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The Evolving Role of Gold as an Inflation Hedge: Evidence from Europe and the United States

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Abstract
This study investigates the intricate relationship between inflation and gold prices, with a focus on temporal dynamics and regional differences in Europe and the United States. Using monthly data and examining lagged effects of up to 4 months, it provides a thorough analysis of how inflation, measured through the Harmonized Index of Consumer Prices (HICP), influences gold prices across various price levels. The results confirm that gold acts as a reliable short-term hedge against inflation, especially for higher price levels, with the strongest effects occurring at lag periods of 1.5 to 2 months. However, over longer lag periods, the relationship weakens significantly, with cumulative impacts turning negative, particularly for lower price ranges These findings underscore the temporal complexity of gold's effectiveness as an inflation hedge and its susceptibility to broader macroeconomic influences. A distinguishing feature of this study is its combination of temporal analysis with a comparative regional framework, which uncovers meaningful differences between Europe and the U.S. While both regions show strong short-term positive correlations between inflation and gold prices, the U.S. exhibits a sharper decline in cumulative effects over longer lag periods, likely due to greater sensitivity to external factors such as monetary policies and currency fluctuations. The findings are particularly relevant for policymakers and investors, highlighting the need for strategies that consider the timing and regional context when using gold as a tool to counter inflation.

Keywords
Gold Price, Inflation, HICP, DLNM, United States, Europe

Introduction

Among metals, gold occupies a special place. It is the oldest metal mined by man and very important in world economics (Habashi, 2016). From an economic and financial perspective, changes in the gold price are both interesting and important (Anandasayanan et al., 2019). vast studies on the relationship of gold prices with inflation have been conducted since the 1970s (Hoang et al., 2016). The current high price of gold indicates that it serves as a costly hedge against inflation, but it offers a low potential for real returns (Erb et al., 2020). As an investment strategy, gold does provide a partial hedge against inflation (Ergül & Karakaş, 2024). Gold serves as a robust safe haven asset against the European sovereign risk (Gomis-Porqueras et al., 2022) and hedge against inflation (Do et al., 2023; Isnin & Zulfa, 2024; Li et al., 2022) . Like the Consumer Price Index (Ghodke & Giri, 2023), the Harmonized Index of Consumer Prices (HICP) is widely regarded as a key indicator of inflation in Europe (Herzberg et al., 2023) and plays a crucial role in policy discussions at the European Central Bank (ECB) (Wynne & Rodriguez-Palenzuela, 2004). So, when examining the relationship between Inflation and Gold price HCP needs to be considered.

In recent years, gold prices have been on a steady rise worldwide. Factors such as monetary policy, inflation expectations, and market volatility all play a role in shaping economic conditions, which can affect the movement of gold prices (Chang, 2024). Investors in countries experiencing high inflation should focus on gold rather than Bitcoin for their portfolios. Gold has a proven track record as a reliable hedge against inflation in different economic situations, whereas Bitcoin's volatility introduces greater risks (Arshad et al., 2023). Gold is gaining popularity as an asset in investment portfolios to help reduce the risk of unexpected inflation (Wang et al., 2011). The relationship between inflation and gold prices varies over time, with increased comovement in recent decades. This evolving sensitivity, influenced by factors like interest rate changes, highlights gold's monetary nature and its role as a hedge against inflation in changing economic conditions (Batten et al., 2014). Gold's responsiveness to inflation and interest rates varies with the level of monthly inflation. During high inflation regimes, such as when inflation exceeds 0.55%, gold shows significant sensitivity, while it remains less responsive in low or moderate inflation periods. This asymmetry explains debates about its hedging effectiveness (Valadkhani et al., 2022).

The attraction of gold is more than a financial instrument-cultural, industrial, and technological relevance make it a must-commodity in world markets. This fact, coupled with its use in jewelry and electronics, not to mention its historical use as a medium of exchange and store of value, further cements its importance. Moreover, geopolitical events and macroeconomic instability generally stir the demand for gold as a safe-haven asset, thereby reinforcing the dual role in both investment and consumption. Interplays of such factors highlight gold's enduring value within a fast-changing economic landscape and emphasize its unique position among metals.

Gold price shocks affect inflation persistence differently across countries, lasting longer in developing nations and shorter in developed ones. Higher income levels and inflation-targeting policies reduce persistence, while intermediate exchange rate regimes show higher persistence than free-floating or pegged systems (Oloko et al., 2021)

Investors and policymakers alike need to comprehend the role of inflation, as represented by HICP in Europe and the US, in determining the price of gold. This analysis seeks to establish the relationship between these inflation measures and prices of gold and the factors that shape the dynamics of this relationship in the context of the economic situation in both regions (Coibion et al., 2020). So, our research question is:

RQ1) How does inflation influence gold prices in Europe and the United States?

Literature Review

A significant rise in gold prices has attracted the attention of investors, speculators, and analysts alike (Pattnaik et al., 2023). Those involved in financial markets need to identify when gold might serve as a hedge against inflation (Batten et al., 2014). Gold is a safe haven (Hussain Shahzad et al., 2020; Tronzano, 2022) as well as an important asset (Erb & Harvey, 2013) , and Inflation refers to the ongoing rise in the prices of goods and services (Steele, 1989). Gold also served as a hedge against the foreign exchange value of the dollar (Capie et al., 2005) and inflation (Bampinas & Panagiotidis, 2015) .

