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# Modeling the Forecast of Gold Price Fluctuations over Short-Term, Medium-Term and Long-Term Periods

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## Abstract

In the modern financial market, gold serves as a vital financial and monetary product, making it essential to examine its price fluctuations. In this regard, the present study aims to model the forecast of gold price fluctuations over short-term, medium-term, and long-term periods. The present study is applied exploratory research. Monthly data from 2010 to 2022 were utilized to estimate the model, evaluating 35 factors influencing gold price fluctuations. Three modeling approaches were employed: Bayesian Model Averaging (BMA), Principal Component Analysis (PCA), and Time-Varying Parameter (TVP) modeling to forecast gold price fluctuations over different periods. The BMA model exhibited the highest accuracy among the tested models. The findings identified 12 key variables impacting gold price fluctuations. Additionally, it was noted that both internal and external factors positively affect these fluctuations over time, with external factors demonstrating stronger influences. Nonlinear modeling approaches proved to be more accurate than linear ones. The analysis suggests that gold price fluctuations are trending upward over time, and the market will likely experience increased volatility in the future.

**Keywords:** Gold price, macro factors, micro factors, GARCH, Bayesian model averaging.

## Introduction

Developing an accurate and correct gold price model is crucial for asset management due to gold's unique characteristics. The gold market is among the most volatile markets, and accurately forecasting its future can significantly enhance decision-making. Understanding and forecasting gold prices correctly aids in making informed decisions regarding the purchase and sales of gold in global markets as well as determining the optimal timing for transactions and investments. Therefore, precise forecasting of gold prices is important from various perspectives. Gold occupies a special position in the global economy (Hashim, 2022), as it helps preserve the value of money against inflation (Ding et al., 2022; Mainal et al., 2023; Qian et al., 2019; Md Isa et al., 2020; Dalam et al. 2019). There are two main challenges in achieving a highly accurate forecast. The first challenge is to correctly identify the predictive factors influencing

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gold prices, and the second is to forecast future gold prices over different periods. To address the first challenge, it is essential to recognize that various factors contribute to fluctuations in gold prices. Studies have identified several influences, including oil prices (Hossaini & Namaki, 2023; Selvanathan & Selvanathan, 2022), interest rates (Dalam et al. 2019), gold reserves and energy prices (Hashim, 2022), inflation (Apergis et al., 2019), the dollar-euro exchange rate (Long et al., 2022), unemployment rates, GDP (Zakaria et al., 2015), and market uncertainty (Apergis et al., 2019). (Qian et al., 2019) emphasized that accurately forecasting gold prices necessitates consideration of both internal and external factors. The second challenge involves predicting the nonlinear price of gold over different time frames.

The primary research problem arises from the lack of a specific model for predicting gold price fluctuations (Mohammadzadeh Emamverdikhan et al., 2023). While both empirical and theoretical studies have proposed various models to forecast these fluctuations, the wide array of effective explanatory variables has generated a fundamental question among researchers: What variables should be included in the empirical model of gold price fluctuations? This issue is referred to as "model uncertainty" (Shayestehfar, 2023). Neglecting model uncertainty can lead to biased and inefficient parameter estimates, resulting in inaccurate forecasts and misleading statistical inferences. Thus, it is essential to address model uncertainty in empirical studies. One effective approach for tackling model uncertainty is known as "averaging all models at once" or the "Bayesian model averaging" (Feizi et al., 2024). Consequently, the first research problem this study aims to address is the application of Bayesian averaging econometrics to mitigate uncertainty in selecting the variables influencing gold price fluctuations. The second research problem involves understanding how the selected variables impact gold price fluctuations over different periods. Although numerous studies have explored the effects of shocks on gold price fluctuations, no research has directly examined these effects using the time-varying parameter factor-augmented vector autoregressive model (TVP-FAVAR). Existing studies indicate that the assumption that the parameters governing gold market patterns remain constant is flawed. In reality, the coefficients can vary across different periods, and overlooking this critical issue can lead to inaccurate economic conclusions. Time-varying parameter models can address this by estimating time-varying coefficients. Therefore, this study employs the TVP-FAVAR method as a novel approach to model gold price fluctuations with consideration for time-varying coefficients across various periods. This distinction is what sets this research apart from previous studies. If the model of gold price fluctuations is not accurately adjusted, any related policymaking could face significant challenges, ultimately reducing the reliability of gold price forecasts. This introduction is followed by a review of the research background in the second section. The third section outlines the research methodology, while the fourth section presents the results of model estimation. Finally, the fifth section includes the discussion and conclusion.

## Theoretical Foundations and Research Background

The price of gold is crucial for managing inflation and enhancing the economic stability of countries. Gold also contributes to stabilizing the trade balance of nations (Gorgbandi & Mousavi, 2023). Therefore, forecasting and modeling fluctuations in gold prices are essential for effective risk management. Among all precious metals, gold is the most popular investment choice (Gorgbandi & Mousavi, 2023). Accurate predictions of gold prices offer numerous advantages to investors. To forecast gold prices effectively, it is important to identify the factors that influence them (Mazrae Farahani et al., 2024). Consequently, both supply and demand factors in the gold market must be considered for accurate price forecasting, as outlined in (Table 1).

