

Predicting the future value of gold: A time series approach

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Abstract

Time series analysis has become an invaluable tool in the realm of financial markets, particularly when it comes to predicting the future value of gold. In addition to conventional methods like technical and fundamental analysis, recent advancements in time series algorithms have opened up new avenues for leveraging technological progress. By employing these techniques, investors can gain valuable insights and make well-informed decisions regarding their gold investments.

One promising approach involves developing a technical analysis tool that utilizes past market data to forecast the future trajectory of gold prices. This tool will rely on time series analysis, which involves analyzing historical price data to identify patterns, trends, and cycles. By understanding these patterns and trends, investors can anticipate potential future movements in the value of gold.

The tool will utilize various time series algorithms to extract meaningful information from the historical data. These algorithms leverage statistical techniques and mathematical models to identify patterns and relationships within the data, enabling the prediction of future price movements. By incorporating these advanced algorithms, the tool aims to provide accurate and reliable forecasts, aiding investors in their decision-making processes.

Time series analysis offers valuable insights into predicting the future value of gold in the financial markets. Traditional approaches such as technical analysis and fundamental analysis continue to be used, while improvements in time series algorithms offer new possibilities by exploiting technological advances. As a results, we have developed a sophisticated technical analysis tool that utilizes historical market data to forecast the future trajectory of the gold price by employing a time series approach.

Keywords: time series, LSMA, trading, prediction, investment, gold forecast

JEL Classification: G11, G12, G13, G17

Paper type: Empirical research

1. Introduction

Gold is one of the most sought-after assets in financial markets due to its intrinsic value and role as a safe haven during times of economic uncertainty. In the past few days, it has surpassed its August 2020 peak, reaching a new all-time high on May 4, 2023, with the price of an ounce of gold surpassing \$2,081. Investors are constantly seeking ways to predict its future daily value in order to make informed decisions about their investments. However, predicting the price of gold is a significant challenge, as numerous factors can influence its trajectory, such as economic policies, interest rates, market volatility, and global demand.

Peter Schiff is known for using a fundamental approach in his gold forecasts, focusing on economic and monetary analysis to evaluate long-term factors that influence the price of gold. He emphasizes that monetary policies, budget deficits, and currency depreciation positively impact the demand for gold as a store of value. Jim Rogers adopts a similar approach by analyzing global macroeconomic trends and identifying investment opportunities. He believes that economic imbalances, geopolitical tensions, and inflation can contribute to an increase in the price of gold. On the other hand, Harry Dent utilizes a method based on demographic analysis and long-term economic cycles to forecast gold movements. He examines consumption patterns, demographic trends, and social changes to assess future demand for gold. As for Jeffrey Christian, he uses historical data, mathematical models, and supply and demand factors to make gold predictions. He considers geopolitical factors, mining production, available stocks, and industry demands to evaluate the price of gold. Lastly, James Turk focuses on technical analysis to predict gold movements. He uses charts, past trends, and technical indicators to identify entry and exit points in the gold market.

In this article, we will discuss the primary methods used to predict the future value of gold in financial markets. We will examine traditional techniques such as technical and fundamental analysis, as well as more recent approaches like machine learning and time series analysis. We will also explore the advantages and limitations of each method, and in the final section, we will build a technical analysis tool that studies past market data to predict the future direction of the gold price through a time series and delve into predictive analysis of time series, which will provide us with a better understanding of the future daily price of gold.

Our statistical tool incorporates a variety of time series algorithms to meticulously analyze extensive historical data, using advanced mathematical techniques and models to efficiently identify complex trends and fluctuations and establish meaningful relationships within the data. With the aid of these algorithms, our tool is purposefully designed to yield precise and dependable forecasts, thereby equipping investors with invaluable insights to inform their decision-making processes. Consequently, our tool serves as a valuable resource for predicting future price movements in the gold market, catering to the needs of investors seeking reliable information to guide their investment strategies. Hence, we can formulate the research question as follows: Can a technical analysis tool using time series algorithms accurately predict the future direction of the gold price based on historical market data?