Many scholars have researched the relationship between gold prices and inflation (Anandasayanan et al., 2019; Aye et al., 2016; Bampinas & Panagiotidis, 2015; Lucey et al., 2017). Beckmann & Czudaj, (2013) examines the hedging effectiveness of gold against inflation in the four biggest world economies (the USA, UK, Euro Area, and Japan) within an MS-VECM framework from 1970 to 2011, showing that gold tends to partially hedge long-run inflation, but regime-dependent hedging effectiveness alters according to different economic conditions. Hoang et al., (2016) uses the NARDL model to examine gold's effectiveness as an inflation hedge from 1955 to 2015 across six countries. Iqbal, (2017) employs EGARCH and quantile regression models from 1990 to 2013 to examine the hedging potential of gold. The findings of Valadkhani et al., (2022) suggest that in the case when US monthly inflation exceeds 0.55%, gold is extremely sensitive to both changes in inflation and the ten-year Treasury interest rate; at moderate and lower levels, this asset is insensitive. That asymmetry, together with dependence on size, can explain why the results from the literature are still controversial about whether it is really good as a hedge instrument.

The results by Blose, (2010) indicate that investors seeking to exploit changes in inflation expectations should target the formulation of speculative strategies in bond markets rather than gold markets. Additionally, gold prices are not a good signal of market inflation expectations, hence a weak signal for such predictions. Oloko et al., (2021) establish that a high level of income is usually characterized by low persistence of gold price-inflation rate cointegration. However, we cannot completely rule out that high-income countries might exhibit higher cointegration persistence compared to low-income countries. We also document that the adoption of inflation-targeting monetary policies tends to decrease the persistence of gold price-inflation rate cointegration. Moreover, cointegration persistence seems to be higher for limited or intermediate floating exchange rate regimes compared to free-floating or currency peg arrangements.

Conlon et al., (2017) tests the aptitude of gold to act as an efficient dynamic hedge against inflation across multiple holding periods using continuous wavelet transformation. The study confirms that, in reality, gold is a good short and long-term hedge for developed economy inflation. Dynamic analysis further showed that the nature of hedging characteristics is not confined to just one point in history. Furthermore, the results indicate that gold comes with surprise inflation in all the countries under study, but the nature of this relationship differs.

Lucey et al., (2017) examine the relationship between gold, inflation, and monetary liquidity in three countries, namely the USA, the UK, and Japan over a period of forty years. Utilizing a formal test for time variation, we extract time-varying cointegration relationships. Formal and graphical results point to a structural break in the gold-official inflation relationship in the mid-1990s for the USA, while the evidence is rather more mixed for the UK and Japan. Equally, gold has seemed to act consistently as a hedge against money supply rises in both the US and the UK over the last forty years, but it has clearly not done so in Japan. Whereas, Kumar, (2017) does not find any evidence of cointegration between gold and WPI. However, the study finds a significant dynamic relationship between gold and inflation using a Kalman filter framework, with an increasing movement observed over the past decade. The results indicate that the differential performance of gold concerning inflation is explained by variations in real effective exchange rates, reinforcing the stand of gold being a very good alternative to paper money. Furthermore, the results show that short-run as well as long-run interest rate adjustments determine the WPI beta of gold and pinpoint the monetary role of gold as an asset of safe haven.

Rafalovich, (2011) reviews the gold bug discourse as a conspiracy story wherein its leitmotif tends towards the critique of inflationary monetary policy. According to Gold Bugs, sustained inflation indicates the deep-lying faults in world capitalism and erodes away the legitimacy of the administrative apparatuses that oversee it. As such, inflation is a key indicator through which the gold bugs forecast the economic circumstances and the inevitable collapse of world monetary authorities. Centered around the belief that gold is, in fact, the only "true" store of value, this position rejects conventional monetary policies, predicts massive, sharp increases in the price of gold, and presupposes the final collapse of all fiat money systems worldwide.

Ding et al., (2023) establish that US dollar depreciation leads to higher commodity prices through the oil-dollar mechanism, which in turn fuels global inflation. Conversely, appreciation of the dollar causes a relative depreciation of other currencies through the substitution effect of the gold-dollar relationship, pulling up their inflation rates. It is, therefore, more likely for gold prices to increase rather than decrease after US interest rate increases. This dynamic dampens the efficiency of such easing monetary policies in other countries since the rising gold price counterbalances the intended results of such policies.

In a paper written by Shahbaz et al.,(2014) it is found that gold investment offers a hedge on inflation, but both in the long as well as in the short run. Gulseven & Ekici, (2020) examined gold as an inflation hedge or safe haven using standard and quantile techniques within volatility models based on TGARCH specifications for four countries. Evidence of gold as a robust hedge is obtained for the US and China. Gold does not always act as protection in all countries since it protects only at discontinuous times. As a hedge, it is a considerable investment in China, while not that important in the UK and India. It could be inferred from these results that gold provides considerable insulation to Chinese investments against high inflationary pressures and proves to be a profitable long-run asset in the US economy. On the other hand, investors in the UK and India should have well-diversified portfolios to achieve sustainable returns and to hedge against purchasing power losses.

Balcilar et al., (2018) begins the analysis by conducting tests for nonlinearity, and the results suggest that the linear Granger causality tests may suffer from misspecification problems. By applying the nonparametric causality-in-quantiles tests, the study identifies evidence of causality from inflation to gold price changes in mean and variance within the range of the 0.20 to 0.70 quantile. This therefore implies that very low and very high changes in the price of gold do not relate to inflation and could most likely be driven by other factors such as financial and exchange market shocks. The findings indicate that gold acts as a hedge against inflation, but only within the mid-quantile ranges. Gold is not an effective hedge against inflation in periods of very low or very high changes in the price of gold, which depict market calmness or extreme volatility, respectively.

The Consumer Price Index (CPI) serves as an indicator for assessing inflation (Białek, 2020), and HICP is a standardized measure of inflation utilized by the European Union to compare inflation rates among its member states. Sharma, (2016) tested that CPI can predict gold price returns.

