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INFLATION AND THE PRICE CHANGES OF SELECTED GOLD FUTURES DURING THE COVID-19 PANDEMIC AND THE WAR IN UKRAINE, 2020–2023

INFLACJA A ZMIANY CEN WYBRANYCH KONTRAKTÓW FUTURES NA ZŁOTO W WARUNKACH PANDEMII I WOJNY W UKRAINIE (2020–2023)

The study's main objective is to determine the relationship between the level of inflation and changes in the prices of selected gold futures contracts during the health crisis and war in 2020–2023. The study hypothesizes that there is a strong linear correlation between rising inflation levels and increases in gold price levels. Quantitative research used dynamic analysis and multiple linear regression analysis to determine the direction of changes in selected inflation indicators and the prices of selected gold futures, as well as to evaluate the impact of inflation on these prices. The study found that inflation showed a strong upward trend in Poland, the Eurozone, Switzerland, and the US. The highest levels of inflation, as measured by the Consumer Price Index (CPI), between 2020 and 2023 were recorded in the USA and Poland, while in the Eurozone and Switzerland, CPI levels were much lower. The article shows that inflation growth is not only due to changes in food and energy prices but also to increases in the prices of other goods and services, as indicated by the rising levels of core inflation in the countries studied. Despite rising inflation, the prices of gold futures remained relatively stable, with the exception of Gold PLN Futures, which saw prices increase. The study demonstrates that inflation affects the prices of selected gold futures, but also that the impact of inflation on their prices is heterogeneous, varying both in terms of the direction and strength of the impact.

Keywords: inflation; gold futures derivatives; financial instruments; alternative investment; uncertainty
JEL: G12, G13, G15

Głównym celem badania jest określenie związku między poziomem inflacji a zmianą cen wybranych kontraktów terminowych na złoto w obliczu kryzysu zdrowotnego i militarnego w latach 2020–2023. W badaniu postawiono następującą hipotezę: istnieje silna liniowa korelacja pomię-

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dzy rosnącym poziomem inflacji a rosnącymi poziomami cen złota. W celu wyjaśnienia charakteru i zastosowania kontraktów terminowych na złoto wykorzystano krytyczną analizę literatury. W badaniach ilościowych wykorzystano analizę dynamiczną i analizę regresji liniowej do określenia kierunku zmian wybranych wskaźników inflacji oraz kierunku zmian cen wybranych kontraktów terminowych na złoto, a także wskazania wpływu inflacji na te ceny. Z badania wynika, że inflacja wykazuje silną tendencję wzrostową w Polsce, strefie euro, Szwajcarii i USA. Najwyższy poziom inflacji mierzony wskaźnikiem Consumer Price Index (CPI) w latach 2020–2023 odnotowano w USA i Polsce, natomiast w strefie euro i Szwajcarii wskaźnik CPI kształtował się na znacznie niższym poziomie. Wyniki badania wykazały, że na wzrost inflacji wpływają nie tylko zmiany cen żywności i energii, lecz także wzrost cen innych towarów i usług, na co wskazuje rosnący poziom inflacji bazowej w badanych krajach. Pomimo rosnącej inflacji ceny kontraktów terminowych na złoto pozostały w miarę stabilne, z wyłączeniem kontraktów terminowych na złoto na złotówkę, których cena wzrosła. Z badania wynika także, że inflacja wpływa na ceny wybranych kontraktów terminowych na złoto, jednak wpływ inflacji na ich ceny jest niejednorodny zarówno pod względem kierunku, jak i siły oddziaływania.

Słowa kluczowe: inflacja; kontrakty terminowe na złoto; instrumenty finansowe; inwestycje alternatywne; niepewność
JEL: G12, G13, G15

I. INTRODUCTION

Gold is recognized as the world's currency in the global economy and should therefore be the foundation of investment. While its value is influenced by its monetary, financial, and commodity functions, it is widely regarded as risk-free asset and a timeless safe haven. Gold is an indicator of wealth and affluence, while at the same time it is seen as a hedge against inflation and declining purchasing power (Borowski, 2016).

Investment in gold can take a direct form and an indirect form. Direct investment in gold involves the physical purchase of gold, in which the investor has several options, including investing in the spot market, in collector/investment bars, in bullion coins, in medals minted from gold primarily for government or government organizations, and through gold certificates offered by financial institutions or private intermediaries (Czech & Puszer, 2021). Direct investment can also include so-called gold accounts, which can take the form of allocated and unallocated accounts (Wang 2012). In addition to direct investment, there are currently many opportunities for indirect investment in gold. The most important forms include: forward contracts, which are divided into forward contracts with delivery (so-called real contracts) and cash-settled forward contracts (so-called unfunded contracts; Krężołek, 2020), futures contracts, options, contracts for difference (CFDs), investment in shares of gold mining companies, structured products related to the gold market, and units/certificates of investment funds operating on the gold market, where a distinction is made between index funds and exchange traded funds (ETFs). Cai et al. (2008) point out that by using gold-based instruments, producers in the commodity market improve their financial stability by neutralizing negative

price movements in the real market. This article takes as its research object the examination and evaluation of the price level of selected gold futures under inflationary conditions during the health emergency and military crisis in 2020–2024.

There are both theoretical and practical reasons for tackling such a research subject. The current state of knowledge regarding the situation on the global gold futures market under conditions of uncertainty is incomplete. The issue of the impact of such factors as inflation, war, and pandemics on the gold market is important not only from a theoretical point of view, but also for economic practice. Meanwhile, the results of this research make it possible to conclude that uncertainty, such as that caused by inflation, determines the situation on the gold futures market. This state of affairs prompted the study of the relationship between the level of inflation and the price level of gold futures.

Consequently, the primary objective of the study is to determine the relationship between the level of inflation and the change in the prices of selected gold futures contracts under the health emergency and military crisis in 2020–2023. The achievement of the stated objective is contingent on:

– examining the level and dynamics of changes in inflation in selected countries (Poland, Eurozone, Switzerland and the USA),

– examining the level and dynamics of changes in the prices of selected financial instruments (Gold PLN Futures, Gold EUR Futures, Gold CHF Futures, Gold COMEX Futures),

– examining the interdependence between changes in prices of gold futures and selected inflation indices.

