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A RESEARCH TO STUDY MODELLING AND ANALYSIS OF GOLD PRICE IN INDIA AND FACTORS AFFECTING GOLD PRICE

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ABSTRACT

This study explores the complex dynamics of gold prices in the Indian context, offering a comprehensive analysis of the numerous factors influencing their fluctuations. Gold occupies a unique and central role in Indian culture and economics, rendering it a subject of profound interest. Employing various statistical and econometric models, this research aims to illuminate the intricate interplay of elements impacting gold prices in India. The research methodology involves a historical examination of gold price data, encompassing both short-term and long-term trends. Multiple regression models are applied to identify the principal variables affecting gold price movements, including global economic indicators, domestic factors, and sentiment-driven market forces. Additionally, time-series analyses are conducted to capture seasonality and trend patterns. The study's findings not only deepen our comprehension of the drivers of gold prices in India but also furnish valuable insights for investors, policymakers, and stakeholders within the gold industry. Given India's status as one of the world's largest consumers of gold, grasping the subtleties of gold price dynamics in this market is of paramount significance. Furthermore, the research underscores the necessity of adopting a comprehensive approach to evaluate gold price fluctuations, considering both domestic and global influences.

KEYWORDS: Some of the keywords for research topic on modelling and analysing gold prices in India and the factors affecting them:

1. Gold market dynamics
2. Econometric modeling
3. Demand-supply dynamics
4. Exchange rates and Interest rates
5. Jewellery industry trends
6. Technological advancements in mining.

INTRODUCTION

Background of the study

For ages, India's cultural, economic, and social identity have been significantly influenced by gold. Beyond its material worth, it has symbolic meaning in religious ceremonies, marriages, and festivals, denoting wealth and social standing in Indian culture. India is the second-biggest consumer of gold globally, and its association with this precious metal has a significant impact on its financial markets and economy.

The price of gold has fluctuated significantly over the last few decades due to a variety of local and global reasons. It is imperative that politicians, investors, and the overall public comprehend the dynamics propelling these shifts. Even though there have been many studies on the worldwide gold market, there hasn't been much thorough research that focuses only on the Indian gold industry and its unique affecting variables. Thus, by carefully examining the variables influencing the price of gold in the Indian setting, this study seeks to close this disparity. This study attempts to offer a complete understanding of the subtleties of the Indian gold market and its reactivity to different economic, financial, and socio-cultural factors by employing sophisticated modelling approaches and extensive data analysis.

The following are the main goals of this study: First, must carefully examine past trends and patterns in the Indian market's gold pricing. The second objective is to determine and assess the macroeconomic variables, such as inflation, interest rates, currency rates, and stock market performance, that have an impact on gold prices in India. Thirdly, to evaluate how sociocultural events like religious ceremonies, weddings, and festivals affect the demand for gold and, in turn, how prices are affected. Furthermore, the study attempts to create a strong model that

incorporates socio-cultural and macroeconomic factors to forecast gold prices in the Indian market. Finally, the study aims to provide insightful information to investors, market players, and policymakers so they may make educated judgments on gold investments and financial planning techniques catered to the specifics of the Indian gold market.

Problem Statement of the study

Problem Statement 1:

Identifying and Understanding the Multifaceted Factors Influencing Daily Gold Prices in India:

The first problem statement attempts to investigate in detail the wide range of variables that affect the daily changes in gold prices in the Indian market. This means closely examining a number of macroeconomic variables, including interest rates, currency exchange rates, inflation rates, stock market performance, and socio-cultural events like weddings, religious ceremonies, and festivals that may have an effect on the demand for gold. Through the identification and comprehension of these complex factors, the study aims to offer a thorough grasp of the complex mechanisms that underlie the daily fluctuations in gold prices in India.

Problem Statement 2

Developing an Accurate and Appropriate Predictive Model for Gold Prices in the Indian Market:

In order to estimate gold prices in the Indian market, a dependable and efficient predictive model must be created, according to the second problem statement. In order to do this, relevant macroeconomic and sociocultural variables that show a strong link with fluctuations in the price of gold must be identified, chosen, and integrated. In order to give investors, policymakers, and market participants a useful tool for making well-informed decisions and developing successful strategies in response to the constantly changing dynamics of the Indian gold market, the research will employ sophisticated econometric and statistical techniques to build a robust model that can produce accurate predictions and forecasts.