**Table 1.** Factors affecting the price of gold

| Factor | Author |
|---|---|
| Gold demand | Zhang & Ci, 2020 |
| Gold supply | Gorgbandi & Mousavi, 2023 |
| Personal consumption expenditure | Besharatnia & Tariqat, 2016 |
| Large countries such as India and China | Ding et al., 2022; Zhang & Ci, 2020 |
| Holidays and occasions | Hossaini & Namaki, 2023 |
| Inflation | Mohammadinejad Pashaki et al., 2023 |
| Consumer Price Index (CPI) | Selvanathan & Selvanathan, 2022 |
| Central banks' expansionary monetary policies | Hossaini & Namaki, 2023 |
| Dollar exchange rate (dollar value) | Hossaini & Namaki, 2023 |
| US dollar index | Hossaini & Namaki, 2023 |
| Speculation factor | Hossaini & Namaki, 2023; Mohammadinejad Pashaki et al., 2023 |
| Bank interest rates | Mohammadinejad Pashaki et al., 2023; Selvanathan & Selvanathan, 2022 |
| Oil prices | Zhang & Ci, 2020; Hossaini & Namaki, 2023 |
| Stock prices | Haddadi et al., 2020; Hashim, 2022 |
| Gross domestic product | Selvanathan & Selvanathan, 2022; Hashim, 2022 |
| Geopolitical events | Hashim, 2022 |
| Crisis conditions | Khonsarian et al., 2023; Ehsani et al., 2021; Hashim, 2022 |
| Chaos and war in oil-producing countries | Selvanathan & Selvanathan, 2022 |
| Economic crises in the US and the worsening global economic situation | Selvanathan & Selvanathan, 2022 |
| The debt crisis in the US, the eurozone, and Japan | Selvanathan & Selvanathan, 2022 |
| SPDR | Hashim, 2022, Long et al., 2022; Selvanathan & Selvanathan, 2022 |

| | |
|---|---|
| Open Interest | Long et al., 2022 |
| Official sales | Long et al., 2022 |
| Housing prices | Selvanathan & Selvanathan, 2022 |
| Government consumption expenditure and gross capital formation | Besharatnia & Tariqat, 2016 |
| Central banks' entry into the gold market | Selvanathan & Selvanathan, 2022 |
| International Monetary Fund and gold sales | Kazemzadeh et al., 2019 |
| Prices of copper and other base metals | Long et al., 2022 |
| Volatility in the gold market | Long et al., 2022 |

The following provides an overview of domestic and foreign research backgrounds (Table 2)

**Table 2.** Domestic and foreign research backgrounds

| **Author (year)** | **Title** | **Results** |
|---|---|---|
| **International studies** | | |
| Yuan et al., (2020) | Using Market Sentiment Analysis and Genetic Algorithm-Based Least Squares Support Vector Regression to Predict Gold Prices | The Genetic Algorithm-Based Least Squares Support Vector Regression (GA-LSSVR) model has higher accuracy. |
| Ding et al., (2022) | Does political risk matter for gold market fluctuations? A structural VAR analysis | There is a positive relationship between political risk and gold price. According to the results, exchange rate and interest rate negatively influence gold returns. |
| Sarvaiya & Ramchandani, (2022) | Time Series Analysis and Forecasting of Gold Price using ARIMA and LSTM Model | The LSTM model provided a more accurate forecast than the classical ARIMA model. |
| Mainal et al., (2023) | Factors Influencing the Price of Gold in Malaysia | The variables of inflation, GDP, stock market indices, crude oil price, and foreign exchange rate have a significant effect on gold price while the variable of government budget deficit has no significant effect on it. |
| Nisarga & Marisetty (2023) | A Study on Various Factors Impact on the Gold Price in India | This study examined regional demand patterns, festivals, government policies, and import/export rules. |
| Hossaini & Namaki, (2023) | Analyzing the Relationship between Oil Prices and Gold Prices before and after COVID-19 | There is a one-way causality relationship from gold prices to oil prices before the pandemic. |
| Zhang & Ci, 2020 | Deep belief network for gold price forecasting | The results identified the global interest rate as the most important factor affecting gold prices. |
| **Domestic studies** | | |
| Ehsani et al., (2021) | | The volume of liquidity and the consumer price index have a direct and significant impact on the increase in gold prices. Additionally, the |

| | | |
|---|---|---|
| | The Effects of Money Market on Gold Market with a Systemic Dynamics Approach | findings indicate that changes in bank interest rates do not affect fluctuations in gold prices. |
| Gorgbandi & Mousavi, (2023) | Forecasting the short-term trend of gold price in the Forex market using deep neural networks | The developed model can predict the short-term trend of gold prices with minimum accuracy of 60% . |
| Hossaini & Namaki, (2023) | Gold price forecasting using LSTM network | The LSTM network can be used as a powerful tool to predict the gold price. |
| Khonsarian et al., (2023) | Price predicting with LSTM artificial neural network and portfolio selection model of financial assets and digital currencies | The LSTM model can predict the price of financial assets with a very low error rate for each asset. |
| Zahedi et al., (2023) | Testing of Reciprocal Transfer of Bubble in Stock Exchange, Currency and Gold Markets (A case study: in Iran Using Copula Functions) | The sequential dependence between gold coins and the exchange rate is much stronger than that between the stock market and gold. |
| Mohammadinejad Pashaki et al., (2023) | Investigating and analyzing the spillover effects of stock market in interaction with currency, gold-coin, crude oil and housing markets: VARMA-BEKK-AGARCH Approach | The results indicate that there is a spillover effect wherein returns from currency influence stocks, and stock returns also affect the housing market. Additionally, shocks from currency, gold-coin, and oil impact stocks, while volatility spills over from currency and gold-coin to stocks, and from stocks to the housing market. Furthermore, the findings reveal a leverage effect, where shocks in the stock market affect the housing market. |

Reviewing domestic and international research has highlighted significant gaps in existing studies. Most research has relied heavily on global macroeconomic indicators and competitive markets, such as oil, currency, and stocks while neglecting intra-market indicators and the internal fluctuations of the gold market. This study addresses this oversight by focusing, for the first time, on these fluctuations in gold price modeling. Another identified gap is the absence of a specific pattern for gold price forecasting across different periods. This study utilizes a data-driven approach known as Bayesian model averaging to eliminate the personalized selection of variables influencing gold price forecasting. Additionally, it applies the TVP-FAVAR method to model gold price forecasting over various time frames.