Distributed lag non-linear models (DLNMs) are a method used to capture non-linear relationships and delayed effects in data (Gasparrini et al., 2017). Gasparrini, (2011) explained that Distributed Lag Non-Linear Models (DLNMs) provide a flexible framework for modeling associations that may exhibit non-linear and delayed effects in time series data. Zhao et al., (2022) used the DLNM method to find the relationship between ambient temperature and stroke occurrence and Talagala, (2022) used the DLNM approach to identify the relationship between climate factors and Dengue incidence. Zheng et al., (2023) explores the effect of temperature on tuberculosis incidence by using the DLNM method. Many other researchers used this technique to find the relationship in various scenarios (Gao et al., 2023; Rodrigues et al., 2019; Yang et al., 2024). Mosquera-López et al., (2024) used the DLNM method to analyze how weather variables affect electricity prices in six European countries. Chien et al., (2018) utilized Distributed Lag Non-Linear Models (DLNM) to examine the non-linear lag effects over a 7-day period in a case study investigating the spatiotemporal impact of fine particulate matter (PM2.5) on acute respiratory infections among preschool children across 41 districts in northern Taiwan from 2005 to 2007.

Many researchers explored various techniques to find the nonlinear relationship between gold price and inflation but not by using the DLNM method So, in this article, we use the DLNM method to find the relationship between Gold Price and Inflation by using HICP. This provides a new insight into researchers in the research field.

Material and Methods

This study investigates the nonlinear and lagged relationships between gold prices and the Harmonized Index of Consumer Prices (HICP) using a rigorous econometric approach. Distributed lag nonlinear models (DLNMs) are designed to assess the effects of an independent variable on a dependent variable not only at the time the independent variable changes but also over subsequent periods (Gasparrini et al., 2010). This research used monthly data sets including gold prices and the Harmonized Index of Consumer Prices (HICP) from 2002 to 2024 in Europe and the United States. The data HICP is taken from the Eurostat site and the monthly gold price is taken from Datahub. The dataset was cleaned and aligned to ensure consistent temporal coverage.

The core of the analysis utilizes the DLNM framework introduced by Gasparrini et al. (2010). This approach models the nonlinear exposure-response relationships between the dependent variable (electricity prices) and meteorological predictors, accounting for their lagged impacts.

The general form of the model is expressed as:

$$g(\mu_t) = \alpha + \sum_{j=1}^{J} s_j(x_{tj}; \beta_j), \quad (1)$$

Where,

$g(\mu_t)$	Link function representing the expected value of gold prices
α	Intercept term.
x_{tj}	Predictor variables, including lagged HICP factors.
$s_j(x_{tj}; \beta_j)$	Smoothing functions capturing nonlinear relationships.

To accommodate lagged effects, cross-basis functions were constructed. This involved the transformation of predictors into a multidimensional space where both temporal lags and nonlinear relationships could be explored. Specifically, we extended the model as:

$$s(x_{tj}; \beta) = Z_t . \beta \quad (2)$$

Where,

Z_t is a matrix of basis variables derived from transformations of the predictors

The lag structure was incorporated using distributed lag models (DLMs):

$$s(x_{tj}; \eta) = q_t^T . C_n \quad (3)$$

Where,

C	Basis matrix capturing the temporal lag structure.
q_t^T	Vector of lagged values for each predictor

The DLNM generalizes this by incorporating cross-basis functions that jointly model nonlinear and lagged effects:

$$s(x_{tj}; \eta) = \sum_{j=1}^{\vartheta_x} \sum_{k=1}^{\vartheta_l} r_{tj}^T . c_k \eta_{jk,} \quad (4)$$

Where,

r_{tj}^T	Transformed vector for predictor j at time t
c_k	Basis coefficients capturing the lagged impacts.

The advantages of the DLNM framework in modeling complex relationships are such that, firstly, the smoothing functions capture well nonlinear relationships typically observed between meteorological variables and electricity prices-in particular, the nonlinear effects of extreme temperatures. Second, a distributed lag model is

embodied within the DLNM framework; it accounts for the temporal unfolding of the impacts in predictors and is an enriching way of understanding both short-run and long-run dynamics. Besides, it can include in the framework cross-basis functions that jointly model nonlinear and lagged effects, extending this to the complete complexity of such relationships. The DLNM framework is highly scalable; it can take more predictors or interactions. Hence, it can be adapted for similar research studies.

Results

Temporal Dynamics in the Relationship Between Inflation and Gold Prices in Europe

The temporal dynamics of the relationship between inflation, as measured by the HICP, and European gold prices turn out to be significant for 2- and 3-month lagged effects. The 2-month lag analysis (Figure 1) focuses on a strong and concentrated positive correlation between inflation and gold prices, especially in higher price ranges above 1500 units. This would therefore suggest that inflationary pressures immediately and conclusively determine the prices of gold in the shorter term, in a way consistent with its traditional role as a hedge against inflation. The few negative correlations are at lower price levels than 1000 units and reflect the limited countervailing factors in the short term, whereas neutral zones are scant, reflecting strong responses within this period. By contrast, the 3-month (Figure 1) lag analysis discloses a weak but more disseminated and permanent positive correlation within higher price ranges, signaling that over time, the effect of inflation becomes less strong; it is just stabilized. Correspondingly, the negative correlations grow in strength and become more ubiquitous, especially in the lower ranges of prices, to the extent that continued market adjustments or exogenous factors such as monetary policy intervention and global market fluctuations might offset the inflationary effect. The neutral zones then widen considerably over the same period, especially in middle-range gold price positions, suggesting stabilization of the inflation-gold price relationship for this longer-lagged position. These findings depict temporal complexity for gold as an inflation hedge. Though at high price levels, gold proves to be a good hedge against inflation, the negative and neutral correlations on the lower price levels and larger lag periods reflect an interaction of the macroeconomic factors. While shorter lag periods, such as 2 months, capture the more immediate and sharp responses of the market to inflationary pressures, longer lag periods, such as 3 months, reflect the delayed but sustained effects that accompany the growing impact of external variables. These results highlight the need to consider both temporal dynamics and broader economic conditions when evaluating the relationship between inflation and gold prices, a fact that is of great value to investors and policymakers alike. The cumulative impact of inflation on the price of gold, as was shown in these two plots (Figure 2), is quite intricate over time, a positive, followed by a decline into negative territory. In the first plot, which captures the relationship over a 2-month lag, the cumulative effect starts near zero and increases slightly to a peak around the 1-month mark. This reflects a short-run positive impact of inflation on gold prices, likely driven by gold's role as a hedge against inflationary pressures. However, after this peak, the cumulative effect starts to decline, turning negative by the end of the 2-month lag period. This would, therefore, suggest that delayed market dynamics, such as profit-taking or external economic adjustments, may suppress gold prices in the medium term. This is further supported by the widening of the confidence interval-the shaded gray area for longer lag periods, showing the increasing uncertainty in the relationship over time. The pattern is continued in extending the analysis to a 3-month lag shown in the second plot. It starts to rise to a peak at around 1–1.5 months, reflecting the same short-term positive response of gold prices to inflation. However, in this prolonged lag period, the decline in the cumulative effect is sharper and more prolonged, turning negative after the 2-month mark and continuing to decrease through the 3-month period. It, therefore, denotes that while the price of gold responds well to inflationary pressures immediately, over long lag periods, it becomes less effective as an inflation hedge with greater market adjustments or exogenous factors such as monetary policy, currency dynamics, or investor sentiment. The width of the confidence interval in this plot also increases significantly beyond the 1-month mark, further emphasizing the increasing uncertainty in estimating the cumulative effect of inflation on gold prices over longer time frames.

