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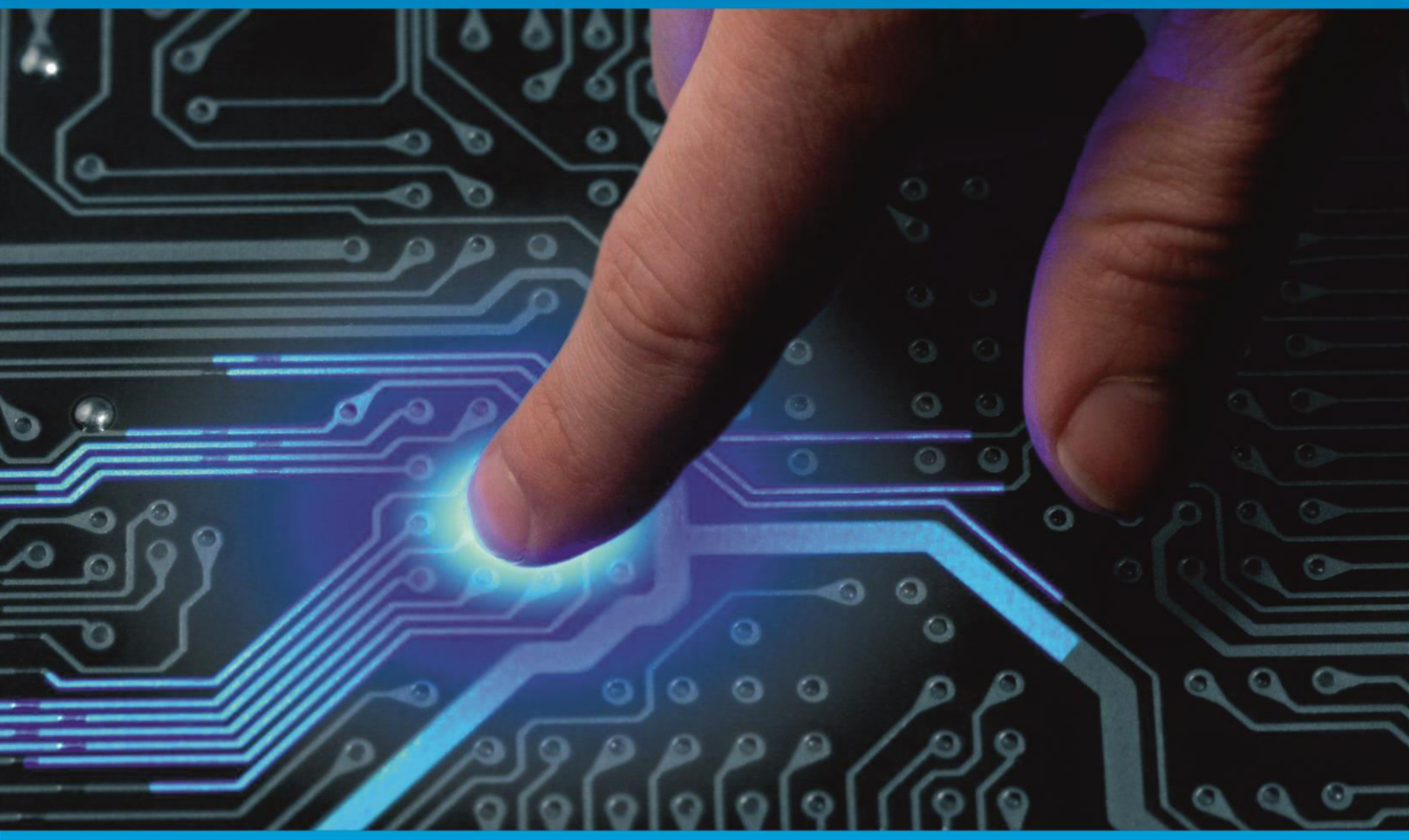

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Auto Regressive Integrated Moving Average Algorithm for Gold Price Prediction

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ABSTRACT: The international gold price has been in the gloom since 2013. The volatility of gold prices will have anintense effect on the investment decisions of individuals, enterprises and countries. This study focuses on the figure of gold prices from September 2000 according to the World Gold Council, and aims to forecast and analyze daily gold price through the establishment of AutoRegressive Integrated Moving Average Algorithm. This study also uses Auto Correlation, Partial Auto Correlation, Akaike's information criterion, Bayesian Information Criteria to estimate the accuracy of models. Empirical outcomes demonstrate that AutoRegressive Integrated Moving Average (8,1,6) is the finest model to predict the gold price of USD. The estimate outcomes of AutoRegressive Integrated Moving Average model are vital for people to understand the efficiency of gold prices and make great investment choices.