The remainder of this paper is organized as follows. Section 2 related literature reviews and discusses the prediction of the price of gold, and then develops the mathematical algorithm. Section 3 presents the research design, including the sample selection procedure, the measurement of the dependent (price) and independent primary (time) variables and the model specification. Section 4 reports empirical results, including main results, robustness tests and additional analyses. Finally, Section 5 concludes the paper.

2. Literature Review

2.1. Time series and their use in predicting the price of gold

Time series are sets of data ordered chronologically, usually collected at regular intervals. These data can provide valuable insights into trends, cycles, and seasonal events that occur within a data series. Time series analysis utilizes statistical and mathematical techniques to forecast future events.

Predicting the future value of gold in financial markets is a common example of using time series to forecast future price fluctuations. Indeed, time series data of price provide crucial information for identifying trends and cycles. By recognizing and analyzing these trends and cycles, investors can predict the future value of gold. This approach enables accurate forecasts for upcoming market fluctuations, which is particularly relevant for maximizing returns and minimizing loss risks.

The use of time series in prediction can be performed at different frequencies, ranging from short-term to long-term forecasts. Short-term predictions often rely on daily price time series data, while longer-term forecasts may be based on monthly or yearly price time series data.

However, enhancing the use of time series for predicting the future value of gold can involve considering additional economic and financial variables, such as interest rates, exchange rates, or market volatility. Incorporating these factors can improve the accuracy of predictions by providing supplementary insights into the factors influencing gold value. Thus, incorporating these external variables can significantly enhance the quality and effectiveness of time series-based forecasts.

2.2. Technical analysis: A traditional method for predicting the price of gold

Technical analysis is a traditional method for predicting the value of gold that relies on the analysis of historical time series data of prices. This approach aims to identify recurring patterns and trends in price data to forecast future market fluctuations.

Technical analysts use charts to represent price data, enabling them to identify trends, support and resistance levels, and significant price patterns. They can apply technical indicators such as least squares moving averages (LSMA), Bollinger Bands, AROON, or momentum oscillators (e.g., RSI) to predict the future direction of gold prices.

However, technical analysis is often criticized for its lack of solid theoretical foundation. Additionally, historical price patterns may not be reliable indicators of future price movements. Historical data can be influenced by unforeseen events or structural changes in the market. Despite these criticisms, technical analysis remains a commonly used method for predicting the value of gold using time series. Many investors continue to use it to develop trading strategies based on identified trends and price patterns. Furthermore, some technical analysts have developed more sophisticated approaches, such as Elliott Wave analysis, which attempts to apply a more robust theory to predict future market movements.

2.3. Fundamental analysis: Another traditional method for predicting the future value of gold

Fundamental analysis is another traditional method for predicting the future value of gold that focuses on analyzing economic and financial data to understand the underlying factors that influence the gold market. This method aims to determine the intrinsic value of gold by examining factors such as supply and demand, interest rates, monetary policies, and general economic trends.

Fundamental analysts use a variety of economic and financial data to predict the future value of gold. For example, they may examine government reports on employment, inflation, and economic growth, as well as key economic indicators such as interest rates and trade balances.

However, fundamental analysis can also be criticized for its subjectivity. Fundamental analysts may have different opinions on the factors that influence the gold market, leading to divergent predictions. Additionally, fundamental analysis can be affected by unforeseen factors, such as political or geopolitical events that can disrupt markets.

Despite these limitations, fundamental analysis remains a popular method for predicting the price of gold. Investors use it to develop long-term trading strategies based on a deep understanding of the economic and financial factors that influence the gold market.

2.4. Machine learning and the natural evolution of the price of gold: Recent approaches for predicting the future value of gold using time series

Machine learning have become an increasingly popular approach for predicting the future value of gold using time series. This method is based on analyzing historical patterns in gold prices and using mathematical algorithms to identify trends and behaviors in the data.

Machine learning algorithms can be used to forecast the future value of gold based on a variety of economic and financial factors such as interest rates, exchange rates, market volatility, etc. These algorithms can also be used to analyze market behaviors, including the buying and selling activities of different market participants, to predict future price fluctuations within a specific time interval. However, using this method also comes with challenges. These models need to be trained with high-quality data, and it is important to select relevant variables for price prediction. Moreover, they are often considered as "black boxes," meaning that it can be difficult to understand how the model arrives at future gold price values.