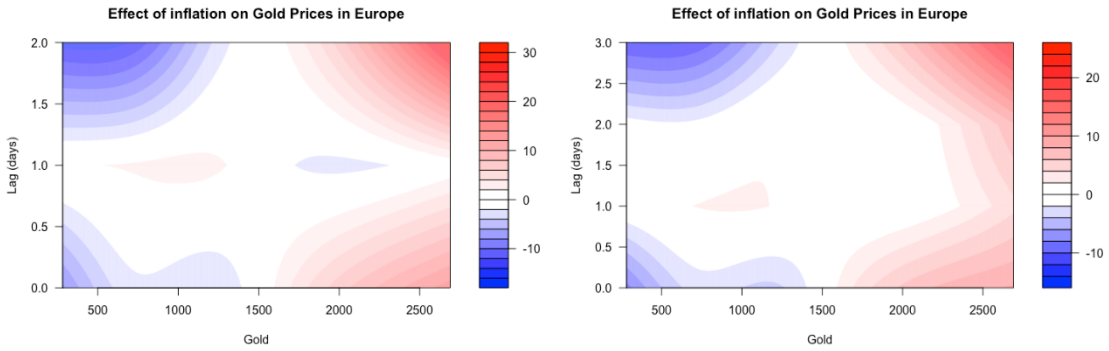

Figure 1: Effects of Inflation on Gold Prices in Europe

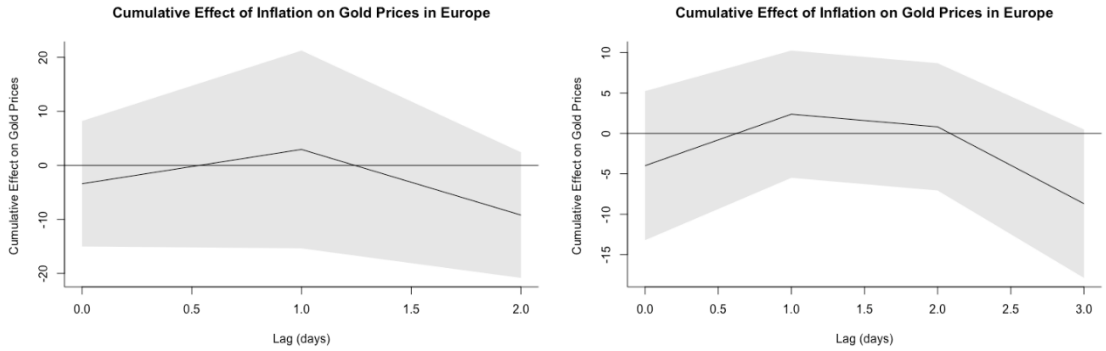

Figure 2: Cumulative Effects of Inflation on Gold Prices in Europe

Temporal Dynamics in the Relationship Between Inflation and Gold Prices in the US

The contour plots (Figure 3) for different lag periods below show a clear temporal and spatial dynamic in the relationship between inflation and the prices of gold in the United States. The first plot, considering lag effects up to 3 months, shows a clear positive correlation between inflation and gold price in the higher price ranges (over 1500 units) with lags from 2-3 months. These red-shaded areas show the persistence of the impact of inflationary pressures on gold prices over time, in line with the traditional role of gold as an inflation hedge. The negative values are seen within the lower price ranges-less than 1000 units-and these are stronger for longer lag periods. Such blue-shaded areas may reflect short-run adjustments in the markets, investor psychology, or external economic factors, including monetary policy. Neutral zones, represented by the white areas, are less dominating. This would indicate that the relationship between inflation and gold price is still on and prevailing during the period. The second plot extends the analysis for a 4-month lag, but the patterns show up somewhat differently. The positive correlation in higher price ranges survives, especially the lags around 3 to 4 months, which reinforces the idea of the inflationary impact on gold prices becoming more pronounced with a longer lag. However, their negative counterparts increase in intensity, too, and spread through the lower- and mid-range price levels. This would reveal the complexity of the delayed adjustment of markets, where the sustained inflationary pressures interact with other macroeconomic variables, producing divergent effects on gold prices. The presence of larger neutral zones, especially in the middle-range gold prices, would therefore suggest a stabilization in the inflation-gold price relationship over the extended lag period. These findings therefore suggest that the relationship between inflation and the price of gold in the U.S. market is dynamic and time-dependent. While it was observed that for higher ranges of prices, gold was an effective hedge against inflation, the observed negative correlations and neutral zones for lower price ranges and longer lags hint at other influencing factors such as monetary policy, currency fluctuations, and global market dynamics. The above results pointed out the lag effect and the price level as significant factors affecting the inflationary impact on the price of gold. These insights may be useful to policymakers and investors in using gold as an asset in an inflationary environment with consideration of time factors and market-specific peculiarities of this relationship Both plots (Figure 4) outline the temporal complexity of the inflation-gold price relationship in the U.S. market. The overall cumulative impact of inflation on gold prices is positive in the short run, peaking in about 1.5 to 2 months, but it diminishes and eventually reverses when the lag period is extended. This, therefore, suggests that effectiveness as an inflation hedge for gold is time-sensitive and subjected to other broader market dynamics. The widening confidence intervals in both plots signal that results should be treated with caution, especially for the greater lag periods. The results underscore the inclusion of lag effects and external economic variables in the analysis of inflation's impact on gold prices; thus, a source of valuable insights for investors and policymakers.

