universität wien

# Bachelorarbeit

## Can Technical Analysis Help to Predict Future Gold Price?


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angestrebter akademischer Grad

Bachelor of Science (BSc)

Wien, >2024<

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|---|---|
| Studienkennzahl lt. Studienblatt: | A >033 514< |
| Fachrichtung: - >Investment in Precious Metals< | |
| Betreuerin / Betreuer: | >ao. Univ.-Prof. Mag. Dr. Jörg Borrmann< |

# Contents

**Abstract**

This research explains how technical analysis can predict gold prices. By examining three used moving techniques such as Simple Moving Average (SMA) Weighted Moving Average (WMA) and Exponential Moving Average (EMA) from May 31 2018 to May 28 2021 the study aims to determine which moving average performed better. Different performance metrics such, as Mean Absolute Deviation (MAD) Mean Squared Error (MSE) Root Mean Squared Error (RMSE) and Mean Absolute Percentage Error (MAPE) provide insights into performance of these indicators. The research offers perspectives for investors, traders and politicians highlighting the real world benefits of using analysis in the unpredictable financial markets.

# 1 Introduction

## 1.1 Background of the Study

Gold has historical value due to the fact that it was used as a currency for many countries, empires and nations. In addition, gold is essential because of its biased value, since in fact, gold is not that useful for its intended purpose, that is, as a raw material for production. Due to the rarity and durability of this precious metal, it has enormous weight as a method of saving, including as an excellent way to counteract inflation. According to Baur & Lucey (2010), gold served until the mid-20th century as the gold standard and was therefore used as a currency for trade. All these factors have made this raw material a critical element of the modern financial market which is traded in huge quantities.

The importance of gold in financial markets cannot be underestimated because most companies cannot imagine their portfolio without this asset. As mentioned earlier, gold resists inflation and is used as a hedge in politically and economically unstable times. A good example is the real estate bubble in the late 2000s when many financial structures collapsed. Investors began to massively buy gold assets, considering it as a safe haven. As a result, the price of gold increased, which stabilized their financial situation.

Gold as an asset is of high importance in the risk management strategy of a large number of individuals and legal entities. If stock markets show high volatility, many prefer to invest in gold, relying on this safe haven. Therefore, in times of financial instability, this precious metal is used to hedge one's resources against inflation and other factors (Hiller, Draper, and Faff, 2010). Bankers use this security as a safety feature in case of losses in other liquidities, especially when changes in monetary policy and other macroeconomic factors occur. All these aspects highlight the value of gold and force society to study the possible factors influencing the price of this asset and in which way the price could be affected.

Due to constant development and changes in the financial environment, periodic collapses often lead to unfavourable circumstances. In this regard, based on what happened, measures are being taken to avoid the occurrence of these incidents in the future. Thus, according to Lucey and Li (2015), in order to avoid a repeat of the 2008 economic crisis, financial institutions have become required to have more liquid resources. These regulations are aimed at stabilizing the financial situation and increasing the solvency of banks. As a result, this significantly increased the demand for gold as an excellent liquid asset. Gold has grown stronger and continues to grow stronger to this day, responding positively to many restrictions and features of the economic world.

In order to predict the subsequent actions of bonds, various types of analysis have been developed, such as technical and fundamental analysis. The first type of analysis, being a part of the investment strategies of a vast majority of asset managers of financial institutions, is considered to be reliable enough to extract useful information (Menkhoff, 2010). While technical analysis focuses on various ways of manipulating historical data in order to determine market

trends, for fundamental analysis it is important to know about various macroeconomic performance and stability factors that could affect changes in the rate of a particular trading unit (Murphy, 1999). The high popularity of technical analysis could be statistically justified if it is truly a reliable tool for forecasting.

One of the most frequently asked questions by society is whether it is possible to make a prediction about the future using historical data. This question is approached quite often because a huge number of forecasts, be it a weather forecast or a quarterly cash flow forecast, are based on historical data. The technical analysis approach can be described by citing the example of descriptive and inductive statistics (Murphy, 1999). Thus, descriptive statistics refers to the method of visual presentation of data. An example of this would be a graph. Inductive statistics is responsible for creating patterns and conclusions about the future based on the same data. It turns out that technical analysis is based on trustworthy statistical concepts, and if someone doubted the veracity of this type of analysis, then one would have to doubt all the other forecasting methods.

It is reasonable to deduce here that the forecast for the future can be assessed by projecting data from the past. This concept is well described by Freund & Williams (1966) who argue that the first step in assessing a future business is to study previous experiences.

The ability to analyze the price of gold and extract valuable information from it is significant for many groups. Both for central banks to create the right strategic decisions regarding the management of national reserves and monetary policies (Menkhoff, 2010), and for funds to increase portfolio profitability. It is impossible not to consider ordinary citizens who decide to invest, for whom the ability to analyze will give a clearer picture of where to invest.

Gold is one of the decisive parameters for politicians and economists. The reason is that changes in the price of this metal can indicate various economic changes such as expected inflation. This signals that fluctuations in the price of gold affect not only the dividends of investors but go beyond these limitations. Thus, processing fluctuations in the price of gold can provide valuable information regarding changes in many areas that help make grounded political and economic decisions (Baur & Lucey, 2010).

Indicators such as Simple Moving Average (SMA), Weighted Moving Averages (WMA), and Exponential Moving Average (EMA) are assessed in detail based on a statistical approach for a certain period of time, covering Covid-19 and post-covid time periods. This approach may have weight since the price of gold was more or less stable before the pandemic whereas during lockdowns significant fluctuations in price were noticed. The critical point is the comparison of mean absolute percentage error (MAPE) where the lowest of the three moving averages will determine the one that showed the best performance. If the indicators are below certain numbers, it will be possible to say whether the indicator is sufficiently reliable or not.

Such is the enormous impact of gold on the environment and the widespread popularity of using technical analysis to create predictions for the future created the reason for the existence of this work. This research introduces readers to the main indicators of this method of analysis and evaluates, based on statistical

parameters, how accurate the verdict of this approach can be. The work may be useful to a wide range of people: businessmen, investors, politicians and many others.