Despite these challenges, the use of time series to predict the future daily price of gold continues to gain popularity due to its ability to identify complex trends and patterns in the data. This approach can be used to assist investors in making informed stop-loss decisions.

3. Methodological framework

3.1. Prediction of the future price of gold through time series analysis

Time series analysis is an important tool for predicting the future value of a given financial variable. Traditional methods such as technical analysis and fundamental analysis, as well as more recent approaches like machine learning, can be used to identify important price trends and patterns. Investors can utilize these approaches to develop effective trading strategies and make informed investment decisions.

In traditional finance, experienced traders typically use various trading tools and technical indicators to time the market and determine optimal entry and exit points to generate maximum profits. These tools and technical indicators can also be applied to gold trading. An example of a technical indicator that traders can use for predicting the price of gold is the 11th-order least squares moving average (LSMA 11 close), another variation of the moving average (MA). This indicator helps traders determine whether the market is in an upward or downward trend. The least squares method is a statistical approach that involves regression analysis and aims to find the best fit for a set of data. In this method, the best fit line can be obtained by minimizing the sum of squared residuals, which are the differences between the observed value and the estimated value of the asset in question.

This is a technical analysis tool that examines past market data to predict the future direction of an asset's price.

We will attempt to interpret and analyze the fluctuation of a sequence of 50 ordered values over time, representing a daily time series of the average least squares of gold (LSMA 11) prices. For this reason, we need to calculate indicators that best reflect this fluctuation.

We will use the analytic method to determine the trend, also known as the long-term trend, denoted as f_t , which represents the long-term evolution of the price of gold and reflects the overall aspect of the ordered LSMA values over time.

Given a time series database representing the average price (LSMA 11) of gold, denoted as X_t representing the value of the 11th order moving average of the least square, our objective is to ascertain the primary component of this time series utilizing an additive scheme.

$$x_t = f_t + S_T + \Sigma_t$$

3.2. Algorithm parameters

• Determination of the Trend (f_t):

In this context, we can express the Trend as follows:

$$f_t = a.t + b$$

with:

$$a = \frac{Cov(t, x)}{V(t)}$$

$$b = \bar{X} - a\tau$$

$$\bar{X} = \frac{1}{N} * \Sigma X_i$$

$$\tau = \frac{N+1}{2} = 25.5$$

with:

$N = 50$ is the number of days used in the study

$$Cov(t, x) = \frac{1}{N} \Sigma i. x_i - \frac{N+1}{2} * \bar{X}$$

Therefore:

$$V(t) = \frac{(n+1)(n-1)}{N}$$

The trend of this time series is the overall direction or the general trend in which the data evolves over time. It can be calculated using methods such as linear regression to identify a trend line that

represents the long-term growth or decline of the data. Therefore, we will use this trend to forecast future trends.

- **Seasonal coefficients: $S(t)$**

Seasonal coefficients are used to eliminate the effects of corresponding seasonal variations from an observation. This results in seasonally adjusted values or deseasonalized values. The advantage of deseasonalization is that it allows for the comparison of two observations subjected to different seasonal variations.

$$S(t) = X(t) - f_t$$

The seasonal coefficient plays a dual role: it determines the adjusted series and the series corrected for seasonal effects. After calculating the seasonal coefficients, we can now deduce the corrected series and the adjusted series.

- **Corrected time series (X^*):**

The seasonally adjusted values characterize both the trend and the random variation. The goal is to remove the seasonal coefficients from the raw series and separate the seasonal variations from the trend:

$$X^* = X(t) - S(t)$$

- **Adjusted series ($\hat{x}$):**

The adjusted series is obtained by adding the seasonal coefficients to the raw series. It is used to establish forecasts for the future.

$$\hat{X} = X(t) + S(t)$$

- **Residual $\varepsilon(t)$:**

The quality of model fit is typically assessed by comparing observed values with their corresponding values in the fitting model. If the fitted model is appropriate, the residuals should behave like white noise. The residual is the series that represents the variation of unexpected variables.