## Methodology

The current study is applied exploratory research aimed at modeling gold price forecasting. The time frame of this study encompasses 13 years, with monthly data from 2010 to 2022. The research process is illustrated in (Figure 1).

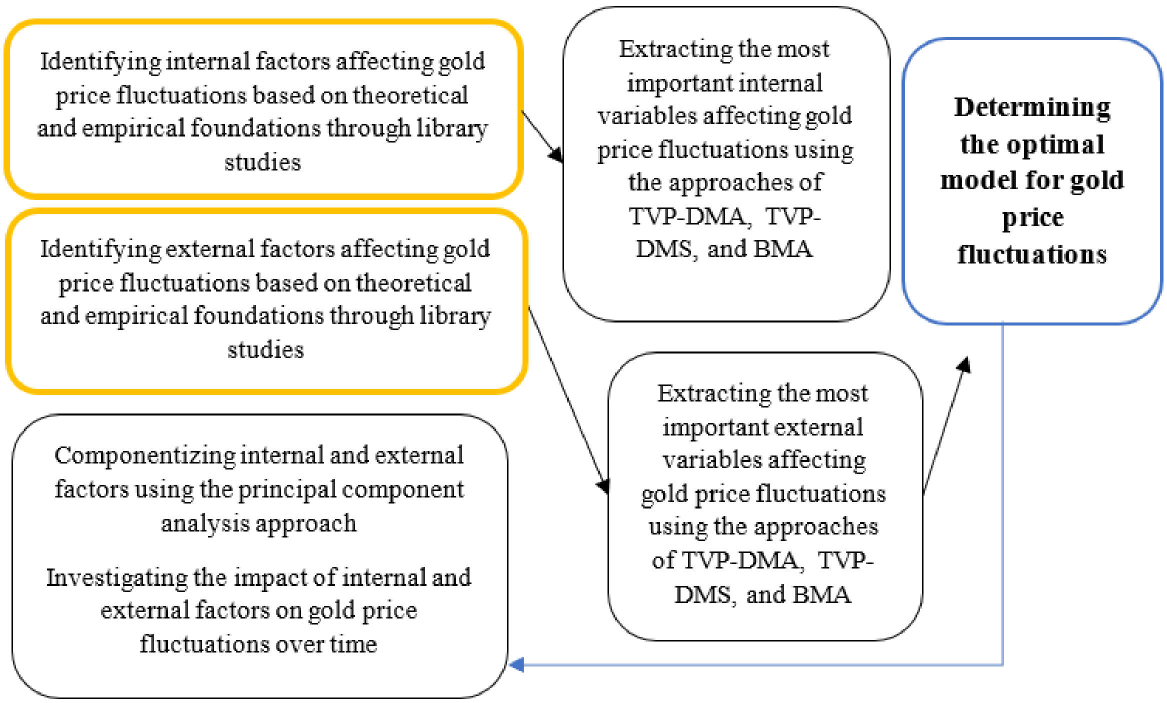



**Figure 1.** Research process

(Figure 1) illustrates the process of analyzing gold price fluctuations. First, internal and external factors (variables) that influence these fluctuations were identified based on both theoretical and empirical foundations. Then, the most significant non-fragile variables impacting gold price fluctuations were determined using Bayesian model averaging, dynamic model averaging, and selective model averaging techniques. Following this, the optimal patterns of gold price fluctuations were extracted from the results of these models. Lastly, the TVP-FAVAR approach was employed to examine how the most important selected variables affect gold price fluctuations over time, as shown in (Table 3)

**Table 3.** Factors affecting gold price fluctuations

| Factor | Index | Authors |
|---|---|---|
| **Macro factors** | Dollar index | Qian et al., 2019; Nisarga & Marisetty, 2023; Sailaja et al., 2022; Choudhary, 2021; Ding et al., 2022 |
| | Federal reserve fund rate | Qian et al., 2019; Nisarga & Marisetty, 2023; Sailaja et al., 2022 |
| | CPI | Qian et al., 2019; Nisarga & Marisetty, 2023; Sailaja et al., 2022 |
| | Unemployment | Zakaria et al., 2015 |