Underlying constant changes in the world of finance and various new approaches to technical analysis, this study could add new points regarding the predictive power of classic indicators of technical analysis. Practical information will show the accuracy of these indicators and help you understand how well they performed in vulnerable times.

## 1.2 Aim

This study aims to discover the effectiveness of technical analysis in predicting gold prices using many of its indicators. Among them, Simple Moving Average (SMA), Weighted Moving Averages (WMA) and Exponential Moving Average (EMA) will be used. They ultimately say whether indicators are suitable as reliable tools in forecasting and which of them is the best in this case.

Statistics such as Mean Absolute Deviation (MAD), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error (MAPE) are calculated to determine those criteria fitfulness. These values are measured for each given moving average and the numbers provide information about the average deviation of each average from the actual values (MAD), while MSE will show the average value of errors squared, which can be compared with the variance of the real and expected values, as well as measure errors in the same units that can be compared with standard deviation (RMSE), and the percentage accuracy will be provided by MAPE. Each of these metrics provides valuable information based on different criteria. So MAD shows the average magnitude of errors, MSE and RMSE - how large the deviations from the real price are, and at the same time MAPE is extremely convenient in interpreting data for comparison and evaluation (Hyndman & Anthanasopoulos, 2018). Processing this data will determine which moving average is more efficient and which is respectively more reliable in forecasting.

This whole process tells in the end whether the forecast is accurate enough to make investment decisions and many other aspects discussed above. If such an indicator were identified, it would likely be useful to many people interested in gold and could be used by them to make their forecasts.

In addition, this study covers the period before and after Covid. The reason for this is studying the market during turbulent periods because it was the pandemic that created chaos in the general public, many managed their finances chaotically, which directly affected the financial market. Also, many banks changed their monetary policies and investors changed their strategic plans. This research states whether moving averages have coped with volatile market conditions.

Comparing values and obtaining statistical patterns can bring new knowledge and expand the range of understanding of technical analysis. It is also observed whether the technical analysis contradicts Fama's (1970) Efficient Market Hypothesis (EMH).

## 1.3 Limitations

Despite the fact that this research adheres to specific goals and areas of knowledge, there are limitations that a priori cannot be avoided. Firstly, it is the specific selected time range for analysing historical data. It covers events related to the pandemic. According to Hyndman & Athanasopoulos (2018), they could lead to unique market behaviour which can mean that the data obtained may not always serve as an ideal way to predict prices in the future. Based on geopolitical events, the market, depending on the type of event, may react differently to the event. Therefore, we cannot avoid the possibility that in the future, due to, for example, changes in the political situation somewhere, the market will behave the same way as during a pandemic.

Secondly, this study is focused on a specific set of technical analysis indicators that are SMA, WMA and EMA. In addition to them, there are many other methods applicable in technical analysis. These indicators were chosen due to their widespread popularity. If it turns out that the forecast is highly accurate, then it is impossible to say the same about all other methods applicable to technical analysis (Murphy, 1999). A good example is the Relative Strength Index (RSI), which is based on completely different calculations from moving averages, which means that they would surely react differently to fluctuations in the gold rate. Therefore, the scope of this study cannot evaluate the performance of all technical analysis techniques.

Thirdly, the work proceeds from the fact that the data is error-free and therefore the indicator calculations are correct. Although the data for processing is taken from a reliable source, there is no denying the fact that even the slightest inaccuracies in the data can dramatically distort the actual values. It also does not take into account transaction costs such as the purchase or sale price, which can also distort the actual figures (Bruce & Bruce, 2017). If there were errors in the sample data or limitations were not recognized, this could negatively affect the investment of people who decide to rely on these technical analysis indicators.

Lastly, market participants are considered to behave rationally and their behaviour directly affects changes in price. However, there exists the version that these units behave more often irrationally, which may affect the veracity of the results of technical analysis (Shiller, 2003). Although this idea is accepted by society, behavioural factors cannot be taken into consideration in this work. It turns out that the results obtained must be considered without ignorance of the stated limitations.

## 1.4 Thesis Structure

Section 1 is an introduction to the work and talks about the background of the study, the reasons why technical analysis is used and the high role of gold in the world of finance. In addition, the reasons why this work is being done, the goals that would be desirable to achieve and the limitations that were encountered during the study are described.

Section 2 begins with the Efficient Market Hypothesis, which is supposed to contradict the fundamentals of technical analysis. Counterarguments are given in support of this type of analysis. This then gradually moves on to the basics of technical analysis, and how it differs from another type of analysis (technical analysis). This part also reveals other technical analysis tools.

The next section covers the dependent and independent variables needed to conduct research, explaining where the dataset came from and how it was filtered and sorted so that the necessary equations could be applied. In addition, the statistical metrics that are measured to obtain the results are described.

Section 4 shows all calculations and compares them with each given moving average.

Section 5 provides a conclusion and section 6 contains references to sources on the basis of which many inferences and conclusions were made, as well as facts in the thesis.

# 2 Theoretical Framework

## 2.1 Efficient Market Hypothesis (EMH)

### 2.1.1 Overview of EMH

The Efficient Market Hypothesis (EMH) was identified by Fama and is one of the most influential theories in the world of finance. According to this theory, financial markets directly respond to any incoming information, be it public or private. It turns out that the price of an asset is instantly reflected by any external information (Fama, 1970). While members of financial circulations adhere to investment strategies for profitability, choosing the right time and stocks, policies for proper budget management, etc., this hypothesis denies the regularity of these actions and claims that the market is unpredictable.

The main idea of the Efficient Market Hypothesis is that attempts to beat the market will be futile because any news or known fact is already reflected in the price of the asset. It turns out that neither technical analysis and its methods of manipulating historical data to find patterns, nor fundamental analysis based on financial statements and geopolitical events will bring significant benefits in predicting prices.

It would be essential only in these conditions of an unpredictable market to have the correct balance of risk and reward, in order to realize profit taking into account the potential risk, which is the risk-return tradeoff principle (Fama, 1970). Anything else is not acceptable according to this ideology because a rise or fall in price is almost impossible to foresee. After all, the arguments on which the investor relies are already taken into account in the current price of the commodity. The EMH also considers a version of random price behaviour, which in turn supports the view that subsequent price fluctuations cannot be determined based on historical price information (Fama, 1965).

