# USING STATISTICAL MODEL AND MACHINE LEARNING FOR GOLD PRICE PREDICTION

## 0. Abstract

This report presents a comparative analysis of three models, including Linear Regression, Gated Recurrent Unit (GRU), Autoregressive Integrated Moving Average (ARIMA), Long Short-Term Memory (LSTM) for predicting gold prices. The models are evaluated using MAE, MAPE, and RMSE metrics on historical gold price indicators data. The model with the lowest MAE, MAPE, and RMSE is recommended for gold price forecasting, contributing to improved understanding and accurate predictions in the gold market.

**Key words**: gold price, forecasting, linear regression, GRU, ARIMA, LSTM, ETS, random forest, BNN, GPR, and RNN

## I. INTRODUCTION

Our research focused on forecasting gold prices, a commodity known for its historical stability and use as a currency and reserve asset. By analyzing key influencing factors, we aimed to generate precise predictions and insights into price fluctuations and trends. To accomplish this, we applied nine predictive algorithms, including GRU, ARIMA, LSTM. Our findings identify the model with the highest accuracy in gold price prediction, offering valuable guidance to investors and the public for making well-informed decisions about gold investments and purchases.

## II. RELATED WORKS

So…

## III. ARTIFICIAL INTELLIGENCE MODELS

### A. Gated Recurrent Unit (GRU)

The Gated Recurrent Unit (GRU) is a simplified type of Recurrent Neural Network (RNN) that is designed to handle the issue of long-term dependencies in time series data. It effectively deals with the challenge of modeling and predicting sequences with long time delays.

GRU employs two key gating mechanisms:

* **Update Gate**: Determines how much of the past information needs to be passed along to the future. It controls the extent to which the previous time step's data impacts the current time step.
* **Reset Gate**: Decides how much of the past information should be ignored or forgotten. It controls how much of the new input should be mixed with the previous state.

The operations in a GRU are expressed as:

*Update Gate Calculation:*

*Reset Gate Calculation:*

*Current Memory Content:*

*Final Memory at Time t:*

Where:

* xₜ is the input at the current time step.
* hₜ₋₁ is the hidden state from the previous time step.
* W and U are the weight parameters.
* σ is the sigmoid activation function.
* tanh is the hyperbolic tangent function.
* ⊙ denotes element-wise multiplication.

GRUs are preferred for their ability to capture both short-term and long-term dependencies efficiently, with simpler architectures compared to LSTMs.

### B. Autoregressive Integrated Moving Average (ARIMA)

ARIMA is a powerful model used for time series forecasting. It integrates three components: Autoregression (AR), Integration (I), and Moving Average (MA).

*AR (p): Autoregression*

The AR component looks at the relationship between the current value and past values (lags). It tries to predict the current value based on a set of previous observations.

* + - Where 𝜀ₜ represents random errors or "shocks" that cannot be predicted.

*I (d): Integration*

The I component deals with making the data stationary by finding differences between observations. It helps to remove trends or make a time series stable over time by comparing the current value with previous ones.

*MA (q): Moving Average*

The MA component predicts the value by accounting for the past errors or random "shocks" in previous observations. It aims to smooth out the time series by combining the random variations that were not explained.

**Model Selection Process**

* **Stationarity**: ARIMA requires the time series data to be stationary, meaning the statistical properties (like mean and variance) are constant over time.
* Once the model is determined, it can be used to make predictions for future points in the time series.

### C. Long Short-Term Memory (LSTM)

LSTM is a type of Recurrent Neural Network (RNN) used in deep learning that is capable of learning long-term dependencies. It is specifically designed to handle the vanishing gradient problem that occurs in traditional RNNs, making it useful for time series prediction.

**Components of LSTM**

*Forget Gate*: Determines how much of the past information should be forgotten.

*Input Gate:* Controls how much of the new information should be added to the cell state.

*Cell State Update:* Updates the cell state with new information.

*Output Gate:* Determines the output of the LSTM cell.

*Final Memory at Time Step:* Combines the updated cell state and output gate to produce the final output.

**How LSTM Works**

LSTM uses gates (forget, input, and output) to regulate the flow of information. This allows it to learn which information to keep, which to update, and which to forget over time, making it effective for capturing long-term dependencies in sequential data.