| | | |
|---|---|---|
| | Foreign Exchange Rate | Qian et al., 2019; Nisarga & Marisetty, 2023; Sailaja et al., 2022; Zhang & Ci, 2020; Ding et al., 2022 |
| | Oil price | Qian et al., 2019; Nisarga & Marisetty, 2023; Sailaja et al., 2022; Choudhary, 2021; Ding et al., 2022 |
| | Dow Jones Stock Return | Qian et al., 2019; Nisarga & Marisetty, 2023; Sailaja et al., 2022; Tanin et al., 2022; Zhang & Ci, 2020; Ding et al., 2022 |
| | S&P 500 Stock Return | Sailaja et al., 2022; Choudhary, 2021; Daga & James, 2020 |
| | GDP | Sailaja et al., 2022 |
| | Budget deficit | Sailaja et al., 2022 |
| | Gold export/import | Pradeep & Karunakaran, 2022; Vallabh, 2022 |
| | Geopolitical risk | Vallabh, 2022 |
| | Economic Uncertainty | Vallabh, 2022 |
| | Epidemic Diseases | Tanin et al., 2022 |
| | Global Interest Rates | Choudhary, 2021; Ding et al., 2022 |
| | Political risk | Ding et al., 2022 |
| | Platinum Price | Yuan et al., 2020 |
| | Palladium Price | Yuan et al., 2020 |
| | Silver price | Yuan et al., 2020 |
| | Cryptocurrency Index | Yuan et al., 2020 |
| **Micro (in-market) factors** | Relative Strength Index (RSI) | Mohammadinejad Pashaki et al., 2023; Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | Simple Moving Average (SMA) | Mohammadinejad Pashaki et al., 2023; Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | Bollinger Bands (bands) | Mohammadinejad Pashaki et al., 2023; Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | Moving average convergence/divergence (MACD) | Mohammadinejad Pashaki et al., 2023; Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | Retracement (Fibonacci retracement) | Mohammadinejad Pashaki et al., 2023; Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | Average Directional Movement (ADX) | Mohammadinejad Pashaki et al., 2023; Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | Oscillator | Mohammadinejad Pashaki et al., 2023; Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | Average True Range (ATR) | Mohammadinejad Pashaki et al., 2023; Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | Ichimoku Cloud | Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | Pivot point | Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | pivot point woodie | Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | Pivot Point DeMark | Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | Pivot Point Camarilla | Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | Pivot Point Floor | Hatamlou & Deljavan, 2019; Qin et al, 2021 |
| | Pivot Point Fibonacci | Hatamlou & Deljavan, 2019; Qin et al, 2021 |

(Table 3) presents the internal and external factors affecting gold price fluctuations. (Table 4) provides the different estimation approaches used in the present study.

**Table 4.** Models used in the present research

| Group | Model | Reasons for use |
|---|---|---|
| **Modeler** | TVP-DMA | To identify the most important variables affecting gold price fluctuations |
| | TVP-DMS | To identify the most important variables affecting gold price fluctuations |
| | BMA | To identify the most important variables affecting gold price fluctuations |
| **Component builder** | PCA | To calculate the average weights of the internal and external factors affecting gold price fluctuations |
| **Estimator** | TVP-FAVAR | To examine how the most important variables affect gold price fluctuations over short-, medium- and long-term periods |

## Results

*Estimation of the Gold Price Fluctuation Model*

This section examines which model—TVP or ordinary least squares (OLS)—is more effective in estimating the fluctuations in gold prices. The likelihood values for both models are presented in (Table 5).

**Table 5.** LR test for comparing TVP and OLS models in efficiency

| No. | lnL | LR |
|---|---|---|
| OLS | 110.12 | $\boldsymbol{\chi^2 = 29.82}^{***}$ |
| TVP | 519.45 | |

***: Significant at the 1% level.
Source: Researcher's calculations

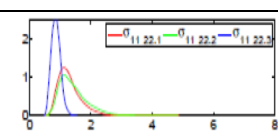
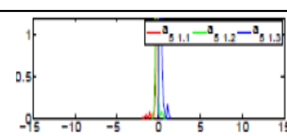
The results of the Likelihood Ratio (LR) test presented in (Table 5) indicate that the Time-Varying Parameter (TVP) model has a significantly higher likelihood ratio compared to the Ordinary Least Squares (OLS) model, with values of 519.45 and 110.12, respectively. This suggests that the TVP (nonlinear) approaches yield more efficient estimations than the OLS (linear) approaches. Additionally, the most important variables influencing fluctuations in gold prices have been identified. The training period for the forecasts ranged from January 2010 to December 2020, while the period for evaluating forecast performance extended from January 2021 to December 20222. In this section, in-sample forecasts were utilized to determine the optimal patterns of the variables with the greatest impact on gold price fluctuations, as shown in (Table 6). To assess forecast performance, the present study utilized the Log (PL) method, as referenced in Lee et al. (2022) and Cope et al. (2020).

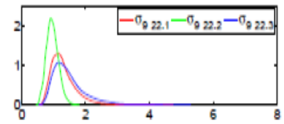
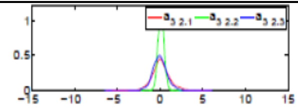
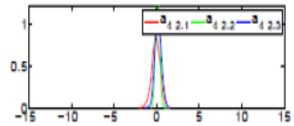
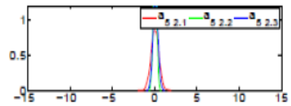
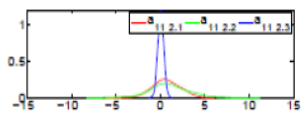
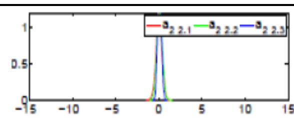
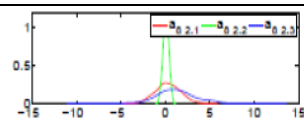
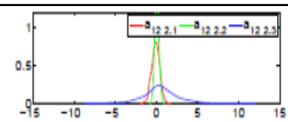
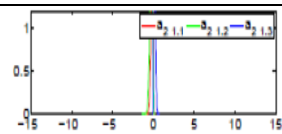
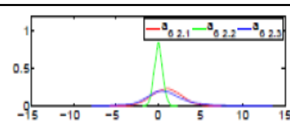
**Table 6.** Forecast performance criteria in different forecast horizons