According to Fama (1970), there are three forms of EMH: weak, semi-strong, and strong. Accordingly, each subsequent form is more radical in relation to

the financial market. While already at the weak form, it is stated that all historical events are already reflected in the security price and therefore the use of technical analysis is contradictory. The subsequent forms cancel the ideology of fundamental analysis and even insider information since the market is already one step ahead. Based on this theoretical knowledge, specific strategies and financial models were developed. Capital Asset Pricing Model (CAPM), for example, considers the efficiency of the market and gives forecasts for possible income and risk.

Under the influence of this hypothesis, certain techniques have emerged that do not try to beat the market but can make a profit from a set of even thousands of indices. A good example of such passive investing is where the core element is not a specific asset, but a large group of them as index funds. Exchange-traded funds (ETFs) are also one of the EMH mechanisms where stocks are traded automatically, which increases the likelihood of profitability by reducing transaction fees (Markiel, 2003). This, of course, increases risks when prices fluctuate greatly because there is no distinct person who monitors the market and, if there are changes in an unfavourable direction, could instantly change the investment path. In this case, ETFs will take a much longer time to proceed.

Thanks to the Efficient Market Hypothesis, not only have new investment methods emerged, but also the integral role of disseminating information among financial market participants has been highlighted. Asset prices are assumed to be reflected immediately as new information becomes available (Fama, 1991). This factor guarantees fewer errors in current prices, which prevents insider manipulation.

This hypothesis, of course, has limitations. At the moment, it is considered barely possible to accurately calculate how quickly received data affects the market value. Shiller (2003) mentioned another limitation that is not likely to have the same interpretation of information by investors. This led to the accumulation of diverse theories around this evidence. The Efficient Market Hypothesis is extremely important for understanding economics. It brought new knowledge and reasons for change to the financial industry. By expressing its specific position on market behaviour, it called into question many types of analysis, especially technical analysis (Fama, 1970). While this hypothesis is not without its limitations and nuances, it is critical to understanding the behaviour of financial markets.

### 2.1.2 Relevance to Financial Markets

The Efficient Market Hypothesis (EMH) fundamentals are used by many participants in the financial environment in their strategic and investment plans. This hypothesis has its principles that call into question methods of predicting prices using historical data as in technical analysis (Fama, 1970). Geopolitical signals and financial statements are also ineffective because the hypothesis notes that prices can change without any patterns, and past events show the current price.

The Efficient Market Hypothesis in stock markets brought doubts about the

applicability of technical analysis. The hypothesis denies the significance of manipulating the historical prices of a product already in its weak form. In other words, what is the point of doing equations for five, ten or 100 past days and trying to get some kind of forecast from it if the next price move in the market will be up or down in a random manner? The hypothesis says that it does not exist. Therefore, the EMH does not suggest that various metrics are more likely to be true and relevant in predicting prices (Markiel, 2003).

Such news in the economy as the quarterly report on US GDP growth, the central bank's report on financial distribution and others are also disputed by those who adhere to the Efficient Market Hypothesis. The above events and geopolitical events cannot indicate the trend of the market because the hypothesis states that the market is extremely efficient and has already adjusted the stock price in advance (Fama, 1970). No investor will be able to take advantage of an emergency news release. According to this assumption, the price on the market has already reacted to the news in advance and the information that is new to society is already part of its own price for a specific asset.

In addition, EMH also influenced the investment decisions of financiers. For those who believe in this prejudice, the method of actively managing stocks became less attractive. Active management means separate investment and monitoring of each specific asset, which leads to high transactional costs and tax fees. This method is applicable if the market is not efficient a priori. People have started to resort to passive ways of investing. The so-called bundles of funds were created as index funds and Exchange-Traded Funds (ETFs) (Markiel, 2003). Investors are not trying to beat the market in this way, but want to make a profit using the efficiency of the market.

The judgment of Fama impacted the assumption of market behaviour. What if those fluctuations in price that are now visible on the charts are a consequence of something that no one yet knows about? What if with a news release where the verdict is obvious that the price should rise, the price, on the contrary, falls or remains unchanged? According to the hypothesis, this news has already been integrated into the price and its appearance in the public will not significantly affect the future price. Those who adhere to the opinion of Fama would behave accordingly and would not make investments in the hope that their actions are well grounded.

What, however, will be the practical side of these prejudices? If everything is so clear in theory, it is definitely debatable whether these patterns will always manifest themselves in a moving market and investors are rational. There is also room for anomalies such as the January effect. It has been noticed that prices in financial markets go up in January more often than in any other month. Such phenomena may, of course, have a further impact on the ability to predict price, which is contrary to the EMH (Jegadeesh & Titman, 1993).

It makes sense to describe another anomaly in the markets. These are bubbles that arise when the price of security goes in one direction for a long time, which does not correspond to its fundamental value (Shiller, 2003). This phenomenon highlights the inefficiency of the market, which is contrary to the EMH. So, if the price of an asset grows rapidly and for a long time, then one day the

bubble will burst. Subsequently, there will be a strong reduction in price and significant financial losses. An excellent example is the Housing Boom of 2008, when real estate prices rose for a long time and then collapsed. This led to a crisis and severe depression.

The Efficient Market Hypothesis assumes that investors are rational and assumes that they will react in a uniform manner. In reality, all investors are individuals and are driven by their own ideas, beliefs and strategies. If such cases occur, then the inefficiency of the stock market may appear. Experienced analysts will be able to recognize this and use the information to their advantage (Lo & MacKinlay, 1999).

Institutional units such as Hedge funds, Mutual funds and others also question the EMH. They have great buying power and in the event of a large transaction, a price change might be noticed. For example, a large investor may sell a large portion of his assets, which will affect the downfall of the asset before it returns to its intended position (Grossman & Stiglitz, 1980).

This hypothesis has a noticeable impact on the financial markets, challenging technical analysis and other methods of analysis. It does not deny passive investment methods and has a distinct theoretical background. In practice, however, some limitations lead it into question.