Objectives of the study

1.To study the present situation of gold price in India:

In order to achieve this study goal, a thorough analysis of the Indian gold market's current situation will be conducted. This analysis will include a look at recent price patterns, the dynamics of the market's supply and demand, and the place of gold in the Indian economy. The research would entail a thorough examination of the historical price trends of gold in India, taking into account both cyclical patterns and longer-term swings. In addition, it will examine the state of the market at the moment, focusing on the elements influencing the desire for gold as well as the general perceptions of the metal as a commodity and an investment. The present analysis will function as a basis for comprehending the current state of the Indian gold market and the variables impacting its pricing dynamics.

2.To study the factors contributing towards the change in the gold price in India:

The research objective involves doing a thorough analysis into the many reasons that are contributing to the increase in gold prices in the Indian market. The study will examine the relationship between the price of gold and a number of macroeconomic indices, including interest rates, exchange rates, and rates of inflation and inflation. It will also look at how geopolitical developments, global economic dynamics, and international market trends affect Indian gold prices. The study will also look at the sociocultural elements that influence the price of gold by driving demand, such as religious events, weddings, and festivals. The several factors influencing the swings in the price of gold in the Indian market will be clarified by this in-depth investigation.

3.To study the impact of increasing gold prices on Indian:

Evaluating the effects of rising gold prices on the Indian economy at different levels is the goal of this study purpose. The study will examine how rising gold prices affect consumer spending habits, investor behaviour, and market sentiment in general. It will assess how the price fluctuations of gold will affect industries including banking, jewellery, and financial markets, taking into account how consumer preferences and investment strategies may shift as a result. The study will also evaluate how changes in the price of gold affect India's trade balances, inflation, and general economic stability. This thorough examination will shed light on the wider economic ramifications of the rising gold prices for the Indian economy.

4.To understand how gold price is influenced by stock market:

Studying the complex relationship between gold prices and the Indian stock market is the objective of this research project. The study will explore the correlation between the price of gold and stock market performance measures, including equity prices, market indexes, and investor mood. It will look into the patterns of investment diversification between stocks and gold, evaluating how much stock market swings impact investor behaviour and how much it impacts gold prices. The study will also examine how investor confidence, market volatility, and risk perceptions influence the relationship between gold prices and the Indian stock market.

LITERATURE REVIEW

Banerjee, D (2014) in her paper "Forecasting of Indian Stock Market using Time-series ARIMA Model" has applied ARIMA model based on which she predicts the future stock indices which have a strong influence on the performance of the Indian economy. In her paper she first determined the ARIMA model then she forecasted the Sensex through model validation and at the end the recurrence validation was done.

Abdullah Lazim (2012) in his paper has addressed the forecasting of gold bullion coin prices through ARIMA model and had concluded by suggesting that the gold bullion coin selling prices are in upward trends and could be considered as a worthy investment. Wouter Theloosen in his research paper "A review on the determinants of the price of gold" has cited the different factors associated with the gold price fluctuation.

Mohamad As'ad (2012) has modelled the peak daily electricity demand using half hourly demand date. He coined for ARIMA Models based past three, six, nine and twelve months of data and suggested that the ARIMA model build based on past three months data is the best model in terms of forecasting two to seven days ahead and ARIMA model based on the past six months data is the best model to forecast one day ahead.

Deepika M G, Gautam Nambiar & Rajkumar M (2012) has tried to study the forecasting of gold price through ARIMA model & Regression but their finding suggests that suitable model was not identified to forecast gold price through ARIMA Model hence Regression analysis was carried out in the later part of their study.

Pung, et al. (2013) forecast the gold prices of Malaysia by using ARIMA and GARCH model. The study concludes that GARCH model is a more appropriate model than ARIMA Model for predicting the gold prices.

