621$$

At last a predicted value of weighted value of weighted Markov SCGM$(1,1)_c$ model for every ratios and the precision of forecasting are calculated by formula (24) and (25) (table 5). The high precision of forecasting values exhibit that the weighted Markov SCGM$(1.1)_c$ model gives the reliable and certified forecasting results.

Table 5. Forecasting results and their precisions for case study ratios.

Ratio	Predicted Value	Actual Value	Precision
Gold/Oil (March 2013)	15.60348	16.60	94%
DJAI/Gold (March 2013)	8.14411	8.62	94.48%
USD/XAU (March 2013)	0.01822	0.019526	93.32%

CONCLUSION

Grey theory utilizes comprehensive mathematics method to forecast the insufficient system of information. Grey SCGM$(1,1)_c$ model looks for obtained information from time series data themselves, seeks for general altering trend and it is valid for arbitrary length series data. Weighted Markov chain shows the influence degree of the stochastic factor by a transition probability and it is applicable to dynamic process with stochastic volatility. As gold holds an important place in financial world, this paper combined these models and has assessed the application of weighted Markov SCGM$(1,1)_c$ model in predicting the monthly ratios of gold/oil, DJAI/gold and USD/XAU. The relative prediction errors 6%, 5.52% and 6.68% for gold/oil, DJAI/gold and USD/XAU ratios, respectively indicate that the model was credible and achieved acceptable performance.

REFERENCES

Denver Gold Group – Representing Precious Metal Equities. (2013). Retrieved from http://www.denverGold.org

Currency converter using official exchange rates. (2013). Retrieved from http://www.fxtop.com

A. Jain, S. Ghosh. (2013). Dynamics of global oil prices, exchange rate and precious metal prices in India. Resources Policy, 38(1), 88–93. DOI:10.1016/j.resourpol.2012.10.001.

B. Zhang, J. Ma. (2011). Prediction of coal output in Wuhau using grey-Markov model improve by nonlinear regression. *Procedia Engineering,* 15, 5020-5024.

C.C. Hsu, C.Y. Chen. (2003). A modified grey forecasting model for long-term prediction. *Journal of Chinese Institute of Engineers,* 26(3), 301-308.

C. Toraman, C. Basarir, M. F. Bayramoglu. (2011). Determination of factor affecting the price of Gold : A study of MGARCH model. *Business and Economics Research Journal,* 2(4), 37-50.

C. Wang, Y. Chen, L. Li. (2007). The forecast of gold price based on the GM(1,1) and Markov chain. *Proceedings of 2007 IEEE International Conference on Grey System and Intelligent Services.* 18-20 Nov. 2007. China, 739- 743.

C. Zhang, C.B. Ma, J.D. Xau. (2006). Apply Grey Markov SCGM$(1,1)_c$ model to predict air disaster death toll. *Systems Engineering Theory and Practice,* 5, 135-144.

F. Zhang, Z.P. Jia, H. Xia, X. Li, E. Sha. (2012). Node trust evaluation in Mobile Ad Hoc Networks based on MuHi-dimensional fuzzy and Markov SCGM(1,1)c model. *Computer Communications,* 35(5), 589-596.

G. Kim, R.S. Yun. (2012). A hybrid forecast of exchange rate based on discrete grey Markov and Grey Neural network model. *arXiv preprint arXiv:1207.2254*

G.C. Nath. (2013). Gold oil ratio and its implications. *Artha-A Newsletter of Finance Lab,* 1(7), 10-12.

G.Q. Xiang, Q.J. Gao. (2007). An algorithm of similarity mining in time series data on the basis of grey Markov SCGM(1,1) model. *IFIP International Conference on Network and Parallel Computing Workshops.* 18-21 Sept. 2007. Liaoning, 937 – 940.

W. Yinao, W. Shuai. (2007). Grey system model of medical diseases diagnosis and treatment. *IEEE International Conference on grey systems and intelligent services*. 18-20 Nov. 2007. Nanjing, 360-363.