### 2.1.3 Arguments Against EMH in Favor of Technical Analysis

EMH challenges the approach of many data analytics methods, including technical data. However, there are many resources and confirmed cases where this method has shown reasonable and time-tested predictions, refuting the basic ideas of Fama's biases. This section analyzes in detail the arguments in defense of technical analysis and demonstrates the effectiveness of this approach. The following arguments supporting the methodology of technical analysis will be considered in turn:

- Behavioral Finance and Market Psychology
- Market Anomalies
- Empirical Evidence
- Testing Methodologies
- Case Studies and Real-world Examples

As described above about asset bubbles (Shiller, 2003), they are a consequence of unexpected price increases. One day, the bubble bursts and this gives technical analysts a good pattern. Given that this pattern has repeated itself more than once in history, and each time it was possible to see an identical response of financial markets to these bubbles, technicians can study this phenomenon in detail and probably successfully predict the next burst of a financial bubble. Both the existence of such bubbles and the irrational behaviour

of investors are psychological and behavioural factors of financial market participants.

Anomalies in the market can also provide valuable information to those who use historical data to predict prices. In addition to the January Effect, the Weekend Effect/the Monday Effect is also a good example. This effect contradicts the fundamentals of EMH and represents a repetition of volatility in the market within one week. While a lot of market activity is seen towards the end of the week, the market is relatively stable on Monday and there are very few strong deviations from the market opening price by the end of the day (French, 1980). Gibbon & Hess (1981) theorize that this is due to investors' expectation of financial news over the weekend, which can lead to large deviations of the closing price from the opening price. To avoid this, those investors who aim for short-term deposits close their positions. As a result, weakly pronounced changes in the market on Monday. Thus, traders can, for example, use these anomalies, coordinating on which days, days of the week, they could monitor the market more and more closely to find the most profitable position.

Another rationale against EMH is empirical evidence. Strong and sharp jumps in price contribute to a further increase in price. It works in inverse proportion with strong and drastic downfalls in price. This phenomenon is an example of Momentum trading. Financial markets have often encountered such cases, which provide the basis for analysis and the creation of useful patterns (Murphy, 1999).

There are also some moments when technical analysis does not try to oppose the basics of the Fama ideology, but on the contrary, corresponds to them. In the inventory of technical analysis indicators, there are various tools that are applicable in efficient market conditions. One of them is the stop-loss option in trading to control risks. Here it could be set the proportion of winnings to the risk in advance could be used as a successful strategy not to outperform the market, but to be consistently profitable. Often, traders resort to a 9:1 ratio, which means that nine losses can pay off with one big win. If the market is efficient and it is impossible to guess the price movement, then this tool could be crucial. In addition, it might be applicable to the relative strength index (RSI). This indicator monitors the volume of buys and sells in the market, which can provide information about the right time to buy or sell an asset such as gold for instance. With regard to the criticism of EHM methodologies in favour of technical analysis, Lo & MacKinlay (1999) criticize the Fama hypothesis for its narrow spectrum of factors considered in the tests. These methodologies do not consider the asymmetry of information in the market, and transactional costs, which in turn takes place in technical analysis. This gives a benefit in this context to the analysis of historical data. It examines fluctuations in the market in more detail and can give more significant figures in the calculations.

In defence of technical analysis, stories and case studies from the implementation of this method of predicting prices on asset markets are given. First of all, it should be noted the contribution of Paul Tudor Jones. Using various patterns of technical analysis and historical data in his calculations, he was able to anticipate the crash of the stock market back in 1987. Tudor Jones realized

large profits due to this and made a name. This gave rise to a greater focus on technical analysis, not only for forecasting but also as a measure for predicting potential market recessions (Schwager, 1989).

A part of the hedge fund Renaissance Technologies, founded by Jim Simons, which is Medallion Fund, has long made depositors much richer. This fund included in its portfolio those stocks that were considered profitable based on the calculations of historical data and the construction of charts based on it. This fund has actually demonstrated the inefficiency of financial markets, as it managed to beat the market at that time (Zuckerman, 2019).

There are many examples of individuals who managed to make a profit using technical analysis indicators. Linda Raschke concluded the buying and selling of derivatives using numerous chart patterns, building trendlines and so on (Schwager, 1993). So, in 1993, she had a return of 216% of her investment.

Finally, it is essential to mention that EMH contributes well-defined ideas to understand how the market behaves. It has its own philosophy and comes from its beliefs regarding the financial market. However, there are many arguments that defend technical analysis. There are a huge number of cases when strategies based on this analysis were successful, and investors, politicians and many others were able to take something from historical prices for their field of activity. To understand what technical analysis is, the next chapter tells about it in more detail.

## 2.2 Technical Analysis

### 2.2.1 Historical Development of Technical Analysis

Through the creation of Dow Theory by Charles, who at the time co-founded Dow Jones & Company and the Wall Street Journal, one can clearly see the development of technical analysis from the late nineteenth century onwards. Largely due to his observations of price movements in the market, he was able to lay the foundations of the current technical analysis. In his articles, he argued that by analysing stock market movements, it is possible to predict and identify future trends (Murphy, 1999). The definitions of primary, secondary, and minor markets, which are key in technical analysis today, were introduced by Mr. Dow in his writings.

In 1930, developed by Ralph Nelson Elliott, Elliott's theory broadly expanded the field. According to him, market prices unfold in repeating patterns, following what he called "waves". Investors oscillate between pessimism and optimism and create these waves through their collective psychology. The foundations of cyclical markets and predictions of future price movements were encapsulated in Ralph Elliott's work on wave patterns. His theory became an incredibly important part of technical analysis and is still widely used by traders to identify market trends and reversals (Frost & Prechter, 2005).

Such an influential figure as W.D. Gann also contributed to the development of technical analysis by developing a unique approach to market forecasting in the early 20th century. Gann's analyses are based on geometric angles, time

cycles, and price levels. By using mathematical and geometric principles, he argued, patterns of market price movements could be explicitly identified (Murphy, 1999). Gann argued that it is important to choose the right time to make trading decisions, which can be helped by methods such as Gann angles and the Square of Nine, which are still widely used by technical analysts today.

Thanks to advanced technology and statistical methods, the 20th century saw a great leap in the development of technical analysis. The emergence of quantitative methods and algorithmic trading made it possible to cope with the analysis of a large mass of data and the automation of trading strategies. An important figure of this time was John Bollinger, who created the Bollinger Bands in the 80s of the last century (Bollinger, 2002). Bollinger Bands have become one of the most important tools for technical analysts.