Hossein and Abdolreza (2015) predict the gold price by using artificial neural networks (ANN) and ARIMA model. The result shows that ANN model outperforms ARIMA model.

Ismail, Yahya & Shabri conducted a study was to develop a model for predicting gold prices based on economic factors such as currency price movements, inflation and interest rates. Due to increase in demand for gold in Malaysia, it is required to make a model that resembles the structure and trend of gold market and forecast changes in the price of gold. After the melt-down of US economy, investors around the world are putting their money in gold as gold can have an important role as a stabilizing influence for investment portfolios. According to them, Multiple Linear Regression (MLR) model is the most appropriate approach to predict the prices of gold. Like every MLR, they also suggested a study in which Gold is the dependent variable and factors like Commodity Research Bureau future index (CRB); Inflation rate (INF); Money Supply (M1); New York Stock Exchange (NYSE); US Dollar index (USDX); USD/Euro Foreign Exchange Rate (EUROUSD); Treasury Bill (TBILL) and Standard and Poor 500 (SPX) were taken into consideration to have influence on the prices.

Christian L. Dunis and Anup Nathani carried out a study in which they tried forecasting the prices of gold and silver and resorted to advanced regression analysis using non-linear and linear models. They compared various non-linear models like Multilayer Perception (MLP), Nearest Neighbours with the ARMA model which is used as a benchmark for linear regression. The aim of the researchers was to establish which of the models generate the maximum returns and if non-linear models can be used to generate returns higher than average in the precious metals market. They did this by implementing a trading simulation where the forecasts were translated into a trading signal. They concluded that non-linear models could be used to forecast the gold prices as there was some non-linearity which existed in the market and which can be exploited to generate returns in excess to those of the market.

Baker & Van Tassel (1985), build a model able to forecast the gold price using Page 6 of 39 regression analysis from 1973 to 1984, the results showed that changes in the gold price can be explained by changes in commodity prices, U.S. prices, dollar value, and future inflation rate. Moreover, speculative bubbles were significant with positive coefficients, supporting the hypothesis that the gold price was pushed above its trend by speculation.

Ghosh, D., & Ghosh, T. (2007) investigate the long-term trends and short-term dynamics of gold prices in India. They employ time series analysis techniques to explore factors contributing to gold price movements.

Chaurasia, A., & Kumar, P. (2018) examine the impact of government policies on gold prices in India, with a focus on import duties and regulations. Their research sheds light on the role of policy changes in shaping gold prices.

RESEARCH METHODOLOGY

Research Design

1.Correlational Research Design

The aim of this study is to determine correlations and links between various factors that impact gold prices in the Indian market, which is why the correlational research design was used. It is possible to determine the strength and direction of correlations between different macroeconomic data, sociocultural elements, and gold prices thanks to this approach. Through correlation analysis, the study seeks to clarify the relationships between variables including interest rates, inflation rates, stock market performance, and gold prices. This will provide readers a more sophisticated knowledge of the interdependencies that influence the Indian gold market. By making it easier to spot noteworthy patterns and trends and create hypotheses about possible causal linkages between important variables, the correlational research design will pave the way for more in-depth examinations and insights into the complex dynamics of the Indian gold market.

2.Longitudinal Research Design

The goal of using a longitudinal research approach is to examine patterns and changes in the Indian gold market over a longer time frame. This architecture makes it possible to analyse changes in the price of gold, the behaviour of the market, and the effects of influencing factors over time, giving rise to a thorough understanding of how the Indian gold market has changed over time. In order to identify long-term market trends and evaluate the market's reaction to diverse economic and socio-cultural stimuli, the study intends to capture the trends, patterns, and cyclical fluctuations in gold prices through longitudinal data analysis. The investigation of the dynamic nature of the Indian gold market will be made possible by the longitudinal study approach, which will provide insights into the market's flexibility, resilience, and reactivity to changing societal factors and economic circumstances. The study aims to create a comprehensive framework for understanding the complex dynamics and changing trends within the Indian gold market by combining the correlational and longitudinal research designs. This will help to contribute to a more comprehensive understanding of the factors influencing gold prices and market behaviour over time.