The main objective of the study is implemented through two complementary goals: theoretical-cognitive and application-oriented. The theoretical-cognitive goal focuses on presenting existing knowledge, which requires identifying key factors influencing the gold futures market under conditions of uncertainty. The application-oriented objective involves deriving conclusions and practical recommendations from the research. These are intended to guide various stakeholders, including investors, institutional actors, economic practitioners and students of various fields of study, in understanding and navigating gold investments during periods of uncertainty.

With reference to the research subject and the adopted objective, the following hypothesis was formulated:

H: There is a strong linear correlation between rising inflation levels and rising gold price levels.

The considerations undertaken in the article fall within the framework of economic sciences, specifically within the discipline of finance, with particular emphasis on the sub-disciplines of financial markets, international finance and alternative investments. The issues addressed pertain to current challenges in contemporary finance, including dilemmas related to the development of financial science.

II. LITERATURE REVIEW

Gold has been known around the world for over 6,000 years. Due to the physical properties of the mineral, it has never been used to make everyday products, but it is a metal that has been a marker of wealth and riches for centuries. Bullion played a key role in the development of the international monetary system – until the twentieth century it served as the main means of payment. Currently, gold is widely used in jewellery, electronics, industry and medicine. It is seen as a hedge against inflation and declining purchasing power. In times of increased uncertainty and economic downturns, gold becomes a safe instrument and an indispensable insurance policy, leading to increased demand (Puszer and Czech, 2024, p. 56).

The global supply of gold is determined by the following primary sources:

– mines – including classic mines, open-pit and deep mines and small illegal adits,

– hedging – sales of futures contracts,

– the official sector – the sale of gold by governments and central banks;

– gold scrap – including the old gold scrap, which consists of gold objects already in use, and new gold scrap created in production processes,

– recycling – consists of recovering gold from gold-plated objects, or from objects with gold in them, for example, small components from electronic scrap and various industrial waste (Mamcarz, 2014, pp. 120–128).

The demand for gold is driven by a number of factors, including dollar volatility, inflation expectations, the continuing high level of geopolitical uncertainty, and the increased acceptance of gold as a diversifying investment portfolio. The trends currently emerging in the gold market may suggest that the role of gold is changing, with increasing demand for gold in jewellery and industry, and lower demand for gold as a reserve asset, but the important role is that of gold as an investment asset (Cai et al., 2008, p. 735).

Mamcarz (2014, p. 229) points out that the demand for gold depends on: the total demand for jewellery products, industrial demand (including medicine) and investment demand. The scale of demand is determined by many factors, both economic in nature, as well as emotional, psychological and cultural factors. This results from the fact that gold can be an object of luxury, an industrial raw material, a guarantee of security and an investment instrument. However, a significant factor determining the scale of market demand is the price.

Gold can be considered a unique investment due to its properties. First of all, it is a valuable metal that can function as a unit of value, a source of wealth and a highly liquid asset. It also has industrial applications, for example in jewellery, dentistry and medicine. Another factor that determines its attractiveness is the fact that demand for gold is growing, while resources are decreasing. The value of gold is also determined by its historical significance. Gold has consistently retained its value since its use as a currency (Juras, 2021, p. 83).

Gold futures contracts are becoming increasingly popular among investors. One of the types are forward contracts (actual contracts – which oblige the parties to deliver the gold and cash-settled forward contracts). They are a kind of contract between the buyer and seller of a contract, which represents a commitment by both parties to buy and sell gold at a forward price fixed in the contract at a date in the future. In addition to the forward price, the contract sets out the other terms of the transaction, including quantity, delivery and settlement date (Krężołek, 2020). The second type of futures contracts are cash-settled futures contracts. These contracts are settled in cash, and are based on profits or losses calculated using the gold price in the market. These contracts are traded on an exchange and their standards are regulated by the market, while the price depends on the price of gold. The purpose of futures transactions for gold producers is to hedge against commodity price volatility, thereby improving financial stability by neutralizing negative price movements in the real market (Cai et al., 2008).

As highlighted by Iwaszczuk, Dvulit and Baran (2021), over centuries of history, gold has served many different functions, but it has been best known as money. With the advent of fiat currency, the connection between gold and money weakened, and this relationship is more often observed during periods of crisis and economic downturn. At such times, gold becomes a 'safe haven' – it is used for hoarding (i.e. storing wealth). However, the gold market does not remain stable, as it is sensitive to the actions of many market and non-market factors, and in addition, the concept of paper gold has emerged, linked to the futures market, where the prices of future gold bullion purchase and sale contracts are formed through futures contracts. According to Iwaszczuk, Dvulit and Baran, the prices set in these contracts, due to the huge size of this market, nevertheless exert an influence on the spot price of physical gold. Furthermore, the authors emphasize the most important factor is the business cycle and, above all, the phase of the crisis, which can follow market or non-market events, such as wars, geopolitical conflicts, natural disasters.

Due to the dominance of gold trading in the form of derivatives (so-called paper gold), it is indicated that this type of gold trading determines the price of bullion on the spot market (physical gold). In addition, the possibility of speculative transactions on different exchanges (arbitrage operations) can also lead to manipulation in this market. The price of gold depends primarily on demand, which has been undermined in recent years (during the pandemic and armed conflict), as well as due to many other factors that are sometimes difficult to predict (e.g. inflation; Iwaszczuk, Dvulit and Baran, 2021).

One of the factors affecting the price of gold (including gold futures contracts) is inflation. The relationship between gold prices and inflation depends on how inflation is framed, either as an already realized increase in the average price level (ex post inflation) or as expected inflation. The first perspective examines changes in gold prices in response to changes in inflation, while the second explores the question of whether gold prices change in response to changes in inflation expectations, and thus also whether changes in gold prices can be used as a proxy for changes in inflation expectations. Both ap-

proaches can be used to determine how gold serves as a hedge against inflation. Two concepts are used here: hedge and safe haven. Taking inflation into account, gold can be assumed to be a hedge if, on average, it is positively correlated with inflation. Conversely, it could be referred to as a safe haven if this correlation occurred during periods of particularly adverse market conditions (Kasprzak-Czelej, 2015).