The beginning of the 20th century brought us another outstanding trader, Richard D. Wyckoff, who had a great influence on the development of technical analysis. His theory consisted of working on the principles of supply and demand in the market and understanding its behaviour based on these principles. The Wyckoff Price Cycle and the Wyckoff Method help to analyse the accumulation and distribution phases of market cycles, identifying trends and reversals in the stock market (Wyckoff, 1931).

The contribution of these great personalities is extremely great and highly valued in the realities of the modern world of finance. Their work created the basis for the creation of such a popular approach as technical analysis, which is used and expands its horizons to this day. This theoretical knowledge has broadened the horizons of investors, politicians, and many others. Subsequently, technical analysis became a separate branch of price forecasting.

### 2.2.2 Description of Technical Analysis

A key aspect of this analysis is to identify patterns and trends in prices that are constructed and based on the repetition of past price behaviours. Using these prices can provide valuable insights into future price changes.

In the philosophy of analysis based on the use of historical price information, there is a hypothesis that trends tend to continue further. This argument is reflected in the Dow Theory that price moves in the expected direction (Murphy, 1999). Studying these trends can increase the likelihood of correctly predicting price behaviour. Price is more inclined to follow the trend than to resist it. Therefore, trend techniques are often used to figure out a trend in its appearing stage.

Another principle of analysis is that the price already contains all the different information. That is, private, public and even insider information is already contained in the price. This suggests that it is working with prices that can give a correct forecast of the price. The principle suggests that the financial market is always correct in determining the price, and the price reflects the actions of each participant in the trade (Murphy, 1999). A change in price is directly proportional to an increase in demand or an increase in supply. So, if demand exceeds supply, then the price of causing a bullish market will rise.

And vice versa if the number of sales exceeds the buying power, the drop in the price would follow causing in this case a bearish market. Chartists do not pay attention to the reason why the price changes. Their task is to correctly interpret the charts and catch the price wave. They do not try to find arguments in price behaviour but look for the necessary pattern that characterizes subsequent changes in price.

Another fundamental argument is the repetition of history. So, for example, if the price of one asset reacted in different periods to the same phenomenon, then there is room for patterns. If such a situation repeats in the future, then using a pattern from the past, you can predict the further direction of the price.

Technical analysis can also anticipate various economic changes. For example, it has been observed that the trend of a commodity has a mediocre effect on the direction of the inflation rate. A commodity price going up signals a stable economy and probable higher inflation danger. Graphs of commodities such as gold, for example, can determine the SWOT criteria of an economy and inflation rates (Murphy, 1999).

### 2.2.3 Technical vs. Fundamental Forecasting

Technical and fundamental analysis are two different ways to anticipate subsequent prices in asset markets. Each of them has its principles, approaches, and decisive variables. The ability to distinguish and correctly apply a certain type of analysis is very important to all those participants of the financial market who are trying to get some benefit through prediction operations.

From the point of view of fundamental analysis, any macroeconomic and geopolitical factors are important. This includes the assessment of the financial income of various companies and their quarterly and annual reports for forecasting and further prospects. Aspects such as the GDP of different countries, the level of inflation and unemployment, the strategic objectives of central banks and their allocation of financial assets, and much more are also taken into account (Graham & Dodd, 2009). All this is done to find patterns that, according to fundamentalists, can lead to certain changes in commodity prices.

While technical analysis is a priority for those trying to capitalize on historical price analysis in the short term, fundamental analysis is more suitable for long-term investments and long-term price expectations. Thus, technical analysis mechanisms are often used by those who focus on buying and selling an asset within a short period of time (Murphy, 1999). This type of analysis is suitable for those who are looking for a short-term entry position. Fundamental analysis, on the other hand, is beneficial for those who seek stability and long-term portfolio management (Graham & Dodd, 2009).

Another difference is the way the data is examined. On the one hand, technical analysis looks at asset prices to identify patterns, create trend lines, or adjust an indicator. Other factors are not important for this method, because the price already stores all the necessary information (Murphy, 1999). On the other hand, the fundamental analysis method looks at world events of both macro and microeconomic scales to identify assumptions about price movement

(Penman, 2012). Here the importance of assessing the true price of the equity is noted. If the current price does not match the estimated value, this might be an appropriate occasion for an entry position.

Although the techniques of technical analysis are quite clear in the application, and in the literature, they are described point by point in order to correctly apply them and find the appropriate signal for action, they do not always lead to the results that the investor expected (Murphy, 1999). The method of fundamental analysis is much more complex and time-consuming in the assimilation of data and the creation of the prediction. However, resorting to this method, might provide more suggestive facts about the future of the asset.

Both of these analysis practices are crucial in the world of finance, and they can provide investors and those who use data in the other direction with important insights. They are categorically different in their approach, which does not deny the possibility of using these two methods of analytics at the same time.

### 2.2.4 Diversification of Technical Analysis Indicators

Technical analysis covers an innumerable number of possibilities to use historical price data in the calculation. On this basis, a huge number of different indicators were developed. Indicators can be divided into several subtypes, depending on the main characteristic on which they rely. There are mathematical equations for designing trend lines, momentum, and other key elements of this analysis. The use of indicators in practice can allow an investor to gain an advantage in building expectations for the price and increase the accuracy of this prediction.

One of the most common types of indicators are trend line indicators. They try to estimate the price of the stock by computing the direction of the price; it may refer to a breakdown in price movement where an uptrend switches to a decline in price. So basically, a trend can be upwards, downwards, or sideways. SMA, WMA, and EMA, which are part of the statistical research provided in this work, are good examples of trend indicators (Murphy, 1999).

Information on the rate of price change and the strength with which it changes is provided by momentum measures. The Relative Strength Index (RSI) is one of the indicators of this type. It looks at the behaviour of prices in the near past in order to assess the conditions under which a certain asset is overbought or oversold (Wilder, 1978). If it turns out that the asset is oversold, then the investor will wait for the right moment when the chart begins to reverse. This would be a signal that the price is likely to go up quickly and to a high degree.