| Forecast period | h=1 | h=4 | h=8 |
|---|---|---|---|
| | Log (PL) | Log (PL) | Log (PL) |
| $TVP - AR(1) - X \quad DMA(\alpha = \lambda = 0.99)$ | 97.091 | 91.7 | 86.6 |
| $TVP - AR(1) - X \quad DMA(\alpha = \lambda = 0.95)$ | 107.4 | 101.6 | 95.9 |
| $TVP - AR(1) - X \quad DMA(\alpha = \lambda = 0.90)$ | 109.8 | 103.3 | 97.3 |
| $TVP - AR(1) - X \quad DMS(\alpha = \lambda = 0.99)$ | 98.2 | 92.1 | 83.8 |
| $TVP - AR(1) - X \quad DMS(\alpha = \lambda = 0.95)$ | 113.3 | 105.7 | 100.9 |
| $TVP - AR(1) - X \quad DMS(\alpha = \lambda = 0.90)$ | 141.2 | 129.6 | 120.0 |
| $TVP - AR(1) - X \quad DMA(\alpha = 0.99, \lambda = 1)$ | 93.8 | 88.7 | 88.9 |
| $TVP - AR(1) - X \quad DMA(\alpha = 0.95, \lambda = 1)$ | 100.1 | 96.7 | 96.0 |
| $TVP - AR(1) - X \quad BMA(\alpha = \lambda = 1)$ | 154.5 | 131.4 | 110.2 |

The results indicate the more favorable performance of the BMA model across all periods tested (h=1,4,8). Consequently, the outputs of the BMA model will be further examined. Following the approach outlined by Cope et al. (2019), out of 35 variables introduced, 12 variables were selected based on their posterior and prior distribution probabilities across three consecutive stages. The non-fragile variables that significantly influence gold price fluctuations, along with their effect sizes and the probability of their inclusion in the optimal gold price forecasting model, are listed in (Table 7). The final column of the table prioritizes the importance of the presence of factors affecting gold price forecasting.

**Table 7.** Identification and prioritization of variables affecting gold price fluctuations in the optimal model

| Symbol | Variable | Sample size: 0.5 million Regression | | Regression ratio With 2≤\|t-stat\| | Priority | Joint distribution |
|---|---|---|---|---|---|---|
| | | Posterior coefficient | Posterior probability | | | |
| Z1 | Dollar index | 0.174 | 0.522 | 0.543 | 12 |  |
| Z2 | Oil price | -0.160 | 0.712 | 0.740 | 3 |  |

| | | | | | | |
|---|---|---|---|---|---|---|
| Z3 | Gold export/import | 0.183 | 0.553 | 0.575 | 10 |  |
| Z4 | Global interest rates | 0.373 | 0.691 | 0.719 | 6 |  |
| Z5 | Cryptocurrency index | 0.283 | 0.742 | 0.772 | 2 |  |
| Z6 | Relative Strength Index (RSI) | 0.153 | 0.711 | 0.739 | 4 |  |
| Z7 | Moving Average Convergence Divergence (MACD) | 0.037 | 0.523 | 0.544 | 11 |  |
| Z8 | Fibonacci retracement | -0.155 | 0.703 | 0.731 | 5 |  |
| Z9 | Average Directional Index (ADX) | -0.369 | 0.566 | 0.589 | 9 |  |
| Z10 | Oscillator | 0.190 | 0.647 | 0.673 | 7 |  |
| Z11 | Pivot Point DeMark | 0.283 | 0.974 | 0.913 | 1 |  |
| Z12 | Pivot Point Fibonacci | 0.247 | 0.624 | 0.649 | 8 |  |

The graphs above illustrate the posterior, prior, and joint distributions. The results indicate that the condition of the 12 variables is satisfactory. However, it is important to note that both the dispersion and the joint distribution of the research variables have deteriorated as the priority increased. Since a Bayesian function has been employed, it is essential to consider the probability of effect alongside the effect size. Based on the outputs of the Bayesian model, the mathematical research model is presented as follows.

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Gold price fluctuation= $0.174\,\Pr(0.522)\,Z1 - 0.160\,\Pr(0.740)\,Z2 + 0.183\,\Pr(0.553)\,Z3 + 0.373\,\Pr(0.691)\,Z4 + 0.287\,\Pr(0.742)\,Z5 0.153\,\Pr(0.711)\,Z6 + 0.037\,\Pr(0.523)\,Z7 - 0.155\,\Pr(0.703)\,Z8 - 0.369\,\Pr(0.566)\,Z9 + 0.190\,\Pr(0.647)\,Z10 + 0.283\,\Pr(0.974)\,Z11 + 0.247\,\Pr(0.624)\,Z12$

In interpreting the factors mentioned above, averaging models differ from classical regression models. While classical regressions focus solely on the effect size of the variables, averaging models also include the probability of a non-fragile variable's presence in the model. In this estimation model, the factors are interpreted as follows: the dollar index has an effect size of 0.174 on fluctuations in gold prices, with an accuracy score of 0.522. This means that the probability of the dollar index being a relevant factor in forecasting fluctuations in gold prices is 0.522. Similar arguments can be made for other variables as well.