The impact of inflation expectations on gold prices can be explained on the basis of the expected inflation effect hypothesis. According to this hypothesis, an increase in expected inflation may induce investors to purchase gold either to hedge against a future decline in the purchasing power of money, or for speculative purposes to take advantage of an inflation-related increase in gold prices. The resulting increased investment demand for gold will result in an increase in gold prices. Consequently, gold prices can be treated as a proxy for the level of inflation, and therefore gold can be used to hedge against future levels of inflation (Beckmann & Czudaj, 2013).

Inflation, which erodes the purchasing power of money, can drive increased demand for gold among investors pursuing a strategy of moving away from fiat money to more secure means of hoarding, as confirmed by studies by Laakso (2019), Dukan (2017), and Iwaszczuk, Dvulit and Baran (2021).

In contrast, Torki et al. (2021), in their examination of effect of inflation on the change in the price of gold futures, demonstrated that inflation has a positive and significant effect on the long-run future change in the price of gold. Highlighting the positive impact of inflation, they recommend that policymakers and governments control inflation through expansionary monetary policy. This approach aims to reduce the risks associated with investing in this financial asset, stabilize the gold futures market, and mitigate trade risk.

According to Ghalayini and Farhat (2020), gold provides a hedge against inflation, and there is a positive relationship between the price of gold and inflation. However, in their study, they unexpectedly found that a 1% increase in the CPI resulted in a 0.05% decrease in the gold price. Therefore, they argue that such a situation is observed during a severe recession or financial crisis, as deflationary forces hit the economy, forcing investors into the safe alternative of gold.

Feldman (2010), on the other hand, points out that investors use gold as a 'safe haven' during political turmoil/conflict or in times of economic or financial uncertainty, as it is an investment that brings diversification to an investment portfolio in both the short and long term, in addition to providing a hedge against inflation and currency depreciation. He also believes that there is an increasing demand from investors for gold during times of political or economic uncertainty, and therefore there are various options for using gold in investment strategies from physical gold to gold derivatives. The price of gold is influenced by a number of factors, the most important being central bank reserves created in gold, the USD exchange rate, political uncertainty, economic concerns around the world, hedging transactions by gold producers, and the trading activities of speculators.

Jakobsson's (2022) research shows that gold should be seen as a safe-haven asset for both foreign and domestic investors. The results suggest that investors and central banks would benefit from continuing to hold gold-based instruments and reserves in their asset portfolios to protect against volatility in financial markets.

In contrast, Baur and McDermott (2010) examined the role of gold as a safe haven in an international context and focused their attention on the role of gold in the financial market in different countries between 1979 and 2009. They found that gold's ability to act as a safe haven varies depending on the economy of the country in question. For example, it is a safe haven for the United States and many developed markets of European countries, whereas it is not a safe haven in the BRIC countries, Canada, Australia or Japan.

In turn, Bauer and Lucey (2010) conducted a study in which they considered investing in gold as a safe haven and its role under conditions of uncertainty. The analysis was limited to the US, UK and German financial markets, drawing on data from 1995 to 2005. They concluded that gold can protect investors from volatility in the stock market, but not in the bond market. They also concluded that gold is a safe haven in all the countries assessed across the world, but only in the short term. This is because the price of gold peaks in the middle of an economic crisis, only to then show a negative return as soon as the market.

In assessing gold behaviour, Beckmann et al. (2017) found that gold acted as a hedge against uncertainty in the stock market until the bankruptcy of Lehman Brothers in 2008. After the financial crisis, they found no evidence that gold could act as a hedge or safe haven in uncertain times. They found that investors respond to uncertainty in the short term by seeking safe assets, such as gold, and that gold can act as a weak safe haven in the event of financial turmoil, mainly in developed countries such as the US. However, in extreme cases of financial ambiguity, they believe that gold investments adjust to a positive correlation with equities and therefore lose their ability to act as a hedge.

Qin et al. (2020) investigated the causal relationship between economic policy uncertainty and the gold price, and examined whether gold could hedge against uncertainty risk and how its price affected global economic policy. They found that gold effectively hedged against the risk of economic policy uncertainty during the Asian financial crisis, the Internet bubble and the global economic crisis. However, this effect is not observed crisis-free periods or during times of heightened global economic policy uncertainty when no crisis is occurring. Therefore, gold's ability to hedge the risk of global economic policy uncertainty depends on whether or not the period in question is one of economic crisis. Furthermore, a decrease in this risk will not lead to an immediate fall in the gold price. The gold price has both positive and negative effects on global economic policy, depending on investor sentiment, returns on other assets and the global economic situation.

Salisu et al. (2023) indicate that the literature clearly identifies gold's 'safe haven' feature. Consequently, investors are often drawn to this precious metal

as a means of portfolio diversification and a hedge during periods of economic downturn and financial market uncertainty. Their findings show that, in addition to gold, silver and platinum are also good assets with which to hedge in conditions of market uncertainty caused by a sudden negative shock from the global financial situation.

Worthington & Pahlavani (2007) found that the quality of inflation hedging through direct and indirect gold investments depends on the presence of a stable long-term relationship between the gold price and the inflation rate. Based on a cointegration analysis with structural breaks, they indicated that gold investment could have served as an effective hedge against inflation in the US between 1945–2006 and 1973–2006.