Volatility indicators, in turn, give the person who uses technical analysis in forecasting information about the stability of the market at the moment. The most common such indicator is Bollinger Bands (Bollinger, 2002). In this case, the level of turbulence of the magnitude of (SMA + standard deviation; SMA - standard deviation). Visually, it is noticeable a corridor within the boundaries of which the price of the asset will most likely vary in the near future.

In addition, there are trading volume indicators. It can be an On-Balance

Volume (OBV) indicator, which assesses the amplitude of stock trades in the financial market. If the indicators are high, then active price movement is expected and can help to identify the beginning of a new trend (Granville, 1963).

Oscillators use a variety of volatility, trend lines, and momentum metrics in prices. It is a kind of modified collection of different indicators of other kinds, the short purpose is to give a signal that the price will go up or down. MACD, for example, computes 12- and 26-period EMA and the devil of graphics (Murphy, 1999). If these lines cross each other (at an acute angle ideally), the price might break down and a reverse direction of price movement could begin.

In practice, it is observed that investors most often use several price forecasting metrics at the same time. It can be a collaboration of momentum and trend-following indicators. While the second will indicate the existence of a trend, the first will tell you if a rapid change in price is expected. If, for example, there is no rapid price action expected, even though a trend is detected that would not be confident that the price follows the trend immediately (Murphy, 1999).

Technical analysis indicators can project an interest in asset prices in a huge variation of the question regarding, starting with the volatility of the market and finishing with providing an entry position. Simultaneous manipulation of diversified indicators to create a better, more substantiated, and probably more accurate forecast is not excluded. In addition, one type of indicator can indicate the relevance of the assumption of another indicator. Proper use and combination of indicators will give investors important information about the current situation in the financial markets if there are any changes to expect or within which magnitude does the price fluctuate at the moment.

### 2.2.5 Moving Averages

Moving averages are one of the most widely used technical analysis techniques. They calculate average prices in various ways, which gives a slightly better understanding of the direction of price ranges. In this section, three types of moving averages are presented: SMA, WMA, and EMA. Subsections describe how averages are calculated and what their strengths and weaknesses are.

**SMA** This indicator is the simplest type of computing an average. Simply put, to determine the price of a certain day in this work, the price data of the past 40 days is taken and their sum is divided by 40. The formula of SMA is:

$$\mathrm{SMA}_n = \frac{1}{n} \sum_{i=0}^{n-1} P_{t-i}$$

where:

- $\mathrm{SMA}_n$ is the Simple Moving Average over $n$ periods.
- $n$ is the number of periods over which the average is calculated.

- $P_{t-i}$ is the price of the asset at time $t - i$, where $t$ is the current time period and $i$ ranges from 0 to $n - 1$.

On the one hand, this method is simple and easy to calculate, since there is no need to determine additional parameters. On the other hand, this method responds worse to recent massive changes in prices. The reason for this is the equal weight of all 40 days in the forecasting of the price of a specific day (Murphy, 1999).

Ignoring these limitations, many people use this technique in forecasting. SMAs of different time ranges can be used to find points of intersection. This is the case with the MACD oscillator, which will be discussed in more detail later in the text.

**WMA** The WMA prioritizes days in expected price calculations, giving more emphasis on recent changes in price by weighting the impact days increasingly from the farthest day of the observed period. The formula of WMA is given as:

$$\mathrm{WMA}_n = \frac{\sum_{i=0}^{n-1} w_i P_{t-i}}{\sum_{i=0}^{n-1} w_i}$$

where:

- $\mathrm{WMA}_n$ is the Weighted Moving Average over $n$ periods.
- $n$ is the number of periods over which the average is calculated.
- $P_{t-i}$ is the price of the asset at time $t - i$, where $t$ is the current time period and $i$ ranges from 0 to $n - 1$.
- $w_i$ is the weight assigned to the price $P_{t-i}$, often $w_i = n - i$ so that more recent prices have higher weights.

WMA may be better able to respond to emerging trends. However, these signals may be more often false, especially in conditions of instability in the financial market (Murphy, 1999). Errors in the calculation of parameters are also more likely since a certain weight is assigned for each day.

**EMA** The EMA, using data from the previous 40 days in this work, gives great importance to the previous day. The formula of EMA is as follows:

$$\mathrm{EMA}_t = P_t \cdot \frac{2}{n+1} + \mathrm{EMA}_{t-1} \cdot \left(1 - \frac{2}{n+1}\right)$$

where:

- $\mathrm{EMA}_t$ is the Exponential Moving Average at time $t$.
- $P_t$ is the price of the asset at time $t$.
- $n$ is the number of periods over which the average is calculated.

- $\text{EMA}_{t-1}$ is the Exponential Moving Average at the previous time period $t-1$.

where $P_t$ is the price today, $\text{EMA}_y$ is the EMA of the previous day, and $n$ is the number of days.

The EMA's reactivity makes it the preferred choice for many traders, especially in the choppy playfield. It helps to recognize trends faster than SMA or WMA. The EMA is often used in conjunction with other indicators to embody trading signals (Murphy, 1999). One of the significant advantages of the EMA is the ability to minimize interference, allowing you to finely monitor market movements. However, EMAs in volatile markets tend to give false readings.

In conclusion, I would like to note that moving averages, which have their own strengths and areas of application, are the most important tools in technical analysis. The SMA depicts average prices in a simple and straightforward way, while the WMA and EMA provide a more advanced and detailed price analysis. Owning and applying a variety of tools can help investors follow market trends and make more balanced decisions.

# 3 Research Methods

## 3.1 Research Variables

The objective of this work is to contribute to quantitative research by measuring statistical components in terms of determining performance and best performance out of chosen indicators. Simple Moving Average (SMA), Weighted Moving Average (WMA), and Exponential Moving Average (EMA) are those indicators whose predicting power of gold price and accuracy are calculated. The results would be driven by the determination of Mean Absolute Deviation (MAD), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error (MAPE).

Based on the fact that this research must test hypotheses using numerical measurements, it must necessarily contain variables. They are the origin of all calculations and results. The variables of this work are:

- Dependent variables:
  - The actual gold price
- Independent variables:
  - SMA
  - WMA
  - EMA

There is a distinction between dependent and independent variables because they serve different purposes. The dependent variable is the value that the analyst is trying to forecast, and the independent variables are those that are used

to predict, in this context, the real gold price. That is, independent variables are given to observe how the dependent variable is affected (John W. Creswell, 2014).