**Componentization of Internal and External Factors**

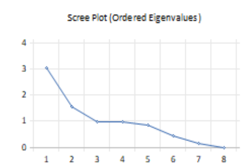
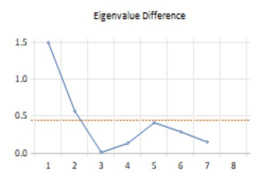
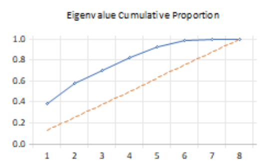
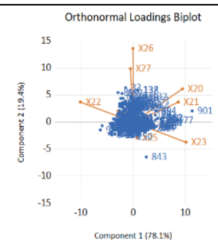
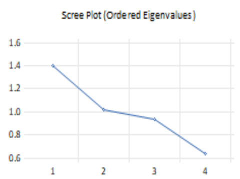
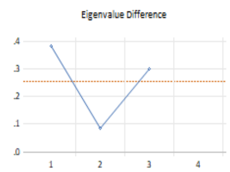
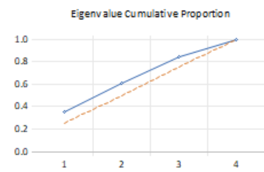
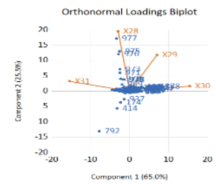
The PCA method was used to index 12 variables that influence fluctuations in gold prices, utilizing EViews 12 software. The number of components extracted in each model corresponds to the number of variables being analyzed. However, a select number of these components can be chosen for further examination. Generally, the first two or three components account for a significant portion of the data's variance, making their selection sufficient for continued analysis. Nevertheless, in some situations, additional criteria must be considered to determine the appropriate number of components. These criteria include:

Scree-scree test: This test displays a plot of eigenvalues against their corresponding principal components. The plot illustrates the change in importance of the eigenvalues for each component, with a noticeable breakpoint indicating the maximum number of principal components to consider. Selecting a component with an eigenvalue below the breakpoint may still be viable. Consequently, as shown in (Table 8), one or two components may be chosen for analysis.

Eigenvalue: This criterion involves selecting components that have an eigenvalue greater than one while disregarding others.

Variance: This criterion focuses on the components that explain a larger percentage of the total variance. Typically, the first component accounts for the highest variance.

**Table 8.** The output of the principal component analysis of the 12 factors

| Test type | Scree-Scree test | Eigenvalue | Variance | Analysis of variance | Result |
|---|---|---|---|---|---|
| External factors (5 factors) |   |   |   |   | The components explain 97.5 percent of the variations. |
| Internal factors (7 factors) |   |   |   |   | The components explain 90.5 percent of the variations. |

After componentizing the internal and external factors, the TVP-FAVAR model was estimated using MATLAB software to investigate the effects of the components of internal and external factors. This analysis presents the instantaneous response of the model variables to changes in gold prices over a span of 10 periods. Before discussing the research graphs shown in (Figure 2), let's consider an example of the instantaneous response analysis related to the components of internal and external factors affecting gold price fluctuations. In econometrics, the significance of an explanatory variable on a dependent variable is indicated by the duration for which it exerts a significant effect. In TVP-FAVAR models, the shock from the explanatory variables (the components of internal and external factors) significantly influences the dependent variable (in this case, gold price fluctuations) when the instantaneous shock graph of the non-fragile variable is either below or at the equilibrium point (which is zero). If the graph aligns with the equilibrium line, the significant effect of the variable is nullified. The graph presents internal factors in greater detail. It indicates that these factors have a positive influence on gold price fluctuations, as the graph remains above the equilibrium level. In the graph, vector A represents the length of the impact period, while vector B shows the total duration of the study, divided into four segments: the short-term period (b1), which accounts for 30% of the study period over three years (2010–2013); the medium-term period (b2), covering 40% over five years (2014–2018); and the long-term period (b3), which encompasses 30% over four years (2019–2022). Vector C illustrates the response of gold price fluctuations to changes in the independent variable across all three periods. Considering vector C, it is clear that the aforementioned component consistently remains above the equilibrium point of zero, indicating a positive effect on gold price fluctuations. However, the intensity of this effect should also be considered. For instance, the size of vector c1 represents the response of gold price fluctuations to the variable in the short-term period b1, c2 reflects the response in the medium-term period b2, and c3 corresponds to the long-term period b3. Since c1 is smaller than c2, and c2 is smaller than c3, we can ascertain that there is an upward trend, as represented by vector D. The influence starts in the short-term period b1 and culminates in the long-term period b3.