Sources of Data

The choice to conduct this research using secondary data was primarily driven by the abundance of reliable and comprehensive information available about the Indian gold market and its influencing factors. Government reports, financial databases, academic journals, industry publications, and market research reports are just a few examples of the secondary data sources that are used to support this decision. These sources allow for a comprehensive and in-depth analysis of the multifaceted dynamics shaping the Indian gold market, as well as a holistic exploration of the macroeconomic, financial, and socio-cultural variables impacting gold prices. Lastly, the comprehensive nature of the secondary data sources that are available thorough and perceptive study of the Indian gold market that provides important information on the underlying causes of gold price movements and the ramifications for investors, decision-makers, and market players.

Data Collection Method

1. Online Databases

Accessing up-to-date information on gold prices, market trends, and economic indicators in the Indian context is made instantaneous using online databases. The gold market is notoriously volatile, and shifts in the economy can quickly affect gold prices, which makes this imperative. I can reliably track and evaluate real-time market dynamics and guarantee the pertinence and timeliness of study findings by employing online databases to continuously monitor and analyse data. This is crucial to comprehending the Indian gold market's current situation and how it reacts to modern sociocultural and economic pressures.

2. Historical Databases

An extensive collection of long-term data on gold prices and associated economic indicators over a sizable time period can be found in historical databases. I can identify cyclical movements and long-term shifts in gold prices by doing a thorough analysis of historical trends and patterns in the Indian gold market with the use of historical datasets. Through the analysis of past data, it is possible to identify pivotal moments and market circumstances that have impacted gold prices in India in the past. This information may be used to get important insights on how the Indian gold market might behave going forward. This thorough historical analysis serves as a fundamental building block for the development of reliable models and forecasting methods, which improves the precision and dependability of the research findings.

Population

For my research paper, I decided to use the 2022-2023 data on gold prices and their swings as the population based on a number of important factors that fit the particular goals and focus of the study. In order to capture the most current and relevant market dynamics and economic conditions within the Indian gold market, a vital and recent time frame was chosen. By concentrating on the data from 2022 to 2023, I hope to capture the most recent trends and patterns in gold prices while taking into account the distinct socio-cultural and economic events that have impacted the market during this particular time period. This methodology enables a comprehensive analysis of the recent swings in gold prices, offering insightful information about the Indian gold market's prompt reactions to current economic changes, policy developments, and socio-cultural influences. Additionally, by choosing this particular population, I am able to perform an analysis that is pertinent and timely, taking into account the most recent changes in the Indian gold market. This will help to develop precise forecasting models and thorough insights into the factors influencing the dynamics of gold prices in India. I can provide a thorough understanding of the current situation of the Indian gold market by concentrating on the data from 2022 and 2023. This will guarantee that the research findings are well-positioned to guide decision-making processes and policy formulation for investors, stakeholders, and policymakers involved in the Indian gold market.

RESULTS

The Autoregressive Integrated Moving Average (ARIMA) model uses time-series data and statistical analysis to interpret the data and make future predictions. The ARIMA model aims to explain data by using time series data on its past values and uses linear regression to make predictions. We have data from 1st April 2022 to 18th march 2024.
With the help of an Arima model we got this data.

Price	Dates
65500.54261	**19-Mar**
65542.59364	**20-Mar**
65651.85405	**21-Mar**
65726.24856	**22-Mar**
65746.49123	**23-Mar**
65796.59313	**24-Mar**
65788.84163	**25-Mar**
65780.36408	**26-Mar**
65833.53749	**27-Mar**
65856.95925	**28-Mar**
65918.73004	**29-Mar**
66010.45285	**30-Mar**
66042.17446	**31-Mar**
66095.42762	**01-Apr**
66134.12878	**02-Apr**
66123.64464	**03-Apr**
66162.86088	**04-Apr**
66194.33305	**05-Apr**
66217.75724	**06-Apr**
66298.00947	**07-Apr**
66345.46241	**08-Apr**
66384.85984	**09-Apr**
66449.38232	**10-Apr**
66460.54619	**11-Apr**
66484.15925	**12-Apr**