KEYWORDS: Gold Price of USD; AutoRegressive Integrated Moving Average Algorithm; Augmented Dickey Fuller test; Forecast; PACF & ACF

I. INTRODUCTION

As a precious metal, Gold is considered as the stock contract products in the commodity market. With the world economic crisis in 2008, a various financial products have performed weakly. Since stocks tend to benefit from economic stability and growth, while gold tends to benefit from economic crises and distress. If the stock market falls, fear is usually high, and investors typically seek safe havens – and gold tends to be the safest of them all. However, only the gold market had outstanding performance. There are many factors influencing the changes of gold price, for example, the dollar exchange rate, inflation and monetary policy. Scholars at home and foreign generally set up regression models from these factors. Time series analysis method used in this paper is to model and analyze the historical data of the financial time series. This article centers on the figure of gold prices since 1st Sept 2000 according to the World Gold Council. In addition, it aims to forecast and analyze daily gold price through the establishment of ARIMA model. This article is composed of six parts, the structure of this article is established as the following: segment 2 describes the literature review, segment 3 describes data processing, segment 4 describes machine learning model, segment 6 describes the results, segment 7 describes conclusion.

II. LITERATURE REVIEW

There are many studies dealing with the price of gold in the literature and also with the market. Although various different variables are used in these studies, it is observed that gold prices are regressed against the USA dollar and stock return in general[2]. The relationship between other macroeconomic variable and gold prices has also been studied by many researchers. The relationship between the gold price and the prices of other commodities, especially crude oil has also been extensively studied. But the results from these studies are found to be contradicted. Some of the studies on the factors influencing the gold price and various techniques used for studying these relationships are discussed in the following sections. Lawrence has found that there are no significant correlations between the returns on gold and changes in certain macroeconomic variables such as inflation and GDP[3]. He has also found that gold returns are less correlated with returns on equity and bond indices than returns of other commodities. But, Sjaastad and Scacciavillani reported that gold is a store of value against inflation and Baker and Van-Tassel also have found that the price of gold depends on the future inflation rate[4] [5]. With respect to the relationship between the gold price and inflation, based on the review of literature Hanan Naser is of the opinion that historical studies with regards to the

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effectiveness of gold as a hedge against inflation are contradicting[6]. Ismail et al.have forecasted gold prices based on multiple economic factors such as commodity research bureau future index, USD/Euro foreign exchange rate, inflation rate, money supply, New York Stock Exchange Index; Standard and Poor 500 index, Treasury bill and USD index[1]. The studyfinds that Commodity Research Bureau future index, USD/Euro foreign exchange rate, Inflation rate and money supply have a significant impact on the gold price. Khaemusunun has examined the impact of currencies of selected countries, Oil Prices and Interest Rate on the gold price [7]. Ewing and Malik find evidence of volatility transmission between gold and oil future prices [8]. Ghosh et al. have concluded that gold prices are related to US Inflation level, interest rates and dollar exchange rate [9]. They have also reported a long run relationship between gold prices and US Consumer Price Index as a result of the cointegration analysis. From the review of related literature, it can be concluded that the relationship between gold price and various factors considered to influence it are contradicting. Instudying volatility in the gold price and the relationship with the factors considered to influence it, researchers have used a variety of techniques. Hossein and Abdolrezahave predicted the gold price by using artificial neural networks (ANN) and ARIMA model.Khaemusunun, (2009) predicts the Thai gold price by using Multiple Regression and ARIMA model[10]. Toramanhas reported that various studies have been conducted using multivariate regression models to test the sensitivity of gold prices among various variables[2]. In this regard Ismail et al.have used multiple linear regression (MLR) model for forecasting the gold prices and are of the opinion that the MLR model appeared to be useful for predicting the gold price[1]. From the review of literature, it can be seen that multiple linear regression is widely used technique for understanding relationship among such variables.