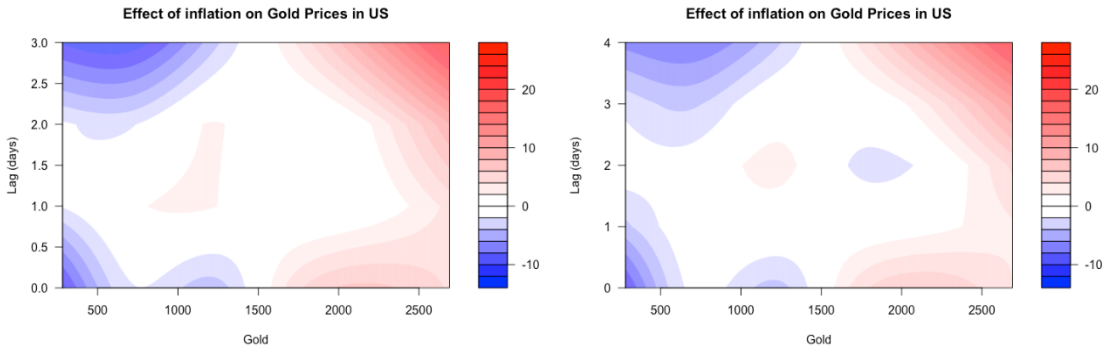

Figure 3: Effects of Inflation on Gold Prices in US

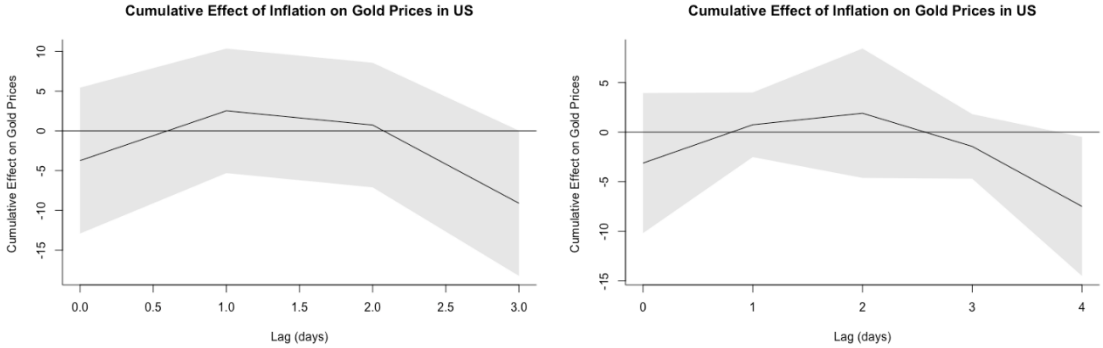

Figure 4: Cumulative Effects of Inflation on Gold Prices in the US

Discussion

RQ1) How does inflation influence gold prices in Europe and the US?

From the analysis carried out, it was depicted that the inflation-gold prices relationship is of a time-varying nature with dynamic characteristics; it showed that in both Europe and the United States, their relationship has varying features. Consequently, short- and medium-run differences regarding these impacts were traced, on diversified contexts occasioned by different market structures and investors' behavior of the two sets of regions.

Gold prices are seen to respond positively to European inflation, where the prices are high and above 1500 units. The impact observed within a small lag period was also more apparent, around 1-1.5 months. That has also been consistent with gold's traditional role of serving as a hedge against inflation, which is a phenomenon when surges in inflation raise the demand for gold as some sort of safe-haven asset. This is explained by the frenzy in market activities as people struggle to retain their purchasing power due to upward-spiraling inflation. However, this positive impact is considerably weakened in the long run. In fact, when lag periods exceed 2 months, the relationship becomes negative. This might be due to several factors, including market corrections, changes in gold prices based on changes in investor expectations, and the general macroeconomic situation. Additionally, the negative correlations are stronger at lower levels of the gold price, below 1000 units, perhaps suggesting that the efficacy of gold as an inflation hedge is conditional on prevailing market conditions and price ranges. At lower price levels, the effectiveness of gold to absorb inflationary pressures seems weaker, maybe because of less confidence by investors or due to the presence of other investment avenues.

In the US, in the European context, the inflation-gold price relationship is positive in the short run and most pronounced for very short lag periods, peaking around 1.5 to 2 months. This strengthens the view that, in fact, gold is a good inflation hedge in the immediate inflationary shock. Whereas, on the other side, when the lag periods are extended up to approximately 4 months, the cumulative sum of the impact of inflation on the price of gold is seen to be more extended and pronounced for a longer period than that in Europe. The cause of such deviation may be the exogenous variables of US monetary policy, US dollar fluctuations, and global economic conditions that are pushing gold prices under immense pressure. As in Europe, positive correlations dominate at higher price levels, while negative correlations are concentrated at lower price levels and longer lag lengths. This, therefore, suggests a duality in the relationship between inflation and the price of gold works optimally as an inflation hedge when the market conditions are ideal but loses effectiveness beyond threshold levels of price and time. While confidence intervals for both regions widen with longer lag periods, this suggests growing uncertainty in the estimation of the inflation-gold price relationship over time. This indicates that the temporal dynamics can be so complicated and

intimates factoring in the time-sensitive variables when such relationships are analyzed. Temporal and contextual factors, thus, seem very important from these findings on the relationship between inflation and the price of gold. Whereas gold is effective in hedging against inflation, especially at higher price regimes over the short run, its strength weakens over time.