Hoang et al. (2016) found evidence that gold is not a hedge against inflation in the long term. In the short term, this is true only for the United Kingdom, the United States and India. They pointed out that there is no long-term balance between gold prices and the CPI for China, India and France, as well as emerging gold markets (China and India). Their results highlight particular aspects of gold investment in China, India and France, for which there is no long-term equilibrium between gold prices and the CPI. In the case of China and India, this can be attributed to the traditional and cultural aspects of gold. As for France, this can be explained by the French people's preference for gold as a hoarding asset rather than a speculative one. On the other hand, they point to the special case of Japan, where there has been a long period of deflation and the relationship between gold prices and the CPI has always been negative. In turn, considering the implications of asset allocation, they believe that investors should invest in gold for its ability to reduce portfolio risk and not for its ability to hedge against inflation. In addition, they stated that gold is not a hedge against inflation in the long term. In the short term, it depends on the country, its gold market and the frequency of data. Their research shows that it is in the United Kingdom, the United States and India that gold can help investors maintain the real value of their portfolios, and therefore their purchasing power, in the short term. Indeed, if gold has a positive relationship with inflation, then including gold in a portfolio allows investors to limit their losses due to inflation. This is thanks to the increase in the price of gold, which compensates for the loss of monetary value caused by inflation. Finally, investors in the UK, US and Japan should watch out for deflationary periods as these lead to an increase in gold prices.

Ghazali et al. (2015), based on correlation analysis and a linear regression model, showed that the price of gold makes it less profitable to use the metal as a hedge against inflation, as there is no systematic relationship between these variables in the shorter term. This indicates that gold is not justifiable in Malaysia as an inflation hedge, at least in the short term. Furthermore, even if an investor has foresight and knows that future inflation will be significantly different from market expectations, investors cannot devise a speculative gold strategy to benefit from this information. Inflation has the potential to reduce the value of gold investments. Therefore, gold investors should diversify their gold investments not only by purchasing physical gold, but also through ETFs,

gold mine stocks, gold futures and gold savings accounts, so as to keep capital gains over time in excess of inflation.

Mamcarz (2018) believes that gold does not fully fulfil its function of preserving value over the long term, nor does it ensure that investors retain the real value of this part of their wealth. Investors should carefully consider whether to engage capital in gold if there are no motives other than inflation protection underlying their investment decisions. Investing in gold to hedge against inflation also has other important implications – both micro- and macroeconomic.

Gillis (2023), in examining the issue of whether gold is the best hedge against inflation, took a time series from, among others, 2020 to early 2023, where inflation approached record levels, and found that there is no correlation between inflation and the price of gold. This research demonstrates that the long-held belief among investors that gold is the most effective hedge against inflation has been shown to be flawed. Investors should lean towards gold when recessions occur in deflationary environments. In general, gold can still be a hedge, but this view is becoming increasingly outdated as investors gravitate towards new and fashionable ways of investing.

Feldstein (2009) considers that gold is a poor security against inflation, as the US government ensures very good security against inflation in the form of bonds protected against treasury inflation (TIPS). However, he also suggests that investors who do not want to tie up their money in government bonds can purchase other securities against inflation as an addition to other investments. He says that there are better ways to secure oneself against inflation than gold. However, while gold may not be the most effective safeguard against inflation risk, it can still be a valuable investment due to its liquidity and its ability to diversify a portfolio of shares, bonds and ownership. Gold is also a high-risk investment and is very unstable. In contrast to normal shares, bonds and property, the value of gold does not reflect basic returns. Gold is a purely speculative investment.

Narinder and Navneet (2019) believe that gold and Indian culture share an age-old relationship. Gold is used for various cultural reasons and is the most popular form of investment because of its ability to provide liquidity. Studies have found that gold and the CPI are integrated and tend to rise over the long term. The results of the VECM and Wald tests indicate that there is only long-term causality between the CPI and the price of gold. However, in the short term, these variables do not show any causality. Therefore, they argue that investment in gold can be used as a hedge against inflation risk. For a country like India, where people purchase more gold – for example as gifts, for personal use or status upgrades – the results of this study suggest that Indians' propensity to hedge against inflation by investing in gold is inseparable. Statistics in India report that a 1% increase in income results in a 1% increase in demand for gold; furthermore, with a 1% increase in inflation, there is a 2.6% increase in demand for gold, indicating that people buy gold to hedge against inflation.

Joshi and Singh (2019) believe that gold and Indian culture share an age-old association. Gold is used for various cultural reasons as well as a means of storing value, and it is the most popular investment avenue because of its ability to provide liquidity. In their research, they concluded that gold investments can be used as a hedge against inflation risk. They believe that the results of this study have direct implications for retail investors, portfolio managers, fund managers, government, and commercial investors. They also point out that in emerging economies, retail investors can invest in gold through various options such as bars, gold ETFs, gold bonds, which would help hedge against purchasing power risk. Similarly, portfolio managers can include gold in their portfolio to protect themselves against inflation and to immunize themselves against real returns on their portfolio.

Wang et al. (2019) believe that supply and demand factors continue to play a fundamental role in shaping the price of gold futures, in addition to which financial factors also have a significant impact, with the US dollar index having the greatest influence. Financialization in the commodity markets is becoming increasingly important as a factor in the gold market. Speculative factors can lead to price changes in the gold futures market and can distort futures prices away from their fundamental values. Speculation in the gold futures market should not be underestimated. In the face of slowing economies and global uncertainty, an increase in the holding of gold futures can optimize the structure of foreign exchange reserves or the hedging of the exchange rate risk against the US dollar. For gold futures investors, it is necessary to pay attention to changes in financial factors, including the US dollar exchange rate, interest rates or stock market price movements. When the global environment changes dramatically, investors should use gold futures to hedge so as to avoid investment losses. In order to reduce and prevent the price volatility caused by excessive speculation in the gold futures market, the relevant authorities should pursue a strict policy on gold futures speculation, and exercise stricter supervision over speculative activities.

Su et al.'s (2022) research focused on the causal relationship between the gold price and the world uncertainty index to investigate whether gold's aura as a hedge against uncertainty has weakened. The results show that there is a positive effect of the world uncertainty index (WUI) on the gold price, indicating that gold still maintains its hedging position against uncertainty in times of economic and political chaos. They believe that the gold price may rise during certain periods of high WUI to hedge losses, and also shows a downward trend during periods of low WUI. They emphasize that the gold price should lead to a positive reaction to the WUI. In contrast, the negative impact of the gold price on the WUI suggests that the global political and economic situation can be predicted through the gold market. Thus, investors can optimize the content of investment portfolios containing gold to hedge against the WUI. Furthermore, governments can analyse global uncertainty trends through the path of the gold price, adjust policy formulas, counteract potential negative effects on the economy, and promote stable global development.