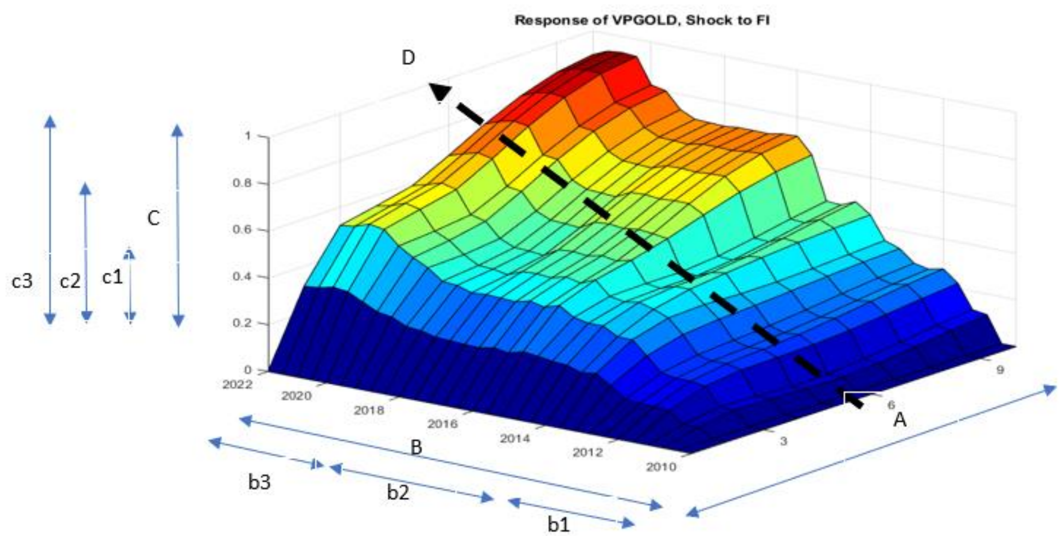



**Figure 2.** Graphical analysis of the instantaneous response of the components of internal factors to gold price fluctuations in TVP-FAVAR models

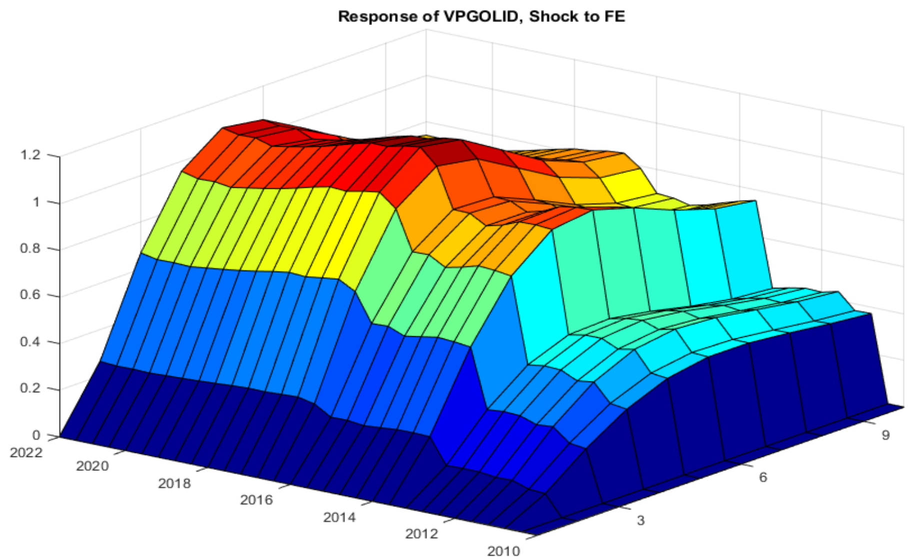



**Figure 3.** Graphical analysis of the instantaneous response of the components of external factors to gold price fluctuations in TVP-FAVAR models

shown in (Figure 3), gold price fluctuations due to external factors are increasing over time, with a greater intensity than that of internal factors. In the following sections, fluctuations will be predicted over short-term, medium-term, and long-term periods.