DISCUSSIONS

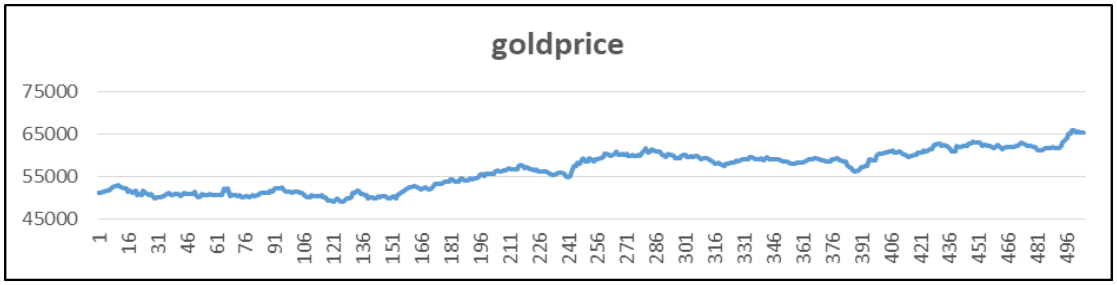
Objective of the study is to forecast price of gold. For this purpose, we have collected data on price of gold from 1st April, 2022 till 18th March, 2024. We have a time series data of daily price of gold.
For the purpose of prediction, we propose a suitable Auto-Regressive Integrated Moving Average, ie ARIMA, model. To determine appropriate ARIMA model, it is necessary to follow the steps of model building as shown below. An ARIMA model is specified by three parameters p, d and q.
Where p: order of autoregression (lags), d: order of differencing and q: period of moving averages.
It is important to note that an ARIMA model is based on error terms.
First, plot the time series data (visualization). Next, test the data for stationarity, ie plot of data should exhibit a constant mean and variance. If data is non-stationary, they are converted to stationary data by using log-transformation or differencing consecutive values. Augmented Dicky-Fuller (ADF) test is used to test stationarity of time series data.
Once data is stationary, by adjusting the remaining parameters, p and q, different ARIMA models are developed. Using criteria like AIC / BIC, appropriate ARIMA(p,d,q) models are determined and ranked. Having determined the value of parameter d, another approach to determine the

values of p and q, is to use ACF and PACF plots of time series data. ACF plot suggests value of parameter '**q**' and PACF plot suggests the value of parameter '**p**'.

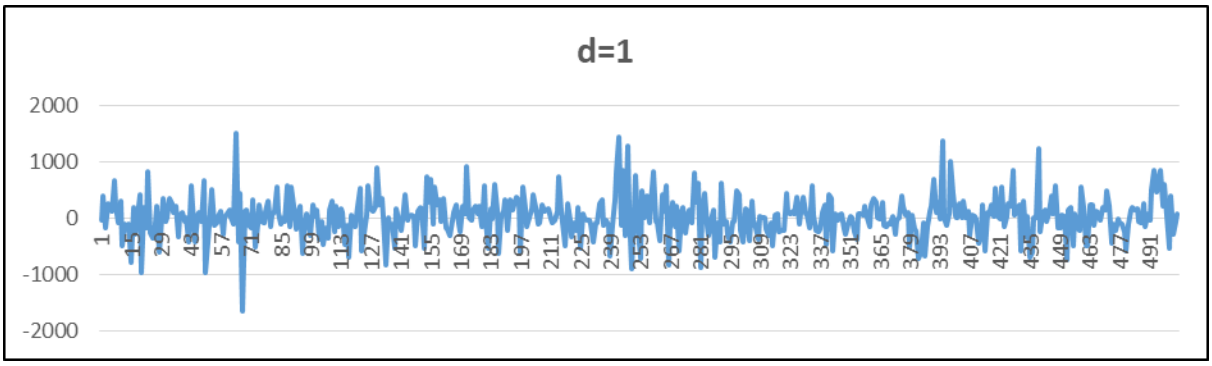
Next, it is required to estimate equation of each appropriate model. For this, it is necessary to determine coefficients and constant term.