However, this weakening is greatly tempered by exogenous factors that include, among others, the state of the macroeconomy, monetary policy interventions, and events unfolding in the world's economy. For instance, such effects may be overstated or muted due to external shocks in interest rate changes, currency devaluation, or geopolitical tensions that have taken place in Europe and the US. This also underlines the role of market conditions and price levels in determining the efficacy of gold as an inflation hedge. Generally, the higher the range of gold prices, the higher the positive correlation with inflation; that is, during periods of high prices, the Hedge performance of gold was better. This relationship is reinforced and even becomes negative for some at the lower ranges, casting some doubt on the viability of gold as a hedge universally across market conditions.

With respect to these findings, the implications for investors and policymakers that employ gold to combat inflationary pressures will involve using time-sensitive and region-sensitive methods. This would be factoring in, for investors, the temporal dynamics of the relationships between inflation and the gold price, the conditions, and the level of prices that prevail in the market. Thus, a short-term strategy may involve the use of gold during those high inflationary periods when its prices are also high, while longer-term strategies must accommodate the likely weakening of the hedge and diversification to other inflation-resistant assets.

On the other hand, policymakers should not be blind to the fact that gold is an effective hedge on inflation only conditionally. Temporal dynamics and macroeconomic insights in economic planning and policy frameworks are essential to be considered by policymakers. For example, policies to stabilize the macroeconomic environment when the inflationary pressures are high can further help stabilize gold as a hedging instrument and dampen volatility in investor behavior.

Conclusion

The present study unraveled the dynamic and temporal complexities in the relationship between European and US inflations and the prices of gold, hence useful for both investors and policymakers. Going into the nuanced interplay between the variables, the findings affirm that, indeed, gold is an effective hedge against inflation, especially in the short run and at higher price levels. That influences the wide perception of gold as a safe store of value during economic uncertainties and periods of inflation. However, this relationship is not fixed; it is evolutionary in time. The analysis has shown that the correlation over time tends to get relatively weaker and sometimes shifts into a negative or neutral position once longer lag periods or lower price levels are introduced. The basis for this divergence shows that the nexus of inflation and gold price is indeed of a multifarious nature and situation-based.

Contributorily, this paper allows us to understand broadly based drivers of inflation and prices of gold: monetary policy decisions, changes in currency value, and a change in global financial markets. This also adds regional differences - Europe and the US. Both have a positive inflation-gold price nexus in the short run, while the US presents a more serious and longer drop in cumulative effects for longer lag periods. It could be indicative of sensitivity to external shock and rapid adjustments that characterize the US market. These regional differences, therefore, underline the need to adopt context-specific strategies in assessing gold's role as an inflation hedge, since a one-size-fits-all approach may not be able to capture the nuanced dynamics at play.

The study also throws light on the inherent uncertainties tied to long-run estimates of inflation's impact on gold price variations. These enlarged confidence intervals with longer lags reflect increased unpredictability and, in turn, raise long-term projections and planning prudently. The results imply that in any further analysis or decision-making framework, one may want to embed temporal dynamics, price level, and external economic variables. They also hint at the relevance of precision and the capability of adaptation while devising strategic plans for preserving wealth and stabilizing the economy.

From a strategic perspective, the present study has underlined how both time and the state of the market are important in assessing the efficiency of gold as an inflation hedge. Policymakers and investors can use this analysis to find their way out of the maze of inflationary economies by understanding how different lengths of time and economic regimes determine the magnitude of protection given by gold. For this reason, gold remains one of the key components in a portfolio hedging against inflation; more precisely, in the short run. It is also the very backbone of broader economic resilience.

Therefore, it would provide fertile ground for the prudent understanding of the association between gold price and inflation levels to develop, thus creating avenues for more targeted and efficient policy-making or better investment. While negotiating such diverse temporal divergence, regional nuances, and influences in outside markets, these findings add an understanding of how gold works while preserving wealth. Such results would lead to reinforcing, on a strategic note, that the role and function of gold are vital in negotiating with inflation and

uncertainty toward economic stability for financial stability over the long term, assisting stakeholders to go through the various challenges with increased efficacy.

Reference

Anandasayanan, S., Thevananth, J., & Mathuranthy, A. (2019). The Relationship Between Inflation and Gold Price: Evidence From Sri Lanka. *International Journal of Accounting and Financial Reporting*, *9*(4), Article 4. https://doi.org/10.5296/ijafr.v9i4.15750

Arshad, S., Vu, T. H. N., Warn, T. S., & Ying, L. M. (2023). The Hedging Ability of Gold, Silver and Bitcoin against Inflation in ASEAN Countries. *Asian Academy of Management Journal of Accounting and Finance*, *19*(1), Article 1. https://doi.org/10.21315/aamjaf2023.19.1.5

Aye, G. C., Chang, T., & Gupta, R. (2016). Is gold an inflation-hedge? Evidence from an interrupted Markov-switching cointegration model. *Resources Policy*, *48*, 77–84. https://doi.org/10.1016/j.resourpol.2016.02.011

Balcilar, M., Ozdemir, Z. A., Shahbaz, M., & Gunes, S. (2018). Does inflation cause gold market price changes? Evidence on the G7 countries from the tests of nonparametric quantile causality in mean and variance. *Applied Economics*, *50*(17), 1891–1909. https://doi.org/10.1080/00036846.2017.1380290

Bampinas, G., & Panagiotidis, T. (2015). Are gold and silver a hedge against inflation? A two century perspective. *International Review of Financial Analysis*, *41*, 267–276. https://doi.org/10.1016/j.irfa.2015.02.007