$$\varepsilon(t) = x(t) - \hat{x}(t)$$

4. Results and discussion

4.1. Descriptive statistics

The objective of this study is to forecast the future price of gold for the next five days. It involves predicting the future values of the LSMA 11 variable based on observed values in the present and past of the same variable. The issue at hand is to estimate a future observation based on historical knowledge. In general, a forecast is an interpretation of a history which consists of a series of observations made at fixed dates and arranged chronologically using Excel. The table below represents the time series of data to perform the prediction:

Table 1: Time series data

Date	t	x_t	f_t	s_t	s_j	x^*	$\hat{x}$	E_t
19/03/2023	1	1986,4	1 979,93	6,47	338,60	1 647,80	2 318,54	(332,14)
20/03/2023	2	1991,8	1 980,60	11,20	339,21	1 652,59	2 319,82	(328,02)
21/03/2023	3	1985,9	1 981,28	4,62	(71,68)	2 057,58	1 909,60	76,30
22/03/2023	4	1984,4	1 981,95	2,45	(71,33)	2 055,73	1 910,62	73,78
23/03/2023	5	1987,9	1 982,62	5,28	(67,86)	2 055,76	1 914,76	73,14
24/03/2023	6	1988,8	1 983,29	5,51	(65,87)	2 054,67	1 917,42	71,38
25/03/2023	7	1984,4	1 983,96	0,44	(65,70)	2 050,10	1 918,26	66,14
26/03/2023	8	1989,8	1 984,63	5,17	(65,20)	2 055,00	1 919,44	70,36
27/03/2023	9	1967,2	1 985,30	(18,10)	(68,29)	2 035,49	1 917,02	50,18
28/03/2023	10	1968,9	1 985,97	(17,07)	(66,96)	2 035,86	1 919,02	49,88
29/03/2023	11	1969,2	1 986,65	(17,45)	(67,13)	2 036,33	1 919,52	49,68
30/03/2023	12	1972,5	1 987,32	(14,82)	(67,80)	2 040,30	1 919,52	52,98
31/03/2023	13	1973,4	1 987,99	(14,59)	338,60	1 634,80	2 326,59	(353,19)
01/04/2023	14	1968,4	1 988,66	(20,26)	339,21	1 629,19	2 327,87	(359,47)
02/04/2023	15	1962,8	1 989,33	(26,53)	(71,68)	2 034,48	1 917,65	45,15
03/04/2023	16	1970,7	1 990,00	(19,30)	(71,33)	2 042,03	1 918,67	52,03
04/04/2023	17	1988,1	1 990,67	(2,57)	(67,86)	2 055,96	1 922,81	65,29
05/04/2023	18	2002,4	1 991,34	11,06	(65,87)	2 068,27	1 925,47	76,93
06/04/2023	19	2010,2	1 992,02	18,18	(65,70)	2 075,90	1 926,31	83,89
07/04/2023	20	2013,5	1 992,69	20,81	(65,20)	2 078,70	1 927,49	86,01
08/04/2023	21	2017,1	1 993,36	23,74	(68,29)	2 085,39	1 925,07	92,03
09/04/2023	22	2017,2	1 994,03	23,17	(66,96)	2 084,16	1 927,07	90,13
10/04/2023	23	2013,2	1 994,70	18,50	(67,13)	2 080,33	1 927,57	85,63
11/04/2023	24	2011,2	1 995,37	15,83	(67,80)	2 079,00	1 927,57	83,63
12/04/2023	25	2011,7	1 996,04	15,66	338,60	1 673,10	2 334,65	(322,95)
13/04/2023	26	2015,8	1 996,71	19,09	339,21	1 676,59	2 335,93	(320,13)
14/04/2023	27	2009,7	1 997,38	12,32	(71,68)	2 081,38	1 925,71	83,99
15/04/2023	28	2009,3	1 998,06	11,24	(71,33)	2 080,63	1 926,73	82,57
16/04/2023	29	2008,8	1 998,73	10,07	(67,86)	2 076,66	1 930,87	77,93
17/04/2023	30	2004,6	1 999,40	5,20	(65,87)	2 070,47	1 933,53	71,07
18/04/2023	31	2004,6	2 000,07	4,53	(65,70)	2 070,30	1 934,37	70,23
19/04/2023	32	2001,2	2 000,74	0,46	(65,20)	2 066,40	1 935,55	65,65
20/04/2023	33	2001,1	2 001,41	(0,31)	(68,29)	2 069,39	1 933,13	67,97
21/04/2023	34	1991,7	2 002,08	(10,38)	(66,96)	2 058,66	1 935,13	56,57
22/04/2023	35	1985,1	2 002,75	(17,65)	(67,13)	2 052,23	1 935,63	49,47
23/04/2023	36	1982,1	2 003,43	(21,33)	(67,80)	2 049,90	1 935,63	46,47
24/04/2023	37	1987,1	2 004,10	(17,00)	338,60	1 648,50	2 342,70	(355,60)
25/04/2023	38	1989,9	2 004,77	(14,87)	339,21	1 650,69	2 343,98	(354,08)
26/04/2023	39	1989,7	2 005,44	(15,74)	(71,68)	2 061,38	1 933,76	55,94
27/04/2023	40	1988,8	2 006,11	(17,31)	(71,33)	2 060,13	1 934,78	54,02
28/04/2023	41	1989,1	2 006,78	(17,68)	(67,86)	2 056,96	1 938,92	50,18