For each model, determine forecast accuracy using RMSE or MAD. Next, a model with lower value of AIC and lower value of errors is selected as most appropriate forecasting model.

In this study, we have determined different ARIMA(p,d,q) models. Here, we applied ADF test on data on gold price. Null hypothesis **H0: Data is Stationary**, was rejected. Data was non-stationary and showing an upward trend. Graph of original time series data on gold price is shown below:



Next, we derived series with first difference, ie d=1, that made the data stationary. Its graph is shown below:



We used ADF test to check if the data with first differencing is non-stationary. Null hypothesis H0: Data is Stationary was rejected. Hence, we determined value of one of three parameters as d= 1.

Next, to determine suitable forecasting model, we derived models with different set of values of two parameters **p** and **q**. Starting with p=0 through p=6 and q=1 through q=6, we obtained 42 different ARIMA(p,d=1,q) models. Among these 42 models, it was necessary to determine best model(s) for forecasting. We used AIC (Akaike's Information Criteria) as the criterion to decide best models. Following table shows AIC of 42 ARIMA models.

d = 1	**↔ q ↔**					
p ↓	**1**	**2**	**3**	**4**	**5**	**6**
0	**5946.93**	**5948.02**	**5949.99**	**5944.04**	**5942.66**	**5943.67**
1	**5936.87**	**5938.17**	**5965.41**	**5933.74**	**5933.34**	**5930.44**
2	**5926.32**	**5952.67**	**5929.32**	**5956.83**	**5923.27**	**5891.47**
3	**5917.48**	**5918.68**	**5886.46**	**5883.91**	**5913.56**	**5912.19**
4	**5901.52**	**5900.76**	**5902.53**	**5902.03**	**5868.98**	**5871.53**
5	**5890.19**	**5891.11**	**5876.87**	**5863.75**	**5860.00**	**5892.93**
6	**5874.80**	**5876.80**	**5876.47**	**5880.09**	**5868.88**	**5879.37**

Using AIC as criterion of comparison of ARIMA models, we decide appropriate models based on lower values of AIC. Following table shows ranking of ARIMA models based on AIC measure.

Rank	Modle (p,d,q)	AIC
1	**5,1,5**	**5860.00**
2	**5,1,4**	**5863.75**
3	**6,1,5**	**5868.88**
4	**4,1,5**	**5868.98**
5	**4,1,6**	**5871.53**
6	**6,1,1**	**5874.80**
7	**6,1,3**	**5876.47**
8	**6,1,2**	**5876.80**
9	**5,1,3**	**5876.87**
10	**6,1,6**	**5879.37**

Hence, using AIC measure, we determined 10 appropriate models out of 42 models to predict future price of gold. Next, to compare, accuracy of these models, we determined average absolute deviation, called, MAD of forecast error for each of these 10 models. Following table shows measure of accuracy of each model, given by MAD, along with AIC measures.

Rank	Model (p,d,q)	AIC	MAE
1	**5,1,5**	**5860.00**	**175.86**
2	**5,1,4**	**5863.75**	**171.65**
3	**6,1,5**	**5868.88**	**186.27**
4	**4,1,5**	**5868.98**	**174.40**
5	**4,1,6**	**5871.53**	**186.39**
6	**6,1,1**	**5874.80**	**184.81**
7	**6,1,3**	**5876.47**	**179.27**
8	**6,1,2**	**5876.80**	**184.82**
9	**5,1,3**	**5876.87**	**179.11**
10	**6,1,6**	**5879.37**	**174.02**

Comparison and Ranking of these models are based on AIC measure. Forecast accuracy of each model is measured using MAD. Hence, three best ARIMA models for prediction of gold price are shown in the following table.

Rank	Model (p,d,q)	AIC	MAE
1	**5,1,5**	**5860.00**	**175.86**
2	**5,1,4**	**5863.75**	**171.65**
4	**4,1,5**	**5868.98**	**174.40**

Here ARIMA (5,1,5), ARIMA (5,1,4) and ARIMA (4,1,5) are top ranked three best models.