Rasheed et al. (2021) believe that investors who operate in a volatile economy are always at risk of losing their assets. Due to the increased scope of uncertainty resulting from rapid changes in the economic and political environment, investors seek safe investment vehicles that can diversify risk and help maintain an optimal portfolio. This is only possible if investors have the right mix of uncorrelated assets in their portfolios, as uncorrelated or negatively correlated assets can provide mutual protection. Their findings based on the Pakistani market indicate that gold is a hedge compared to the stock market under normal conditions, but also acts as a safe haven during market declines and socio-political events. They also stated that gold provides protection for Pakistani investors and could protect them during market downturns and from the risk of political uncertainty. They suggest that gold can act as a diversifier in the market, including during times of political uncertainty in Pakistan, and therefore investors in politically unstable economies should include gold in their asset allocation strategies to cope with uncertainty during market downturns and political events.

III. RESEARCH METHODS

The quantitative research used time series analysis and multiple linear regression analysis. The time series analysis made it possible to examine inflation trends (2020–2023). Based on the time series analysis, the direction and rate of change of prices of the following gold futures contracts were also determined:

– Gold Futures PLN
– Gold Futures EUR
– Gold Futures CHF
– Gold COMEX Futures.

Multivariate linear regression analysis examined the impact of inflation caused by the pandemic and the war in Ukraine on the price of the above contracts. The analysis was conducted on a sample of 192 observations of changes in the price of individual contracts (in monthly intervals), and 768 observations of changes in inflation in individual countries (Poland, Eurozone, Switzerland and the USA).

Four multiple linear regression models were constructed based on the observed changes in the prices of the aforementioned gold futures, where the dependent variables are the monthly average prices and monthly returns of the aforementioned futures contracts, while the independent variables (predictor variables) are the following monthly inflation indices:

– Consumer Price Index CPI (x_1)
– Producer Prices Index PPI (x_2)
– Core Inflation Rate (x_3)
– Inflation Rate (x_4).

The explanatory variables were selected for the models using the Hellwig method. The values of the individual indicators were taken from the databases of the central government offices involved in the collection and release of statistical information, as well as the stooq.com database. Statistica software and Excel were used in the research process.

In the multiple linear regression analysis, a stepwise progressive regression method was used. The indicators listed above, which were statistically significant, were entered into the model sequentially (step by step). Statistical significance was assessed using a *t*-test, assuming a maximum 5% probability of error in the inference (alpha level). Thus, those variables whose $p < 0.05$ were considered statistically significant. Then, after including all statistically significant variables in the model, linear significance was tested for the entire constructed model using the *F*-test statistic. The collinearity (redundancy) of the predictors was tested using the tolerance factor.

The estimated linear multiple regression model is described by the equation:

$$\hat{Y} = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + \zeta\,, \tag{1}$$

where: b_i – partial regression factors, b_0 is the price of gold futures and the others are model parameters representing independent variables affecting the price and daily returns of gold futures.

In particular, we analyse the role of gold in times of rising inflation around the world. The research period adopted covers the period from 1 January 2020 to 31 December 2023. The research used monthly gold futures prices and monthly inflation data.

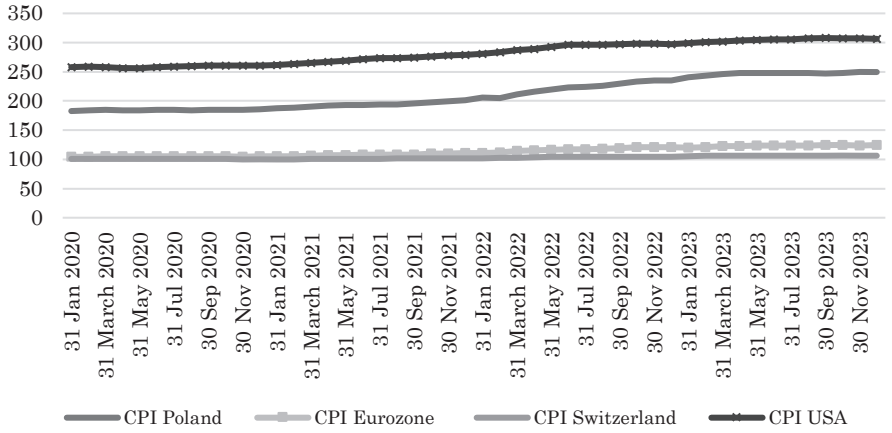
The application of the multiple linear regression model allowed us to answer the question of whether changes in the level of inflation are correlated with concurrent changes in the price of gold futures, and enabled an assessment of how increasing inflation rates (independent variables) affect the price of selected gold futures (dependent variable). The study allowed us to determine whether there is a statistically significant relationship between the level of inflation and gold futures prices.

IV. RESULTS

Figure 1 and Figure 2 show that over the period from 2020 to 2023, both the Consumer Price Index CPI and the Producer Prices Index PPI showed a sustained upward trend in all the countries studied except Switzerland. Over the entire period analysed, the largest increases in the CPI were observed in Poland (an average increase of 0.67% month-on-month) followed by the USA and the Eurozone (an average increase of 0.37% month-on-month in both), with the smallest increases in Switzerland (an average increase of 0.12% month-on-month; Figure 1).