Batten, J. A., Ciner, C., & Lucey, B. M. (2014). On the economic determinants of the gold–inflation relation. *Resources Policy*, *41*, 101–108. https://doi.org/10.1016/j.resourpol.2014.03.007

Beckmann, J., & Czudaj, R. (2013). Gold as an inflation hedge in a time-varying coefficient framework. *The North American Journal of Economics and Finance*, *24*, 208–222. https://doi.org/10.1016/j.najef.2012.10.007

Białek, J. (2020). Proposition of a hybrid price index formula for the Consumer Price Index measurement. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *15*(4), Article 4. https://doi.org/10.24136/eq.2020.030

Blose, L. E. (2010). Gold prices, cost of carry, and expected inflation. *Journal of Economics and Business*, *62*(1), 35–47. https://doi.org/10.1016/j.jeconbus.2009.07.001

Capie, F., Mills, T. C., & Wood, G. (2005). Gold as a hedge against the dollar. *Journal of International Financial Markets, Institutions and Money*, *15*(4), 343–352. https://doi.org/10.1016/j.intfin.2004.07.002

Chang, X. (2024). Gold Price Inflation and Its Implications for Financial Markets: Strategies for Mitigation. *Advances in Economics, Management and Political Sciences*, *119*, 189–194. https://doi.org/10.54254/2754-1169/119/20242530

Chien, L.-C., Guo, Y., Li, X., & Yu, H.-L. (2018). Considering spatial heterogeneity in the distributed lag non-linear model when analyzing spatiotemporal data. *Journal of Exposure Science & Environmental Epidemiology*, *28*(1), 13–20. https://doi.org/10.1038/jes.2016.62

Coibion, O., Gorodnichenko, Y., Kumar, S., & Pedemonte, M. (2020). Inflation expectations as a policy tool? *Journal of International Economics*, *124*, 103297. https://doi.org/10.1016/j.jinteco.2020.103297

Conlon, T., Lucey, B. M., & Uddin, G. S. (2017). Is gold a hedge against inflation? A wavelet time-scale perspective. *Review of Quantitative Finance and Accounting*, *51*(2), Article 2. https://doi.org/10.1007/s11156-017-0672-7

Ding, Y., Hu, Y., & Zhang, Z. (2023). The impact of the triangular US dollar, oil, and gold model on global inflation. *Applied Economics Letters*, *0*(0), 1–5. https://doi.org/10.1080/13504851.2023.2278591

Do, M. D., Tran, T. D., Nguyen, H. N., Le, N. M., & Ninh, D. H. (2023). Is gold an inflation hedge in Vietnam? A non-linear approach. *Cogent Economics & Finance*, *11*(2), 2244857. https://doi.org/10.1080/23322039.2023.2244857

Erb, C. B., & Harvey, C. R. (2013). The Golden Dilemma. *Financial Analysts Journal*, *69*(4), 10–42. https://doi.org/10.2469/faj.v69.n4.1

Erb, C., Harvey, C. R., & Viskanta, T. (2020). Gold, the Golden Constant, and Déjà Vu. *Financial Analysts Journal*, *76*(4), 134–142. https://doi.org/10.1080/0015198X.2020.1817698

Ergül, Ö., & Karakaş, T. (2024). Analysis of the relationship of gold prices with inflation and bitcoin in the post-tapering period. *Borsa Istanbul Review*, *24*(4), 797–805. https://doi.org/10.1016/j.bir.2024.04.009

Gao, S., Yang, T., Zhang, X., Li, G., Qin, Y., Zhang, X., Li, J., Yang, S., Yin, M., Zhao, J., Wei, N., Zhao, J., Li, L., Li, H., Yue, X., Zhang, W., Jia, X., Fan, Y., & Liu, H. (2023). A longitudinal study on the effect of extreme temperature on non-accidental deaths in Hulunbuir City based on DLNM model. *International Archives of Occupational and Environmental Health*, *96*(7), Article 7. https://doi.org/10.1007/s00420-023-01986-5

Gasparrini, A. (2011). Distributed Lag Linear and Non-Linear Models in R: The Package dlnm. *Journal of Statistical Software*, *43*, 1–20. https://doi.org/10.18637/jss.v043.i08

Gasparrini, A., Scheipl, F., Armstrong, B., & Kenward, M. G. (2017). A Penalized Framework for Distributed Lag Non-Linear Models. *Biometrics*, *73*(3), 938–948. https://doi.org/10.1111/biom.12645

Ghodke, M., & Giri, P. (2023). Consumer Price Index (CPI) – Types & Sources. *Indian Journal of Community Health*, *35*(4), 520–525. https://doi.org/10.47203/IJCH.2023.v35i04.020

Gomis-Porqueras, P., Shi, S., & Tan, D. (2022). Gold as a financial instrument. *Journal of Commodity Markets*, *27*, 100218. https://doi.org/10.1016/j.jcomm.2021.100218

Gulseven, O., & Ekici, O. (2020). *The role of real estate and gold as inflation hedges: The Islamic influence* (world). https://doi.org/10.1108/IMEFM-01-2019-0038

Habashi, F. (2016). Chapter 1—Gold – An Historical Introduction. In M. D. Adams (Ed.), *Gold Ore Processing (Second Edition)* (pp. 1–20). Elsevier. https://doi.org/10.1016/B978-0-444-63658-4.00001-3

Herzberg, J., Knetsch, T. A., Schwind, P., & Weinand, S. (2023). Quantifying Bias and Inaccuracy of Upper-Level Aggregation in the Harmonised Index of Consumer Prices for Germany and the Euro Area. *Review of Income and Wealth*, *69*(3), 581–605. https://doi.org/10.1111/roiw.12602

Hoang, T. H. V., Lahiani, A., & Heller, D. (2016). Is gold a hedge against inflation? New evidence from a nonlinear ARDL approach. *Economic Modelling*, *54*, 54–66. https://doi.org/10.1016/j.econmod.2015.12.013