H.F. Chang, L.C. Huang, M.C. Chin. (2013). Interactive relationships between crude Oil prices ,Gold prices and the NT-US dollar exchange rate - A Taiwan study. *Energy Policy,* 63, 441-448.

H. Mostafaei, Sh. Kordnoori. (2011). Residual Grey Markov Model for the developments of GDP, Population and Energy Consumption in Iran. *Advances in Management & Applied Economics,* 1(2), 93-105.

J. Barunik, E. Kocenda, L. Vacha. (2013). Gold, Oil and stocks. *arXiv preprint arXiv:1308.0210*

J. Beckmann, R. Czudaj. (2013). Oil and gold price dynamics in a multivariate cointegration framework. *International Economics and Economic Policy,* 10(3), 453-468.

J.C. Reboredo. (2013). Is gold a hedge or safe haven against oil price movements? *Resources Policy,* 38(2), 130-137.

J. Gu, N.H. Viehare, B. Ayyub, M. Pecht. (2010). Application of grey prediction model for failure prognostics of electronics. *International Journal of Performability Engineering,* 6(5), 435-442.

J. Min, W. Shang-Xu, C. Shuang-quan. (2005). The application of grey theory in geophysical exploration. *Progress in Geophysics,* 4, 041.

J. Simakova. (2011). Analysis of the relationship between oil and gold prices. *Journal of Finance,* 651-662.

K.S. Sujit, B.R. Kumar. (2011). Study on dynamic relationship among Gold price, Oil price, exchange rate and stock market returns. *International Journal of Applied Business and Economic Research,* 9(2), 145-165.

L. Juan, W.J. Liu. (2011). Population forecasting in China based on the Grey-Markov model. *International Conference on Information Management, Innovation Management and Industrial Engineering,* 3, 133-136.

S. Liu, Y. Lin. (2006). *Grey information: theory and practical applications*. Springer Science and Business Media. London: Springer-Verlag.

S. Liu, Y. Lin, J.Y.L. Forrest (2010). *Grey systems: theory and applications.* German: Springer-Verlag Berlin Heidelberg.

M.M. Baig, M. Imran, M. Jabbar, Q.U. Ain. (2013). Long run relationship between gold prices, oil prices and Karachi stock market. *Acta Universitatis Danubius (Economica),* 9(5), 28-39.

N. Apergis, D. Papoulakos. (2013). The Australian Dollar and Gold Prices. *The Open Economics Journal,* 6, 1-10.

B.T. Ewing, F. Malik. (2013). Volatility breaks transmission between gold and oil future under structural. *International Review of Economics & Finance,* 25, 113-121.

T.H. Le, Y. Chang. (2011). Oil and gold: correlation or causation? *Economics Bulletin, 31*(3), A31.

W. Zeng-min, W. Kai-Jue. (2012). Mobile Communication forecasting based on grey weighted Markov model. *Mathematics in Practice and Theory,* 22.

X.C. Jiang, S.F. Chen. (2009). Application of weighted Markov SCGM$(1,1)_c$ model to predict drough crop area. *Systems Engineering- Theory & Practice,* 29(9), 179-185.

Y.M. Tian, H.L. Shen, L. Zhang, X.R. Lv. (2010). Utility water supply forecast via a GM(1,1) weihgted Markov chain. *Journal of Zheijiang University - Science A (Apllied Physics & Engineering),* 11(9), 677-682.

Z. Gong, C. Chen, X. Ge. (2014). Risk prediction of low temperature in Nanjing city based on grey weighted Markov model. *Natural Hazards*, 71(2), 1159–1180.

Z. Ling, X.-H. Ke. (2012). Traffic accident prediction based on grey weighted Markov SCGM$(1,1)_c$. *Computer Engineering and Applications,* 48(31), 11-15.

Z. Yunlong, L. Mao. (2011). Application of grey model GM(1,1) to environmental pollution and destruction accidents. *2nd IEEE International Conferences on Emergency Management and Management Sciences,* 8-10 Aug. 2011. Beijing, 10-13).