Figure 1

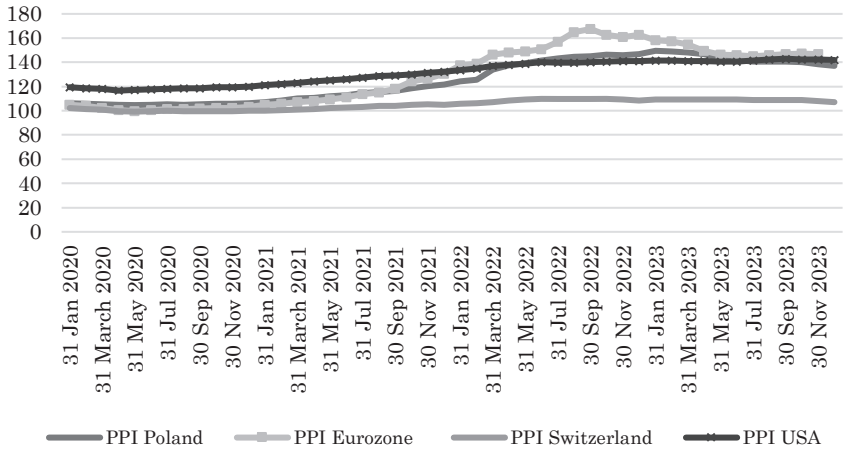
Consumer Price Index (CPI) in Poland, Eurozone, Switzerland and the USA from 2020 to 2023



Source: Central Statistical Office of Poland (2024); Eurostat (2024c); Swiss Federal Statistical Office (2024a); U.S. Bureau of Labor Statistics (2024a).

Figure 2

Producer Prices Index (PPI) in Poland, Eurozone, Switzerland and the USA from 2020 to 2023



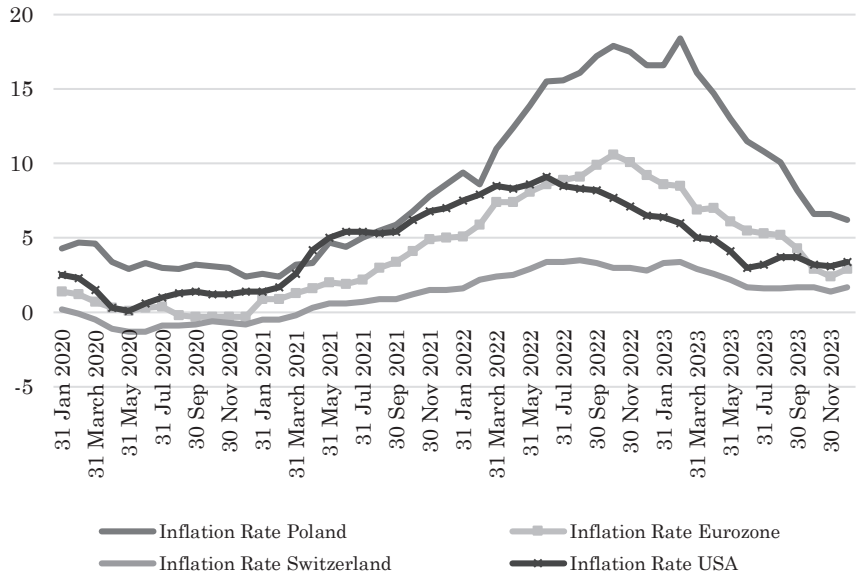
Source: Eurostat (2024b); U.S. Bureau of Labor Statistics (2024b).

Figure 1 indicates that the highest level of inflation measured by the CPI in the period under review was in the USA, ranging from 258 to 307 points. The second highest inflation rate was in Poland, where the CPI ranged from 183 to 250 points. In the Eurozone and Switzerland, the CPI was at a similar level (100 to 124 points).

The statistics presented show that during the initial period, the CPI and PPI in all the countries studied remained relatively stable. This is due to the fact that during this period, a number of restrictions were introduced worldwide that resulted from the COVID-19 pandemic, with the aim of limiting the transmission of the SarsCov-2 virus (including restrictions on mobility, the necessity to work and learn remotely, customer limits in retail establishments, restaurant and hotel closures, etc.). As a result of the measures taken, both supply and demand were significantly reduced. With the relaxation of lockdown and social distancing measures, the demand for goods and services increased; however, supply, due to the previous lockdowns, remained at a reduced level. As a result, the price of produced goods and raw materials increased (Figure 2), which directly contributed to the overall level of prices and consumer inflation between March 2021 and March 2023. Thereafter, the supply of goods and services increased, leading to a supply-demand equilibrium, resulting in a decrease in the overall price level and consumer inflation as of April 2023 (Figure 3 and 4).

Figure 3

Inflation Rate in Poland, Eurozone, Switzerland and the USA from 2020 to 2023



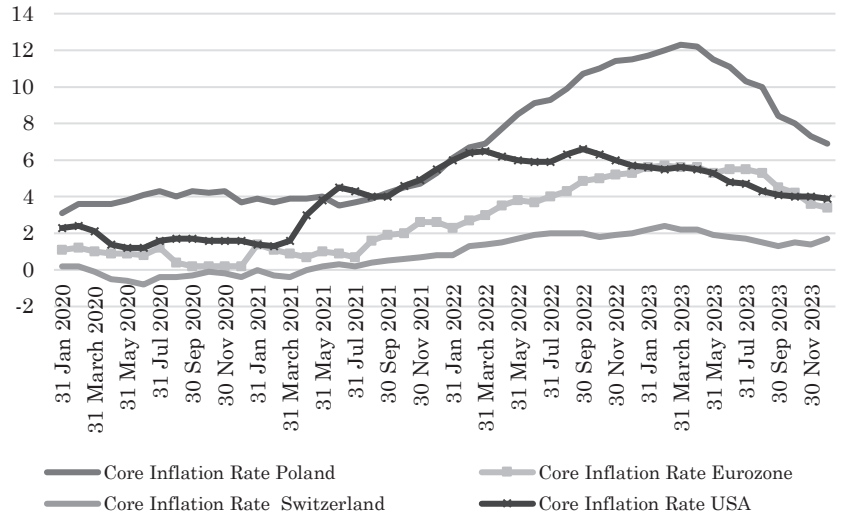
Source: Eurostat (2024a); US Inflation Calculator (2024a).