FACTORS AFFECTING GOLD PRICES

Rupee-Dollar Impact on Gold

It is important to understand how the rupee-dollar equation affects the gold price in India. Considering the fact that the majority of physical gold is imported, there will be an appreciation in the price of gold in rupee terms, if the rupee weakens against the dollar. Thus, a depreciating rupee could hurt the demand for gold in India

Inflation

Inflation, or the increase in price of goods and services can have a significant impact on gold prices. Inflation usually is directly proportional to the change in gold price; that is, higher levels of inflation usually result in high gold prices due to the value of currency going down. This is because people usually prefer holding wealth in the form of gold during inflation, considering the gold value remains stable in the long run, resulting in an increase in demand. Thus, gold also acts as a hedging tool against inflation.

Interest Rates

Interest rates and gold prices traditionally have had an inverse relationship under normal circumstances; i.e., with increasing interest rates, people usually prefer selling gold to earn higher profit. However, with a decrease in the interest rate, people prefer buying more gold, resulting in an increase in its demand, and its price.

The Indian Jewellery Market

Traditionally, gold has been viewed by Indian households as a strategic asset, while also becoming an integral part of the Indian culture. From its use during elaborate wedding ceremonies, to embellishing oneself with jewellery during important festivals like Diwali, gold holds a special place in the Indian households. Thus, during the wedding and festival seasons, the price of gold goes up, as a result of the increase in consumer demand.
A report in 2019 by the World Gold Council (WGC) estimated that as much as 25,000 tonnes of gold might have been accumulated by Indian households, making India the world's largest holders of the precious metal.

Good Monsoon Rains

According to reports, rural India accounts for as much as 60 percent of India's gold consumption, while India annually consumes anywhere between 800-850 tonnes of gold. Thus, the rural demand is extremely vital to the demand for gold in the country, and the farmers depend on good crops for their earnings. Good monsoon rains spur the gold demand in the country, which results in farmers, who also account for nearly a third of the country's gold consumption, buying gold to create assets.

Government Reserves

The Reserve Bank of India (and central banks of most countries) holds gold reserves along with currency, and when RBI begins to buy more quantities of gold than it sells, it results in an increase in the gold price. This is due to the increase in cash flow in the market, while there is insufficient supply of gold.

Protection from Uncertainty

People usually prefer to invest or buy gold as an asset when there is volatility in the market. This could stem from political instability, or an economic slowdown. The value of gold remains stable in the long run, and is thus looked at as a favourable option when other assets lose their value. Furthermore, uncertainty, unlike other factors influencing gold price, isn't a quantifiable statistic, and is more psychological.

Geo-Political Factors

Any movement in the price of gold globally affects its price in India, considering India is one of the largest consumers of gold. Furthermore, gold is also considered by investors as a safe haven during political uncertainty or geopolitical turmoil, resulting in an increase in its demand, and subsequently its price. While other asset classes would generally see a fall in their value during such crises, the demand for gold tends to go up, making it a crisis commodity for parking funds.

CONCLUSION

- Our original time series is non stationary and we convert it to stationary
- For ARIMA Modelling, the actual and forecasted values have difference due to factors affecting gold price
- The present paper deal with the modelling and forecasts of gold prices in India using ARIMA
- Model (5,1,4). The fitted model shows the increasing trend in gold prices
- This study aimed to explore the various factors that significantly impact the price of gold in India.
- Gold price and Dollar value share an inverse relationship i.e. an increase in gold price will result in decrease
- in the Dollar value.
- Gold prices and Crude oil price share a positive correlation which can be understood from the analysis. It can
- be inferred that an increase in the gold prices will increase the crude oil prices.
- Gold prices and inflation rates are also dependent and positively correlated i.e. increase in inflation increases gold prices also

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- Furthermore, we would like to express our gratitude to the diligent staff at the university library, whose assistance and expertise were vital in accessing relevant literature and data crucial for the empirical analysis. Their dedication and support have greatly enriched the quality and depth of this research.