Economic and Financial Determinants of Gold ETF Price Volatility on the U.S. Futures Market (COMEX)

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The price of gold ETFs on the COMEX market in the USA is influenced by both domestic and international economic and political factors. In our study, we focus on domestic economic variables as key drivers of gold ETF prices, using the Newey-West estimator to assess their impact, particularly in the presence of significant autocorrelation. Our analysis of domestic determinants over the past 15 years revealed noteworthy insights. CPI, the US dollar exchange rate, interest rates, and crude oil prices negatively affect gold prices. However, the 30-year fixed mortgage rate and the U.S. Economic Policy Uncertainty index had a positive impact. Gold remains a safe haven in times of economic uncertainty, but our model displayed some weaknesses with strong positive autocorrelation and heteroscedasticity in residuals. To address these issues, we constructed an alternative model, focusing on the most recent five years. Since 2017, we've observed a shift where inflation and interest rates no longer significantly affect gold prices. Recent interest rate hikes and high inflation had minimal impact, especially during stock market declines. Gold does not appear to act as a hedge against bear markets as it did during the Global Financial Crisis; instead, the US dollar may fulfill this role. Given the unprecedented economic disruptions caused by the Covid-19 pandemic, further research is needed to explore the effects of domestic financial and economic KPIs on gold prices and their interconnections and spillover effects.

Keywords: ETFs; Commodity Exchange; US Commodities; Gold Futures; Quantitative Analysis;

1. Introduction and brief literature review

Gold has been commonly considered to be a safe haven for investments since the beginning of the modern trade and the exchange system. Its rarity, durability, and inimitability have created a perception for intrinsic value and maintained its reputation of a risk-free, stable investment, guaranteeing the preservation of value over time. Recent gold price volatility, however, has raised the question whether gold is a real safe haven and what are the driving forces behind its price fluctuations. After the start of the Covid-19 pandemic, gold price

fluctuations have become frequent and with no evident cause [1]. Price swings became sudden and sharp, increasing the risk in gold investment. Such a market has cast a shadow of doubt over gold's reputation of being a safe haven investment. Many investors, especially in the post-Covid-19 era started to question the driving forces behind the increased gold price volatility.

Gold is traded on several major markets worldwide. The London OTC market is the largest by volume, followed by the US COMEX gold futures market and the Shanghai Gold Exchange (SGE). These top tree account for more than 90% of the gold trade worldwide. The US gold futures market comprises nearly 35% of the global trade, according to the World Gold Council [2]. It is operated by the CME Group, as its importance has grown in recent years.

With the development of the financial markets, the perception of gold shifted from being a precious metal, to more of a financial instrument, a relatively risk-free opportunity to invest, and an asset easy to acquire and dispose without significant storage and logistic costs. Such change was due to the introduction of gold ETF's in 2003.[1]

Extensive academic research was performed on the gold price determinants in various economies and time periods. Indicatively, [3] investigate the dynamic spillovers and linkages between gold and economic and financial variables, including 3-Month Treasury bill secondary market rate, and the economic policy uncertainty index for the USA, while [4] identify the level of M2 money supply as one of the gold price determinants. [5] finds a link between corporate bond yields and gold prices, and [6] captures the link between the gold price and the mortgage rates during the global financial crisis of 2007–2009.

By using the mentioned economic and financial variables as gold price determinants, this research aims to estimate the extent that domestic macroeconomic factors in the U.S. influence the price of gold ETF futures on the domestic COMEX gold market by using more recent data and different econometric specifications (a Newey-West regression process).[2] Moreover, market data from the last two years pictures unknown patterns of high gold and stock volatility, seemingly hard to explain. Over the course of the last years gold fluctuated sharply in the short run, as the causes of such high volatility were hard to identify. Similar behavior was experienced in the stock and the bond markets, and as such is further interesting to investigate the determinants of gold.[3]

The paper is structured as follows: this section proceeds with a brief literature, section 2 is referred to the methodology, section 3 presents the data and the empirical results, while section 4 analyzes the findings, and Section 5 concludes.

1.1 CPI (Consumer Price Index)

[7], [8] and [9] spot a positive, statistically significant relationship between inflation and gold. These studies are delivered in the context of various counties and periods, leading to a similar conclusion: CPI is a determinant of the gold price, and the relationship is positive. A rational explanation of such a dependency is that as inflation increases, it is a natural behavior to invest in gold as it is perceived as a safe haven [10]. On the other hand, [11], [12], [13] and [14] find a weak relationship between them. They stipulate that inflation is not a strong determinant of the gold price and other factors play a more significant role in this respect. [15]

[1] These funds hold gold derivatives, such as gold futures that track the gold price, or physical gold. They may be bought and sold at any financial market as their prices are updated multiple times a day, making them more liquid and attractive to investors than physical gold. Although gold demand is still a significant factor, the gold ETFs price became interrelated to the prices of other investment alternatives assets – corporate stock, corporate and government bonds, real estate and other commodities and their derivatives. Acting as their substitute for investors, the gold ETF's price became interrelated to their prices, as well as to some domestic economic indicators.