Figure 3 and 4 compare the increase in the general level of prices and core inflation. The results of the dynamics analysis show a decline in the purchasing power of money (an increase in inflation) in all the countries studied. The largest decrease in purchasing power was recorded in Switzerland (a more than sevenfold decline over the entire research period), then in the Euro-

zone (107.14% decrease over the entire research period), followed by Poland (44.19% decrease over the entire research period and the USA (36% decrease over the entire research period). At the same time, it should be noted that the dynamic increase in inflation (and thus the decline in the purchasing power of money) occurred following the outbreak of the war in Ukraine. At that time, inflation in both Poland and the Eurozone increased, by 8.9 pp in Poland (from February 2022 to November 2022) and by 4.2 pp in the Eurozone (from February 2022 to November 2022), while inflation began to decline in the USA (Figure 3). The rise in inflation in the Eurozone halted in the second half of October 2022, while in Poland and Switzerland, the trend of rising inflation only reversed in February 2023. Figure 4 shows that the rise in inflation amidst increased uncertainty (as a result of the pandemic and the war in Ukraine) resulted from an increase in the general level of prices, excluding electricity and food prices. Core inflation continued to trend upwards until March 2023 and increased throughout the study period in all the countries (Figure 4).

Figure 4

Core Inflation Rate in Poland, Eurozone, Switzerland and the USA from 2020 to 2023



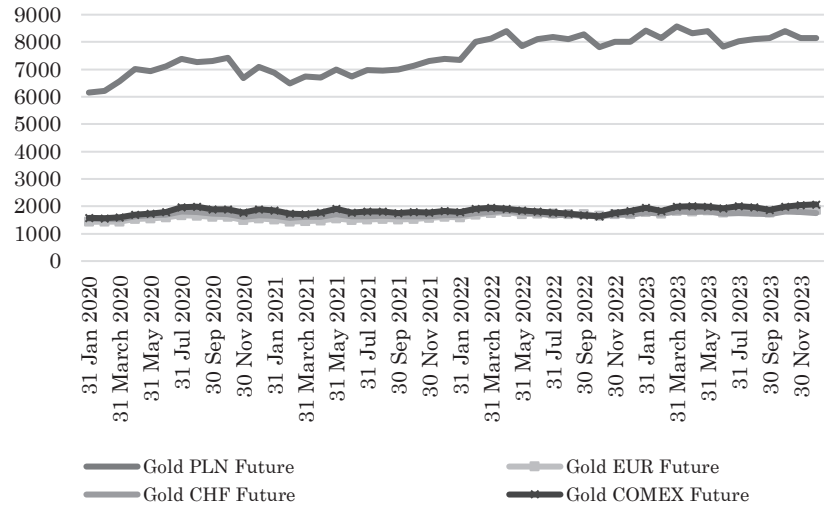
Source: Narodowy Bank Polski (2024); Investing (2024); Swiss Federal Statistical Office (2024b); US Inflation Calculator (2024b).

The results of the literature study show that as inflation increases, the price of gold increases (Torki, 2021; Ghalayini & Farath, 2020). Meanwhile, the results of the analysis in this research are ambiguous. The research results indicate that during the period of rising inflation in Poland, the price of Gold PLN Futures increased slightly. In contrast, the rise in inflation in

the Eurozone, Switzerland and the USA did not significantly affect the price of gold futures, as the price of these instruments remained relatively stable (Figure 5).

Figure 5

The gold futures price from 2020 to 2023



Source: Stooq (2024a, 2024b, 2024c, 2024d).

The results of the analysis showed that the price of the individual gold contracts increased, but unevenly. The largest price increase (PLN40.78 on average from month to month) was observed for Gold PLN Futures, followed by an average increase of EUR8.22 from month to month for Gold EUR Futures. Gold COMEX Futures had a much smaller increase (average USD4.87 month-on-month), while Gold CHF Futures had the smallest average increase (3.12) month-on-month.

The results of the multiple linear regression analysis confirm the varying impact of inflation on the gold futures price during the period considered (Table 1).

Based on the findings in Table 1, gold futures were primarily influenced by three factors between 2020 and 2023: the Consumer Price Index (CPI), the Producer Prices Index (PPI) and the Inflation Rate. The CPI influenced the prices of three contracts examined during the study period, but the influence was not uniform. The results of the study showed a positive correlation between CPI and both Gold EUR Futures and Gold CHF Futures. In contrast, a negative correlation was found between the CPI and Gold PLN Futures. There was no correlation between Gold COMEX Futures. A homogeneous impact on individual gold futures was demonstrated by the PPI variable, which showed a positive correlation with Gold PLN Futures and Gold EUR Futures,

as well as with Gold COMEX Futures. However, the study found that the strength of this impact varied. Only the Inflation Rate negatively affected the price level of all gold futures, except for Gold CHF Futures, where no correlation was shown. In the multivariate linear correlation analysis, the Core Inflation Rate variable only affected Gold PLN Futures (positive correlation).

Table 1

Results of multiple linear regression analysis

Dependent variables	Parameters of the independent variables			
	CPI	PPI	Core Inflation Rate	Inflation Rate
Gold PLN Futures	–33.337	97.23	231.61	–190.766
Gold EUR Futures	10.467	4.86	–	–25.25
Gold CHF Futures	17.901	–	–	–
Gold COMEX Futures	–	10.24	–	–26.30

Source: the authors' calculations, based on the data contained in Figure 1–4.

Thus, the results of the analysis indicate that the impact of inflation on gold futures is heterogeneous, both in terms of the direction of impact and the strength of impact, which is also confirmed by the model fit parameters (Table 2).

Table 2

Model fit parameters

Dependent variables	Model adjustment parameters				
	Determination coefficient $R2$	Estimation error	F-test statistic value	Test probability level ($p < 0{,}05$)	T-test statistic value (intercept term)
Gold PLN Futures	0.8238	297.50	57.09	$p < .00001$	2 396.82
Gold EUR Futures	0.7771	62.40	54.46	$p < .00001$	–60.83
Gold CHF Futures	0.2862	65.62	19.85	$p < .00001$	–145.86
Gold COMEX Futures	0.3294	100.05	12.54	$p < .00001$	608.51

Source: the authors' calculations, based on the data contained in Figure 1–4.