Depending on the method of study, different variable parameters can be used. It can be the gender of a person, his age, the colour of the object, and so on. This information does not exclude the possibility of using and the logic of using other methodologies for studying and manipulating a large number of dependent variables. For this resource, the method of quantitative research was appropriately chosen, so the variables are only numerically presented.

## 3.2 Data Collection and Analysis

In order to be able to conduct quantitative analysis, first of all, it is necessary to find a reliable resource that stores reliable documentation about the price of gold. This source turned out to be the World Gold Council (`https://www.gold.org`). This resource has gold prices in its database from December 30, 1978, to the present day. The file was downloaded in xlsx format.

All work with the dates and numbers provided by this file is done in the latest version of Microsoft Office Excel. Many operations were carried out related to the preparation of data for analysis.

First of all, it was determined that the daily closing prices would be used for the calculation. This research focuses on a specific time range from May 31, 2018, to May 28, 2021. Therefore, the data was filtered using Excel mechanisms. This specific timeframe is selected because it occupies a vulnerable period for financial markets caused by the COVID-19 pandemic. This condition was a new challenge for the world and, as Hyndman & Anthanasopoulos (2018) mentioned, a deep understanding of the causes of this pandemic could bring new insights into market behaviour.

In the sheet, only columns containing date and price were left; all other columns were deleted from the file. Moreover, for a better visual assumption of the numeric data, the date formatting was changed from DD.MM.YY to YYYY-MM-DD. This might be beneficial for reading graphs constructed by filtered materials.

The dataset was checked for the existence of unrealistic outliers and N/A cells that might lead to mistakes by running formulas of moving averages or even give numbers not corresponding to reality. Fortunately, none of them were detected. Finally, the dataset was ready for the first analytical actions. That ready-to-use set of data was copied and inserted into 3 different worksheets to avoid the handling of parameters dedicated to another moving average.

Calculations for each of all 3 moving averages correspond to a 40-day time period. That is, in order to calculate the price forecast for a specific day, the 40 previous days were used in the equation.

The next step is to apply moving averages equations. To calculate the SMA, it was not necessary to calculate additional parameters, while for the EMA, a smoothing parameter was calculated by dividing 2 by the sum of 40 (40-day period) and 1, which is equal to 0.048780488. Furthermore, it was important to

weight the impact of the previous 40 days for WMA increasingly, which means that the last few days are more crucial for defining a forecasted price than those that were way before (see Table 3)). Actually, weightings say that the closest day impacts the forecasted price 20 times greater than the farthest day.

## 3.3 Statistical Approach

To estimate moving averages, it is important to rely on distinct methods that could be empirical research, for example, which basically within a variety of interviews and questionnaires might test several hypotheses. In this case, it is essential to differentiate if the hypothesis occupies the whole population or just a sample of the crowd. Insofar as technical analysis in predicting gold price directly depends on the historical price of the asset, the statistical approach is a methodology applied in this research. As in empirical research, statistical metrics of this study discover potentially new insights within an in-sample containing 782 elements. However, there is no forecast for the first 40 elements of the sample data. Therefore, to calculate the mean of MAD and MSE, 742 units of data are taken into consideration. This subsection will introduce the formulas maintained by this type of approach.

Mean Absolute Deviation (MAD) is calculated by subtracting the modulus of actual values from the forecasted value and dividing by the number of elements of the sample. The formula is:

$$\text{MAD} = \frac{1}{n} \sum_{i=1}^{n} |A_i - F_i|$$

where:

- $n$ is the number of observations.
- $A_i$ is the actual value at time $i$.
- $F_i$ is the forecasted value at time $i$.

MAD is widely used in the finance area to define the accuracy of any numeric metric. It presents an average magnitude of errors in the observed dataset and also is easy to interpret (Hyndman & Athanasopoulos, 2018).

Mean Squared Error (MSE) squares errors between actual and predicted prices and takes an average of it. The formula is:

$$\text{MSE} = \frac{1}{n} \sum_{i=1}^{n} (A_i - F_i)^2$$

MSE is useful in terms of detecting numerous large errors that a forecasting might cause and comparing statistical metrics used (Hyndman & Athanasopoulos, 2018).

Root Mean Squared Error (RMSE) is the square root of the MSE:

$$\text{RMSE} = \sqrt{\text{MSE}}$$

This statistical evaluation shows an approximate magnitude of errors emphasizing huge errors (Hyndman & Athanasopoulos, 2018).

Mean Absolute Percentage Error (MAPE) calculates an accuracy percentage by dividing the differences between actual prices and forecasted prices by actual prices, dividing the modulus of it by 742 and multiplying by 100. The formula is given as:

$$\text{MAPE} = \frac{100}{n} \sum_{i=1}^{n} \left| \frac{A_i - F_i}{A_i} \right|$$

A moving average with MAPE lower than 5% is estimated to be a good measure for the prediction of gold price.

All given metrics will provide informative conceptions about moving averages. These metrics tell how well the given technical indicators performed during COVID-19 and a year before it. New knowledge might flow to the accumulated understanding of financial markets and potentially might encourage skeptics to experience technical analysis tools if the results received highlight an ability of historical data manipulation to outperform the market.

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# 4 Results

## 4.1 Empirical Findings

In order to make it clearer and to have something to start from, the main indicators of the real gold price (Table 1) were calculated in the calculations. It turned out that the average value of real gold prices is $1541.99. It can also be noted here that the difference between the highest and lowest values of gold prices is $888.75, which indicates quite strong fluctuations in gold prices over 3 years. Taking into account that the dataset considers events related to COVID-19, such a magnitude could be expected. The variance could be mapped to the Mean Squared Error of each moving average.