There are a large number of researches and studies in regard to the prediction of gold price, for which remains a popular topic in both literature and industry. Nambier (2012)applied ARIMA model in forecasting gold price [11]. By pointing out the limitation of ARIMA model, it can just forecast immediate future. Pung et al. (2013) used ARIMA model and GARCH model to predict gold price of Malaysia and reached a conclusion that GARCH is more appropriate than ARIMA in simulating changes in the volatility of time series variables [12]. ARIMA is sufficient when the article does not predict the volatility of variables. Baur (2016) used Dynamic Model Averaging (DMA) method to evaluate possible gold price determinants and predict gold price when the forecasting model and the parameter were uncertain [13]. There are also some hybrid models being used to predict gold price. Yr. (2014) established ARFIMA-GARCH model to analyze and predict gold price and these results were proved to be highly accurate [14]. Mombeini and Yazdani-Chamzini (2015) adopted ANN (Artificial Neural Network) model and ARIMA model to forecast gold price [15]. Hence, it is essential to choose an accurate and appropriate model for the prediction of the gold price.

III. DATA PROCESSING

This study predicts the international gold price that is priced.The data are collected from the World Gold Council, consisting observations of the daily gold price from 2000. we have build a machine learning model by using the datasets since 2000. There are many factors that influence the sustained weakness of international gold price in 2014, including the strong dollar rally, the fulfillment of QE in the US and the rise of the fed's interest rate. Gold prices did not experience a sudden drop during the whole year, and even saw a slight increase at the end of the year.

Apparently, it can be visible that the most dramatic change happens during 2015 after that the Federal Reserve announced an interest rate increase four times. The overall structure of gold prices in 2015 shows a trend which declines, with occasional strong rises. In 2016, the global macroeconomic environment has been improving generally, and the inflation expectations of the major economies have rebounded. The investment preference of the global market for gold has increased significantly. In 2017, the demand for hedging caused by political uncertainty can be the most important factor driving the periodic rise in gold prices. In 2020, the outbreak of COVID-19 has brought pandemic risk in the international market. The panic arising amongst people is understandable because epidemic and pandemic have accompanied humanity throughout history. For instance, the best known and the most devastating pandemic in human history was the mediaeval Black Death. It was estimated that it had caused the death of 200 million people all over the world. Now due to this pandemic more than 2.5 million people was dead and the count still continues. The daily life and routines of individuals was affected. Focusing on the gold market in the times of pandemics, investors should rely on the historic gold price movement in order to apprehend the precious metal movement in similar periods.

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IV. MACHINE LEARNING MODEL

The ARIMA stands for Auto-Regressive Integrated Moving Average. It explains that the given time series based on its own past values, that is, its own lags and the lagged forecast errors, so that the terms can be used to predict future values.ARIMA is a statistical analyzing model that enables making future tendency predictions based on time series data. It is basically used to forecast stocks as well as market fluctuations. The graph showed in Fig.1. is the daily gold price since September 2000.

In fact, forecasting the future value of the dependent variable relies on a combination of historic values and errors of the independent variables. The stationarized series lags in the forecasting equation are called autoregressive terms, forecast error lags are called moving average terms, and a time series which needs to be differenced in order to make it stationary is said to be an integrated version of a stationary series. By subtracting the previous value from the current value is generally called as differencing. Sometimes, based on the complexity of the time series, more than one differencing is needed. The value of d, therefore, is the minimum number of differencing needed to make the series stationary. d = 0 is when the time series is already stationary. To check if the series is stationary use the Augmented Dickey Fuller test (adfuller()), from the statsmodels package. The Fig.2. shows that the time series is stationary.

A random variable which is a time series is stationary only if its statistical properties are all constant over time. A stationary series has zero trend, its variations around its mean have a constant amplitude. The latter condition means that its autocorrelations remain constant over time, or equivalently, that its power spectrum remains constant over time. In this form a random variable can be viewed as a combination of signal and noise, and the signal could be a pattern.It could also have a seasonal component. An ARIMA model can be seen as a purifier that tries to separate the signal from the noise, and the signal is then extrapolated into the future to obtain forecasts.

Autoregressive models, random-walk and random-trend models, and exponential smoothing models are all special cases of ARIMA models. The ARIMA model is classified as an ARIMA(p,d,q) model, where:

- p is the number of autoregressive terms,
- d is the number of differences needed to attain stationarity, and
- q is the number of lagged forecast errors in the prediction equation.

The forecasting equation is constructed as follows. Let y denotes the dth difference of Y, which means:

- If d=0, then yt = Yt
- If d=1, then yt = Yt - Yt-1
- If d=2, then yt = (Yt - Yt-1) - (Yt-1 - Yt-2) = Yt - 2Yt-1 + Yt-2

To identify the suitable ARIMA model for Y, you can start by determining the order of differencing (d) needing to stationarize the series. However, the stationarized series may still have autocorrelated errors, suggesting that some number of AR terms ($p \geq 1$) and/or some number MA terms ($q \geq 1$) are also needed in the forecasting equation. With the help of the Fig.3. we can able to calculate the p and q values.