Table 2 shows that all the estimated multiple linear regression models are statistically significant. This is confirmed by the F statistic values for the individual models (closing in the range 12.54–57.09) and $p < 0.05$. This is because

the value of the F statistic reflects the significance of the model components: if $F = 0$, the model components are insignificant, and if $F \neq 0$, the components are significant. The significance of the model is further confirmed by the estimation errors and the t-statistic values (free expression). The estimation error indicates the average difference between the observed values of the dependent variable and the theoretical values (Rabiej, 2012). In the estimated models, the free expressions are different from zero.

The $R2$ determination coefficients indicate how well the constructed model explains changes in the level of prices on individual instruments. For Gold PLN Futures, the coefficient of determination is equal to 0.8238, which means that the model explains slightly under 82.38% of the changes in the level of gold futures prices. The same is true for the Gold EUR Futures model, which explains as much as 77.71% of the price changes in this instrument. In contrast, the Gold COMEX Futures model only explains 33% of the price changes of the instrument and the Gold CHF Futures model explains only 28% of the changes. This implies that 67% of the change in the price of Gold COMEX Futures and 72% of the change in the price of Gold CHF Futures are the result of other, non-inflationary factors.

V. DISCUSSIONS AND CONCLUSIONS

This study aimed to determine the relationship between the level of inflation and the change in the prices of selected gold futures contracts under the rising inflation triggered by non-economic factors, such as a health crisis (like the COVID-19 pandemic) and the war in Ukraine. Undoubtedly, the pandemic recently had an adverse impact on the global macroeconomic environment. Numerous restrictions, including total lockdowns, hampered businesses. Moreover, the outbreak of military conflict in Ukraine contributed to the rupture of supply chains and consequently exacerbated the difficult situation. As a result, the supply of goods and services has decreased and directly translated into rising price levels and the falling purchasing power of money. Consequently, the goal of the article was to examine the evolution of gold futures prices in an environment of rising inflation, between 2020 and 2023. The achievement of the set objective was conditioned by:

– examining the level and dynamics of inflation changes in selected countries (Poland, Eurozone, Switzerland and the USA),

– examining the level and dynamics of changes in the prices of selected financial instruments (Gold PLN Futures, Gold EUR Futures, Gold CHF Futures, Gold COMEX Futures),

– examining the interdependence of changes in prices of gold futures and selected inflation indices.

The study of the level and dynamics of inflation changes in selected countries (Poland, Eurozone, Switzerland and the USA) showed a strong upward trend in all the countries covered. The highest level of inflation measured by

CPI in the period under study was in the USA and Poland, while in the Eurozone and Switzerland the CPI was at a much lower level (from 100 pts to 123 pts). The development of the PPI index showed a slight difference, as in the initial period it was relatively stable and was at a similar level in all the studied countries. However, from September 2022, it increased dynamically in Poland and the Eurozone. In the remaining countries, the increase in this indicator was modest.

The increase in price levels was also reflected in the development of the inflation rate, which, especially in Poland, increased significantly, more than sevenfold, after the outbreak of the war in Ukraine (70.93% from February 2022 to March 2023). The results of the research showed that the increase in inflation was not only caused by changes in food and energy prices, but also by an increase in the prices of other goods and services, as indicated by the level of core inflation in the countries studied.

It can be seen from the data in Figure 3 and 4 that from March 2023 core inflation and the Inflation Rate were decreasing in all the countries surveyed, and PPI behaved similarly, declining gently in all the countries surveyed except the US. What is surprising, however, is that at the same time the CPI continued to be in a sustained upward trend in all the countries surveyed. The findings therefore allow us to hypothesize that it is the CPI that has the greatest impact on the price of gold futures. This hypothesis was verified negatively, using multiple regression analysis. However, the research results indicate that the CPI affects gold futures prices unevenly, which is not in line with the results of previous studies. Surveys, such as the one conducted by Ghalayini and Farath (2020), have shown that an increase in the CPI causes the price of gold to fall during a severe recession or financial crisis, and research by Hoang et al. (2016) has also confirmed this during deflation. Our study showed a negative correlation only between CPI and Gold PLN Futures, while in the other contracts (except Gold COMEX Futures) the correlation was positive. This finding, on the other hand, is consistent with results from Malaysia, where it was shown that there is no systematic relationship between inflation and the gold price over a shorter period (Ghazali et al., 2015).

The hypothesis put forward in the study assumed that there is a strong linear correlation between rising inflation levels and rising gold futures price levels. The results of the study confirmed the hypothesis, but at the same time revealed that the inflation impact as measured by the four indicators is ambiguous. Both the strength and direction of the inflation impact on gold futures prices is nonhomogeneous. The results of previous studies indicate a positive impact of inflation on the level of gold futures (Ghalayini & Farath, 2020; Torki, 2021), but this study does not confirm this. For example, the Inflation Rate shows negative correlation with Gold PLN Futures, Gold EUR Futures and Gold COMEX Futures, while other inflation indicators show a positive correlation.

For centuries, gold has had a hoarding function, and as evidenced by Iwaszczuk, Yakubiv, and Baran (2021) or Feldman (2010), under conditions of heightened uncertainty caused by armed conflict, its price has increased.

However, this study has not confirmed this. The results of this study justify the conclusion that an increase in uncertainty about the epidemiological and military situation does not translate into a long-lasting upward trend in futures gold prices. The literature also indicates that in conditions of rising expected inflation, investment demand for gold increases in the long term, and consequently its price (Torki, 2021). For example, Beckmann and Czudaj (2013) justify this with hedging (protection against a future decline in the purchasing power of money) or speculation (hope of a future inflation-related increase in the price of gold). On the other hand, the results of our study showed that despite the increase in inflation, the price of paper gold remained relatively stable over the period studied. Only Gold PLN Futures showed a slight increase in the price level during the outbreak of war in Ukraine, while this relationship does not exist for the other studied gold futures. The research results therefore revealed that gold can be a safe haven, but only in the short term, which aligns with the conclusions of Hoang et al. (2016) and Bauer and Lucey (2009).

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