29/04/2023	42	1991,4	2 007,45	(16,05)	(65,87)	2 057,27	1 941,58	49,82
30/04/2023	43	1992,2	2 008,12	(15,92)	(65,70)	2 057,90	1 942,42	49,78
01/05/2023	44	1992,8	2 008,80	(16,00)	(65,20)	2 058,00	1 943,60	49,20
02/05/2023	45	1999,8	2 009,47	(9,67)	(68,29)	2 068,09	1 941,18	58,62
03/05/2023	46	2017,4	2 010,14	7,26	(66,96)	2 084,36	1 943,18	74,22
04/05/2023	47	2030,2	2 010,81	19,39	(67,13)	2 097,33	1 943,68	86,52
05/05/2023	48	2031,9	2 011,48	20,42	(67,80)	2 099,70	1 943,68	88,22
06/05/2023	49	2034,2	2 012,15	22,05	338,60	1 695,60	2 350,76	(316,56)
07/05/2023	50	2033,3	2 012,82	20,48	339,21	1 694,09	2 352,04	(318,74)

Source: ourselves

4.2. Regression results

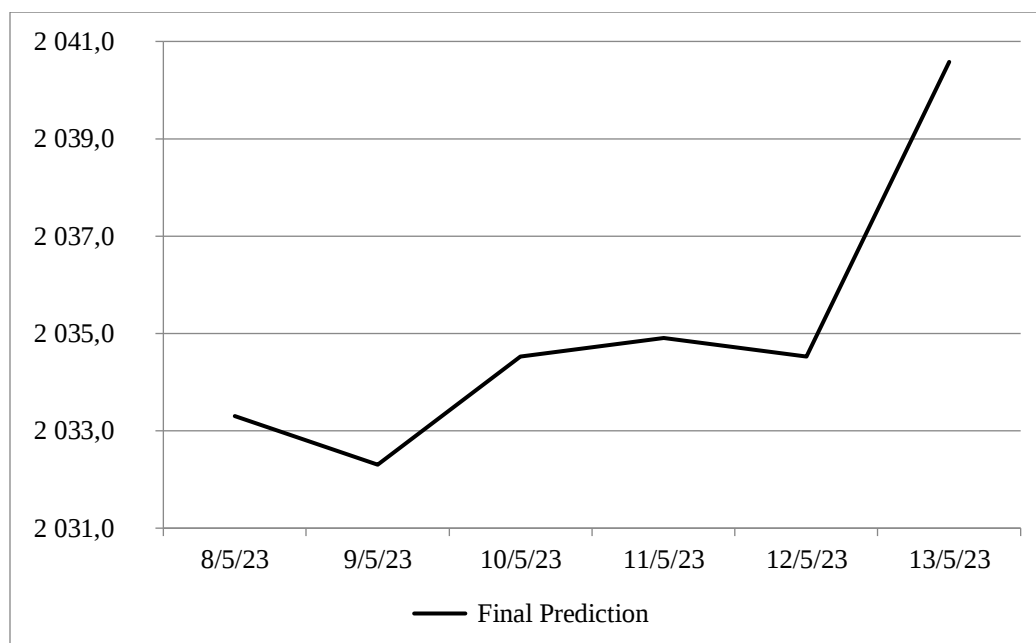
The chronological analysis conducted previously indeed enables us to provide forecasts for the aforementioned time series (the 11th order least squares moving average of the gold price), which is subject to seasonal variations caused by temporary effects that recur regularly over time following an additive model where the seasonal variation is simply added to the trend.