This model, also known as the Box-Jenkins model, is generally used in analysis and forecasting. It is extensively regarded as the most prominent forecasting technique. The use of ARIMA for forecasting time series is essential with uncertainty as it does not assume knowledge of any underlying model or relationships as in any other methods. ARIMA also relies on previous error terms for forecasting. However, ARIMA model is more robust and efficient than more complex structural models.

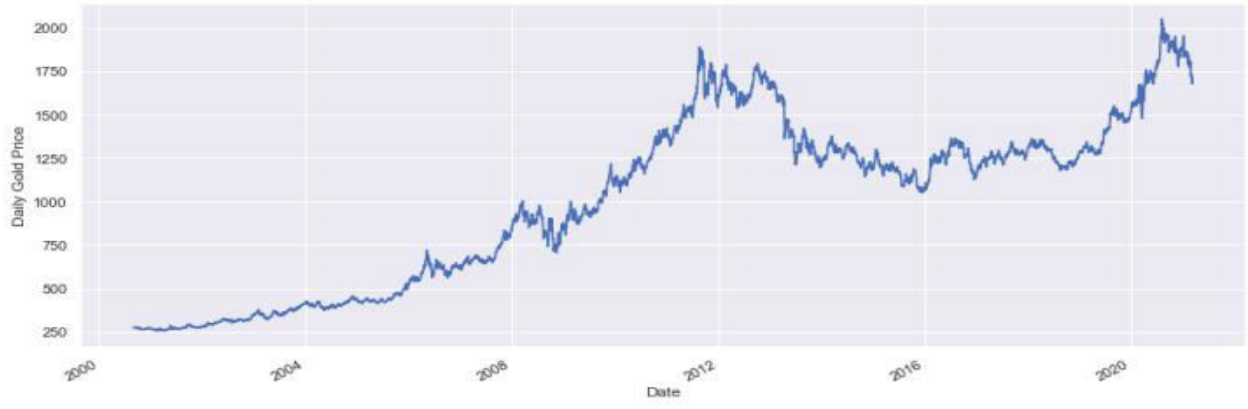

Fig.1. Daily Gold Price

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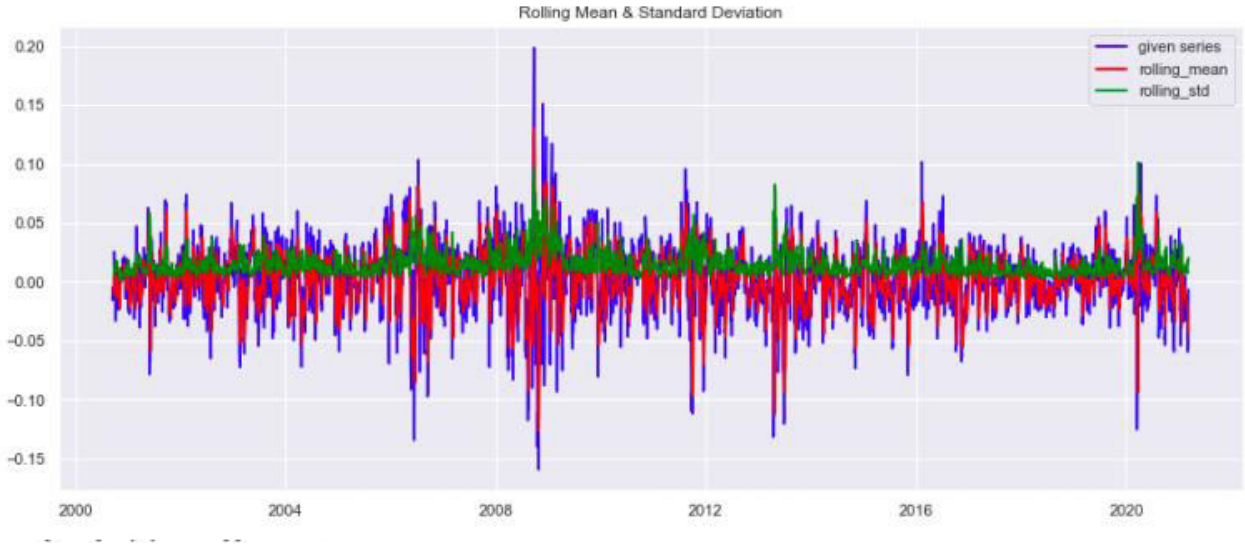