Hussain Shahzad, S. J., Bouri, E., Roubaud, D., & Kristoufek, L. (2020). Safe haven, hedge and diversification for G7 stock markets: Gold versus bitcoin. *Economic Modelling*, *87*, 212–224. https://doi.org/10.1016/j.econmod.2019.07.023

Iqbal, J. (2017). Does gold hedge stock market, inflation and exchange rate risks? An econometric investigation. *International Review of Economics & Finance*, *48*, 1–17. https://doi.org/10.1016/j.iref.2016.11.005

Isnin, M., & Zulfa, I. (2024). Predicted Increase in Gold Price Every Year with Impact on Economic Factors. *International Journal of Economics and Management Sciences*, *1*(4), Article 4. https://doi.org/10.61132/ijems.v1i4.359

Kumar, S. (2017). *What determines the gold inflation relation in the long-run?* (world). https://doi.org/10.1108/SEF-04-2016-0084

Li, J., Rao, X., Li, X., & Guan, S. (2022). Gold and Bitcoin Optimal Portfolio Research and Analysis Based on Machine-Learning Methods. *Sustainability*, *14*(21), Article 21. https://doi.org/10.3390/su142114659

Lucey, B. M., Sharma, S. S., & Vigne, S. A. (2017). Gold and inflation(s) – A time-varying relationship. *Economic Modelling*, *67*, 88–101. https://doi.org/10.1016/j.econmod.2016.10.008

Mosquera-López, S., Uribe, J. M., & Joaqui-Barandica, O. (2024). Weather conditions, climate change, and the price of electricity. *Energy Economics*, *137*, 107789. https://doi.org/10.1016/j.eneco.2024.107789

Oloko, T. F., Ogbonna, A. E., Adedeji, A. A., & Lakhani, N. (2021). Fractional cointegration between gold price and inflation rate: Implication for inflation rate persistence. *Resources Policy*, *74*, 102369. https://doi.org/10.1016/j.resourpol.2021.102369

Pattnaik, D., Hassan, M. K., DSouza, A., & Ashraf, A. (2023). Investment in gold: A bibliometric review and agenda for future research. *Research in International Business and Finance*, *64*, 101854. https://doi.org/10.1016/j.ribaf.2022.101854

Rafalovich, A. (2011). Gold Dreams, Gold Nightmares: The Social Construction of Inflation as Delegitimation Discourse. *Sociological Research Online*, *16*(1), 21–31. https://doi.org/10.5153/sro.2228

Rodrigues, M., Santana, P., & Rocha, A. (2019). Effects of extreme temperatures on cerebrovascular mortality in Lisbon: A distributed lag non-linear model. *International Journal of Biometeorology*, *63*(4), Article 4. https://doi.org/10.1007/s00484-019-01685-2

Shahbaz, M., Tahir, M. I., Ali, I., & Rehman, I. U. (2014). Is gold investment a hedge against inflation in Pakistan? A co-integration and causality analysis in the presence of structural breaks. *The North American Journal of Economics and Finance*, *28*, 190–205. https://doi.org/10.1016/j.najef.2014.03.012

Sharma, S. S. (2016). Can consumer price index predict gold price returns? *Economic Modelling*, *55*, 269–278. https://doi.org/10.1016/j.econmod.2016.02.014

Steele, G. R. (1989). *Inflation*. https://doi.org/10.1007/978-1-349-09994-8_11

Talagala, T. (2022). Distributed Lag Nonlinear Modelling Approach to Identify Relationship between Climatic Factors and Dengue Incidence in Colombo District, Sri Lanka. *Epidemiology, Biostatistics, and Public Health*, *12*(4), Article 4. https://doi.org/10.2427/11522

Tronzano, M. (2022). Optimal Portfolio Allocation between Global Stock Indexes and Safe Haven Assets: Gold versus the Swiss Franc (1999–2021). *Journal of Risk and Financial Management*, *15*(6), Article 6. https://doi.org/10.3390/jrfm15060241

Valadkhani, A., Nguyen, J., & Chiah, M. (2022). When is gold an effective hedge against inflation? *Resources Policy*, *79*, 103009. https://doi.org/10.1016/j.resourpol.2022.103009

Wang, K.-M., Lee, Y.-M., & Thi, T.-B. N. (2011). Time and place where gold acts as an inflation hedge: An application of long-run and short-run threshold model. *Economic Modelling*, *28*(3), 806–819. https://doi.org/10.1016/j.econmod.2010.10.008

Wynne, M. A., & Rodriguez-Palenzuela, D. (2004). Measurement Bias in the HICP: What do we know and What do we need to know? *Journal of Economic Surveys*, *18*(1), 79–112. https://doi.org/10.1111/j.1467-6419.2004.00216.x

Yang, Y., Li, X., Wang, S., Lei, Y., Xu, W., Li, Y., Yang, L., Miao, J., Wang, W., & Yin, L. (2024). Assessing the impact of temperature on acute exacerbation of chronic obstructive pulmonary disease hospitalizations in residents of Panzhihua City: A multi-districts study using a distributed lag non-linear model. *BMC Public Health*, *24*(1), 2151. https://doi.org/10.1186/s12889-024-19677-2

Zhao, J., Zhang, Y., Ni, Y., He, J., Wang, J., Li, X., Guo, Y., Li, C., Zhang, W., & Cui, Z. (2022). *Frontiers | Effect of ambient temperature and other environmental factors on stroke emergency department visits in Beijing: A distributed lag non-linear model*. https://doi.org/10.3389/fpubh.2022.1034534

Zheng, Y., Emam, M., Lu, D., Tian, M., Wang, K., & Peng, X. (2023). Analysis of the effect of temperature on tuberculosis incidence by distributed lag non-linear model in Kashgar city, China. *ENVIRONMENTAL SCIENCE AND POLLUTION RESEARCH*, *30*(5), 11530–11541. https://doi.org/10.1007/s11356-022-22849-5