**Gold Price Prediction using Ensemble based Machine Learning Techniques**

**Abstract:**

This article is based on a study conducted to understand the relationship between gold price and selected factors influencing it, namely stock market, crude oil price, rupee dollar exchange rate, inflation and interest rate. Monthly price data for the period January 2000 to December 2018 was used for the study. The data was further split into two periods, period I from January 2000 to October 2011 during which the gold price exhibits a raising trend and period II from November 2011 to December 2018 where the gold price is showing a horizontal trend. Three machine learning algorithms, linear regression, random forest regression and gradient boosting regression were used in analyzing these data. It is found that the correlation between the variables is strong during the period I and weak during period II. While these models show good fit with data during period I, the fitness is not good during the period II. While random forest regression is found to have better prediction accuracy for the entire period, gradient boosting regression is found to give better accuracy for the two periods taken separately.

**Keywords - Machine Learning, Regression, Prediction**

INTRODUCTION Savings and Investments form an integral part of everyone’s life. Investments refer to the employment of present funds with an objective of earning a favourable return on it in future. In an economic sense, an investment can be considered as the purchase of assets that are not consumed today but are used in the future to create wealth. In finance, an investment is purchase of a monetary asset with the idea that the asset will provide income in the future or will later be sold at a higher price for a profit. The Indian economy being one of the fastest growing in the world has resulted in higher disposable income level and a plethora of investment avenues. There are a number of investment avenues available for investors, which includes stocks, deposits, commodities and real estate. Each of them differs in terms of risk and return characteristics. Gold is another asset which is being considered as an attractive investment avenue by many investors due to its increasing value and the area of usage. Investors preference for gold as a protective asset increases due to their negative expectations concerning the situation in the developed foreign exchange markets and the capital markets[1]. Gold is also considered to be “the asset of final instance” i.e. is the asset investors rely on, when the developed world capital markets are not capable to provide desirable profitability[2]. Thus it can be said that investors see gold as a tool to hedge against the fluctuations in other markets. Gold is a precious metal, so like any other goods, gold’s price should depend on supply and demand. But, since gold is storable and the supply is accumulated over centuries, this year’s production has little influence on its prices. Gold is used both as a commodity and as a financial asset. Gold behaves less like a commodity than long-lived assets such as stocks or bonds. Price of gold depends on a myriad of interrelated variables, including inflation rates, currency fluctuation and political turmoil[3]. This raising value of gold coupled with the volatilities and fall in prices of other markets like capital markets and real estate markets has attracted more and more investors towards gold as an attractive investment. But, of late price of gold is also witnessing high volatility and investments in gold are turning to be riskier. There is a fear as to whether these high prices are sustainable and when the prices would reverse. Eventhough there are a number of studies analyzing the correlation between the price of gold and some economic variables. It is still considered that a study to reveal the influence and impact of various macro-economic factors on the price of gold in the present situation will be helpful in determining the dynamic effects of these relationships. Thus this paper is aimed at studying the relationship between gold price and selected economic and market variable. Understanding such relationship will be helpful not only to monetary policymakers but also to investors, fund managers and portfolio managers to take better investment decisions in the market. Further this study uses three machine learning algorithms, linear regression, random forest regression and gradient boosting regression in analyzing these data. Comparison of these three methods will help us in identifying the accuracy of these methods under various conditions. This paper is structured with literature review in the next section followed by sections on data and methodology, results and discussion and conclusion

**LITERATURE REVIEW**

There are many studies dealing with the price of gold in the literature. Although various different variables are used in these studies, it is observed that gold prices are regressed against USA dollar and stock return in general[4]. The relationship between other macroeconomic variable and gold prices has also been studied by many researchers. The relationship between gold price and prices of other commodities especially crude oil has also been extensively studied. But the results from these studies are found to be contradicting. Some of the studies on the factors influencing gold price and various techniques used for studying these relationships are discussed in the following sections. Lawrence[5] has found that there is no significant correlations between returns on gold and changes in certain macroeconomic variables such as inflation and GDP. He has also found that that gold returns are less correlated with returns on equity and bond indices than returns of other commodities. But, Sjaastad and Scacciavillani[6] reported that gold is a store of value against inflation and Baker and VanTassel [7] also have found that the price of gold depends on the future inflation rate. With respect to the relationship between gold price and inflation, based on the review of literature Hanan Naser[8] is of the opinion that historical studies with regards to the effectiveness of gold as a hedge against inflation are contradicting. Ismail et al.[3]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. The study finds that Commodity Research Bureau future index, USD/Euro foreign exchange rate, Inflation rate and money supply have a significant impact on gold price. Khaemusunun [9] has examined the impact of currencies of selected countries, Oil Prices and Interest Rate on the gold price. Hammoudeh et al. [10] conclude that there is an interdependent exist between the volatility of gold price and the exchange rate. Ai, et al.[11] report empirical evidence that the exchange rate relates to the gold price both in the long-run and short-run. Ewing and Malik [12] find evidence of volatility transmission between gold and oil future prices. Ghosh et al. [13] have concluded that gold prices are related with US Inflation level, interest rates and dollar exchange rate. 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.

**CONCLUSION :**

This study was conducted to understand the relationship between gold price and selected factors influencing its price, namely stock market, crude oil price, rupee dollar exchange rate, inflation and interest rate. Monthly price data for the period January 2000 to December 2018 was used for the study. The data was further split into two periods, period I from January 2000 to October 2011 during which period the gold price exhibits a raising trend and period II from November 2011 to December 2018 where the gold price is showing a horizontal trend. Three machine learning algorithms, linear regression, random forest regression and gradient boosting regression were used in analyzing these data. It is found that the correlation between the variables is strong during the period I and weak during period II. While these models show good fit with data during period I, the fitness is not good during the period II. Random forest regression is found to have better prediction accuracy for the entire period and gradient boosting regression is found to give better accuracy for the two period taken separately. It is concluded that machine learning algorithms are very useful in such analysis, but the characteristics of the data influences their accuracy. Further research with such data and different techniques may be conducted for better understanding of the performance of these techniques.

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