Table 2: Gold Price Forecasts for the Next Five Days

Date	Final Prediction:
08/05/2023	2 033,3
09/05/2023	2 032,3
10/05/2023	2 034,5
11/05/2023	2 034,9
12/05/2023	2 034,5
13/05/2023	2 040,6

Source: ourselves

Figure 1: Gold Price Forecast Graph for the Next Five Days



Source: ourselves

4.3. Discussion

We observe that it is possible for the price of gold to continue to trend positively in the coming days. However, it is important to note that the gold market can be volatile, and price fluctuations can be influenced by various external factors. Therefore, it is crucial for potential investors to conduct their own research and analysis before making investment decisions.

We have observed that this statistical model can be used to predict the future daily value of gold. This model allows the analysis of historical trends by identifying recurring patterns in past data. By using the above-mentioned statistical additive technique and specific mathematical logic for the time-series data of the average price, it is possible to extrapolate patterns and relationships observed in historical data to predict future movements. These predictions are based on the idea that past trends and patterns may repeat in the future, allowing for estimations of the future value of gold. However, it is important to note that time series-based forecasts are subject to a certain margin of error and can be influenced by unpredictable external factors such as economic and geopolitical events (*Jim Rogers & Jeffrey Christian*). Therefore, it is recommended to consider time series-based forecasts as a general indication rather than an absolute prediction of the future value of gold.

5. Conclusion

Time series analysis is a powerful tool for forecasting future events based on chronological data. Predicting the value of gold is a common application of time series analysis in financial markets, where historical price data is used to identify trends and cycles. Incorporating additional economic and financial variables can improve the accuracy of predictions. Technical analysis, relying on historical price patterns, and fundamental analysis, examining economic and financial factors, are traditional methods for predicting gold prices. Machine learning algorithms have also emerged as a popular approach, leveraging historical patterns and mathematical algorithms to forecast future gold values. Although challenges exist, the use of time-series analysis in predicting the daily price of gold is gaining popularity, aiding investors in making informed decisions.

Our research aims to examine the daily time series of gold prices using the average least squares moving average (LSMA 11) in an additive scheme. Through this approach and by employing Excel, we successfully identified the main components of this time series. In conclusion, the value of gold is a complex subject that can be analyzed using various methods, including technical analysis, fundamental analysis, and machine learning. Time series analysis is a particularly important method for predicting the future value of gold by identifying relevant price trends and patterns. While each method has its advantages and limitations, investors can combine them to develop effective trading strategies and make informed investment decisions. Fundamental analysis can be used to understand the economic and financial factors that influence the value of gold, while technical analysis can be used to identify short-term trends.

Ultimately, the decision to invest in gold should consider multiple factors, including investment goals, risk tolerance, economic trends, and market conditions. By using a combination of time series analysis approaches, investors can make informed decisions to maximize their returns on gold.

Forecasting gold prices using time series has both limitations and opportunities. Volatile fluctuations in the gold market make it difficult to predict long-term prices accurately. In addition, external factors such as monetary policy, geopolitical tensions and inflation can have a significant

impact on the price of gold, making models based on time series less reliable. In addition, historical gold price data can contain statistical noise and outliers, which can distort forecasting models. However, despite these limitations, time series analysis can help to identify long-term trends in the price of gold. By observing historical patterns and cycles, it is possible to predict general movements in the gold price over an extended period. In addition, improved forecasting models, using more advanced machine learning techniques and combining multiple data sources and influencing factors, offer the prospect of improving the accuracy of gold price forecasts. By integrating macroeconomic variables, market data and geopolitical factors, it is possible to capture complex relationships and better forecast gold price fluctuations.

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