Fig.2. Stationary Time Series

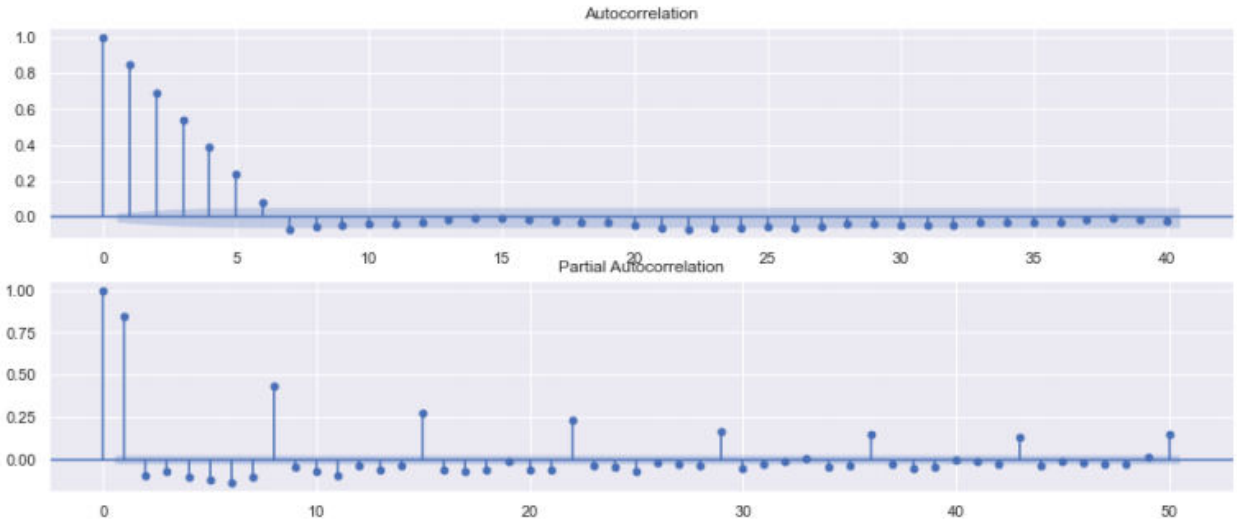

Fig.3. p and q values

V. RESULT

Gold has always occupied a predominant place in the country's economies, and among populations. Even though its importance has declined over the centuries, since it is no longer used as a currency, it is still used as a safe haven and as a hedging tool against uncertainty and risk. Furthermore, we have attempted to build predictive models based on time series analysis. Thus, we have used Auto regression Integrated Moving Average(ARIMA) algorithms. A widely used statistical method for time series forecasting is the ARIMA (AutoRegressive Integrated Moving Average) model. In this study, a time series model is selected by using the data of the daily Gold price. By using ARIMA model with the daily time series data, this study briefly predicts the future gold price. For the model, we will need to figure out what is p,d and q. For d, we have already determined differencing the data once is the best way to make the data stationary. P and q can be determined by using auto correlation and partial correlation. Based on the study results shown, ARIMA (8, 1, 6) appears to be the best model for predicting gold price.

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VI. CONCLUSION

There are five factors are present in the gold data which are open value, close value, low value, high value and volume. Gold provides an effective and useful means of diversifying a portfolio. The way to achieving success with the gold is to know your goals and risk profile before jumping in. The volatility of the gold can be harnessed to accumulate wealth, but left unchecked, it can also lead to ruin. Based on these attribute we have predicted the result from both an autoregressive integrated moving average (ARIMA) model. This model is fitted to time series data either to better understand the data or to predict future points in the series (forecasting). In the future, we intend to improve our results by using deep learning algorithms like (CNNs), (LSTMs), (RNNs), (GANs), (RBFNs), (MLPs), (SOMs), (DBNs). Deep learning can be considered as a subset of machine learning. It is a field that is based on learning and improving on its own by examining computer algorithms. While machine learning uses simpler concepts, deep learning works with artificial neural networks, which are designed to imitate how humans think and learn. Until recently, neural networks were limited by computing power and thus were limited in complexity. However, advancements in Big Data analytics have permitted larger, sophisticated neural networks, allowing computers to observe, learn, and react to complex situations faster than humans. Thus the results can be predicted effectively.

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