The final calculations of the SMA are provided in Figure 1:

| DATE | PRICE | SMA | Error | Absolute Value of Error | Square of Error | Absolute Values of Errors Divided by Actual Values |
|---|---|---|---|---|---|---|
| T | P | F | A-F | \|A-F\| | \|A-F\|^2 | \|(A-F)/A\| |
| **TOTALS** | | | **11.961,44** | **29585,11** | **2.062.671,74** | **18,44949604** |
| /742 | | | MAD | MSE | RMSE | MAPE |
| | | | 39,87 | 2.779,88 | 52,72 | 2,49 |

Figure 1: Final calculations of the SMA

The WMA showed the following figures (Figure 2):

| DATE | PRICE | WMA | Error | Absolute Value of Error | Square of Error | Absolute Values of Errors Divided by Actual Values |
|---|---|---|---|---|---|---|
| T | P | F | A-F | \|A-F\| | \|A-F\|^2 | \|(A-F)/A\| |
| **TOTALS** | | | **8.490,40** | **22.720,63** | **1.287.640,37** | **14,15** |
| /742 | | | MAD | MSE | RMSE | MAPE |
| | | | 30,62 | 1.735,36 | 41,66 | 1,91 |

Figure 2: WMA calculations

EMA indicators are shown in Figure 3: Already at this stage, without ap-

| DATE | PRICE | SMA | Error | Absolute Value of Error | Square of Error | Absolute Values of Errors Divided by Actual Values |
|---|---|---|---|---|---|---|
| T | P | F | A-F | \|A-F\| | \|A-F\|^2 | \|(A-F)/A\| |
| **TOTALS** | | | **10.850,63** | **25.055,57** | **1.476.909,75** | **15,69** |
| /742 | | | MAD | MSE | RMSE | MAPE |
| | | | 33,77 | 1.990,44 | 44,61 | 2,11 |

Figure 3: EMA indicators

proaching the comparison of moving averages, you can find such a pattern that the MAPE of all three indicators is below 5%. According to Hyndman & Athanasopoulos (2018), this means that each of these matters in predicting gold prices, and they are accurate enough to be trustworthy. In financial markets, those indicators that show a MAPE lower than a given percentage can be assumed as valuable tools for being a part of investment strategy setting mechanisms. This says that even during vulnerable times in the economic area moving averages were quite distinct in prediction. It leads to another argument in favour of technical analysis as it is a proper way of forecasting stock values.

| Statistic | Value |
|---|---|
| Mean | $1,541.99 |
| Variance | $63,125.72 |
| Max | $2,067.15 |
| Min | $1,178.40 |
| Difference (Max - Min) | $888.75 |

Table 1: Main indicators of real gold price

## 4.2 Comparison

The results of the data above have been conveniently packed into a single table so that the values can be compared to each other (Table 2). The MAD of all three moving averages is different. The highest MAD is granted by the SMA at 39.87 and successively followed by the EMA at 33.77 and the WMA at 30.62. The lowest indicator was shown by the WMA, which means that it was on average smaller than other indicators and differed from the real values.

The SMA has the highest MSE at 2779.88, followed by the EMA and WMA with 1990.44 and 1735.36 respectively. Therefore, it can be argued that WMA

had the least amount of massive outliers in the observed diapason from May 31, 2018, to May 28, 2021.

As for the RMSE, it is logical that the positioning of all three indicators will remain the same since the position of the positive values and their square roots will be directly proportional. You can consider this pattern in detail in Table 5. The bottom line here is that WMA has fewer errors with an emphasis on huge outliers.

MAPE of SMA, WMA, and EMA are calculated with 2.49%, 1.91%, and 2.11% accordingly. Although SMA generates the highest average absolute percentage error, this does not say that SMA is not accurate in prediction enough. A percentage lower than 5% is considered an accuracy of moving average as high enough to create reasonable predictions of gold price (Hyndman & Anthanasopoulos, 2018).

In all four computed statistical metrics, the lowest figures display WMA. EMA presents a lower number in all four criteria in comparison to SMA. Therefore it can be said that EMA has an absolute dominance over SMA. The same context applies to WMA and EMA. WMA's MSE, MAD, RMSE, and MAPE are lower than those of EMA which reflects the stand that WMA absolutely dominates over EMA. Since WMA dominates EMA and EMA dominates SMA this derives that WMA has an absolute dominance over SMA. The position of WMA delivers that this moving average is more accurate, and reliable, has fewer and smaller mistakes in prediction, and has a stronger forecasting power than the other two averages within the in-sample.

Table 2: Comparison of Moving Averages

| | MAD | MSE | RMSE | MAPE |
|---|---|---|---|---|
| SMA | 39.87 | 2779.88 | 52.72 | 2.49% |
| EMA | 33.77 | 1990.44 | 44.61 | 2.11% |
| WMA | 30.62 | 1735.36 | 41.66 | 1.91% |

| **WMA** | **820,00** |
|---|---|
| 1,00 | 0,0012 |
| 2,00 | 0,0024 |
| 3,00 | 0,0037 |
| 4,00 | 0,0049 |
| 5,00 | 0,0061 |
| 6,00 | 0,0073 |
| 7,00 | 0,0085 |
| 8,00 | 0,0098 |
| 9,00 | 0,0110 |
| 10,00 | 0,0122 |
| 11,00 | 0,0134 |
| 12,00 | 0,0146 |
| 13,00 | 0,0159 |
| 14,00 | 0,0171 |
| 15,00 | 0,0183 |
| 16,00 | 0,0195 |
| 17,00 | 0,0207 |
| 18,00 | 0,0220 |
| 19,00 | 0,0232 |
| 20,00 | 0,0244 |
| 21,00 | 0,0256 |
| 22,00 | 0,0268 |
| 23,00 | 0,0280 |
| 24,00 | 0,0293 |
| 25,00 | 0,0305 |
| 26,00 | 0,0317 |
| 27,00 | 0,0329 |
| 28,00 | 0,0341 |
| 29,00 | 0,0354 |
| 30,00 | 0,0366 |
| 31,00 | 0,0378 |
| 32,00 | 0,0390 |
| 33,00 | 0,0402 |
| 34,00 | 0,0415 |
| 35,00 | 0,0427 |
| 36,00 | 0,0439 |
| 37,00 | 0,0451 |
| 38,00 | 0,0463 |
| 39,00 | 0,0476 |
| 40,00 | 0,0488 |

Table 3: Weighted Moving Average (WMA) Values

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