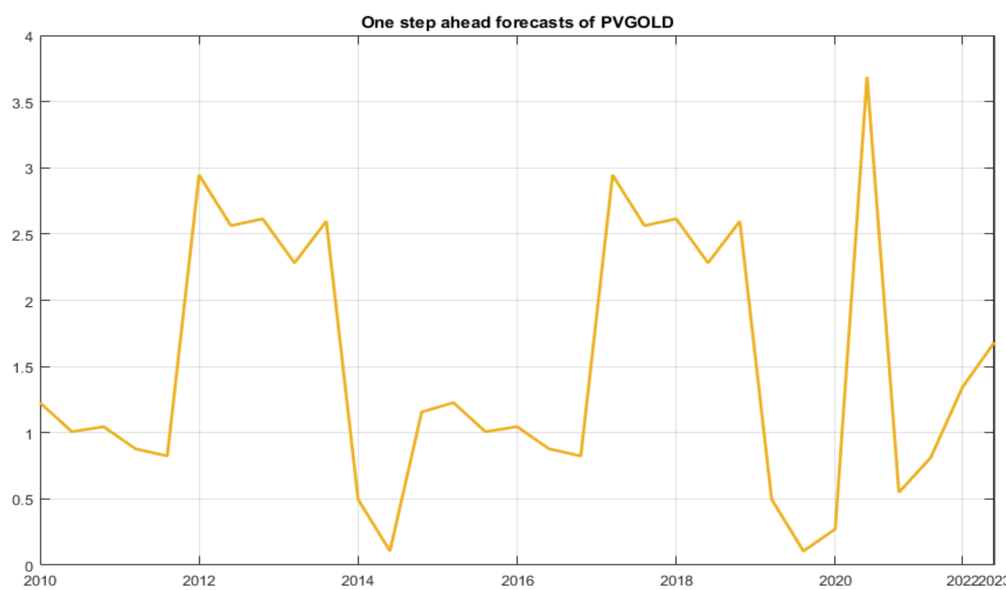



**Figure 4.** Forecasting gold price fluctuations in the short-term period

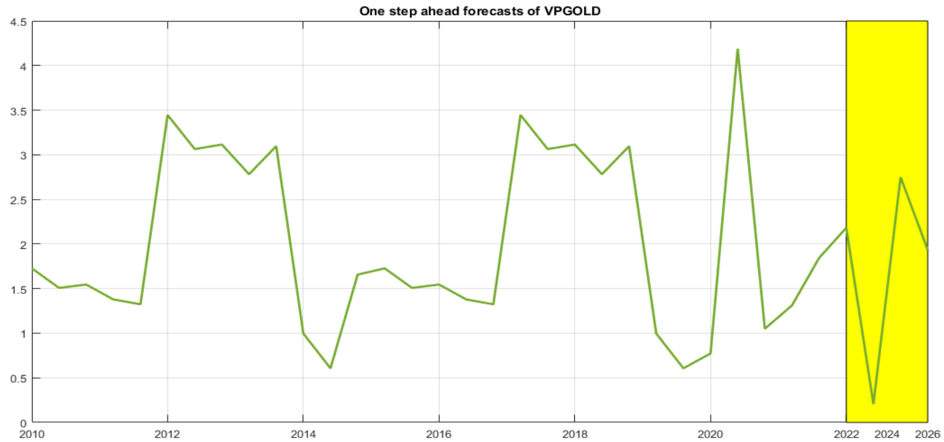



**Figure 5.** Forecasting gold price fluctuations in the medium-term period

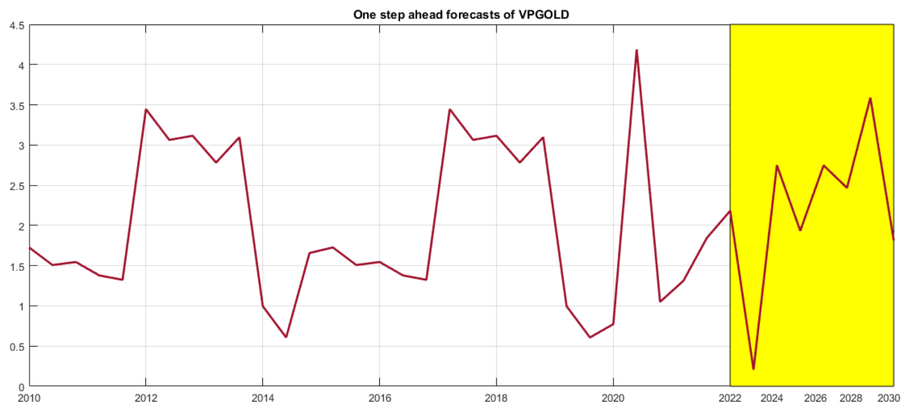



**Figure 6.** Forecasting gold price fluctuations in the long-term period

As shown in (Figures 4-6), gold price fluctuations have increased across all three periods, indicating a trend of rising volatility.

## Discussion and Conclusion

The present study employed a Bayesian time-varying parameter optimization algorithm to forecast fluctuations in gold prices. The results indicated that the BMA model outperformed the TVPDMA and TVPDMS models in terms of accuracy. Twelve key variables were identified as influencing gold price fluctuations: the dollar index, oil price, gold imports and exports, global interest rates, cryptocurrency index, Relative Strength Index (RSI), Moving Average Convergence Divergence (MACD), Fibonacci retracement, Average Directional Index (ADX), oscillator, Pivot Point DeMark, and Pivot Point Fibonacci. The findings suggest that internal factors within the market are more effective at explaining fluctuations in gold prices than external market factors. Additionally, it was observed that nonlinear modeling techniques are significantly better at predicting gold price changes compared to linear approaches. This underscores the importance for investors and policymakers in this sector to closely monitor shifts in both global macroeconomic and microeconomic indicators, particularly concerning the twelve identified significant variables. The outputs of the TVPFAVAR model revealed that both internal and external factors positively influence gold price fluctuations, with external factors exhibiting a stronger effect. Furthermore, a consistent upward trend was noted in gold price forecasts across short, medium, and long-term periods. Given the influence of both internal and external factors on gold price fluctuations, it is recommended to adopt a systemic approach that considers all dimensions affecting this market. This perspective could enhance the development of forecasting models for gold price fluctuations, ultimately improving investment strategies in this area. Additionally, implementing global economic stabilization policies could contribute to a more stable gold price trend.

Given the varying intensity of factors influencing gold price fluctuations over different periods, it is recommended to utilize the factors that have the highest impact during specific timeframes for price predictions. Since nonlinear models have been shown to operate more efficiently than linear models in explaining gold price movements, it is advisable to apply them when modeling these markets. Previous domestic and international studies have mainly concentrated on the factors that affect gold price forecasting, without specifically modeling gold price fluctuations. Therefore, the present study's findings are compared with earlier research only in terms of trend results. The findings align with those of studies conducted by (Zhang & Ci, 2020; Nisarga & Marisetty, 2023; Hossaini & Namaki, 2023; Ding et al., 2022; Yuan et al., 2020; Hatamlou & Deljavan, 2019; Ehsani et al., 2021 and Haddadi et al., 2020), as well as (Kazemzadeh et al., 2019). Furthermore, the results of this study reaffirm the conclusions of previous research. This work makes a significant contribution to gold price forecasting and lays a foundation for further exploration and innovation in various fields that require advanced forecasting techniques. Future studies may focus on adapting this framework to particular market dynamics and assessing its applicability across diverse environments, from commodities to other critical sectors. This comprehensive approach establishes a new benchmark for forecasting models, especially for volatile commodities such as gold.

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