[2] There are distinct limitations to the scope of this research. It does not cover the price determination of physical gold, used for jewelry or industrial purposes. It is not as well including international factors affecting the gold price, such as global demand and supply, technological progress, the level of global geopolitical risk and other international factors (see [58], [59]).

[3] Previously established, considered to be obvious in the past, stock market declines stopped causing abrupt rises in the gold price. A 20% market decline on the NYSE in 2022 did not cause a stable increase in the gold price, as it would have previously been expected. Bond yields do not fluctuate in the similar, previously known patterns in line with the stock market.

moreover find a negative impact of the inflation on gold; according to their study high inflation asserts a negative pressure on the gold price.

1.2 The Nominal Broad US Dollar Index

[11] provides evidence for a statistically significant negative relationship between the US Dollar exchange rate and the gold price. The same result is evident in [7], [16], [12], [17], [13], [14] and [18]. Also, [19], [8] and [20] found a weak negative impact of the US dollar exchange rate on gold. Their research concludes the US dollar rate has some negative relationship with the golds price but is a weak determinant of the latter. [9] reports a positive impact of the US Dollar rate on the gold price. There is a consensus between the researchers on the significant negative impact of the strong US dollar on the gold price, than on the effect of inflation. Despite that, there are still different conclusions on the relationship.

The US Dollar exchange rate enters into “collusion” with other macroeconomic key performance indicators before they collectively affect the gold price. For this evidence see [10], [21], [22]. A dynamic relationship between the gold price, US dollar exchange rate, the oil price, and the stock index is demonstrated also by [23].

1.3 Wilshire 5000

Previous academic research shows evidence of a negative relationship between stock prices and the gold price. [8], [24], [16], [9] observe a statistically significant, negative relationship between the stock market and the gold price. Other research, done by [17], [25], [26], suggests a negative influence of the stock market on the gold price, but weak and statistically non-significant; they note a high volatility and spillover between the stocks, bonds, and the gold price in a dynamic relationship between them. [27] concluded in their research with an anomaly (in 2020) spotting a positive relationship between the stock prices and gold. This is another challenge for gold’s status of being a safe haven.

1.4 The Federal Funds Effective Rate (FFER), or the Interest Rate

The interest rate is yet another determinant of the gold price mentioned frequently. The majority of literature mentions a negative relationship between interest rates and gold price. [28] and [29] observe a significant negative impact on gold.

[30], find a negative impact on gold by rising interest rates, but it is not statistically significant. According to them the interest rate is a weak determinant of gold price and may be neglected in forecasting it. On the contrary, [31] have identified a positive, statistically significant dependence of gold on the interest rates. They have observed such a relationship in times of increasing interest rates. The authors conclude that gold may be used as a hedge against interest rate risks.

1.5 The Crude Oil Price (Spot Price, Texas Intermediate, TXI)

Almost every research on gold price determinants analyzes its relationship with and dependency on the crude oil price. The two economic KPI’s are closely related. [7], [24], [16], [15], and [32] find a significant positive influence of oil on the gold price. The main rationale behind such observations is that the oil price determines the prices of all other consumer and industrial goods and hence inflation. As already noted, the CPI may be a statistically significant factor in determining the gold price. Other research, done by [9] and [13] describe a weak, statistically insignificant positive relationship of crude oil on gold. They find inconclusive evidence of the influence of oil prices on gold. [33] conclude that, not only is the effect of oil prices on gold weak, but it is negative. In their case study an increase of crude oil tends to lead to a decrease in the gold price. Furthermore, [34] find a statistically significant negative

relationship between oil and gold prices. They research conclusively shows evidence in this direction. [22], [35], [36], [37] and [38] search for more dynamic effects and cointegration between oil prices, gold, the exchange rate, interest rates and the US dollar rate.

1.6 Moody's AAA Corporate Bond Yield (DAAA)

Academic research was done on the influence of bond yields on the gold price. [5] observes a tendency for the gold prices to fall when the yield on corporate bonds rises. AAA bonds act as a substitute to gold as an investment, and a rise in their yield increases the opportunity cost of investing in gold. [39] and [26] perform independent research on the dynamic relations between stocks, government bonds and golds prices. They both reach the same conclusion: gold is being used as a hedge against stock market risk, but there is no evidence of any role of the bond yields in the gold price.

1.7 The Fixed 30-Year US Mortgage Rate

On the relationship between mortgage rates and the gold price the academic research is scarce. Investing in real estate is a possible alternative to investing in gold futures. However, do higher mortgage rates play any role in the demand for gold and its price by suppressing the demand for investing in real estate? There is no academic literature on the topic, neither in the U.S., not in the rest of the world. The study of the sample of 172 observations between June 2008 and September 2022 will test the existence and the statistical significance of such a relationship.

1.8 The Unemployment Rate (UR)

Unemployment is rarely considered a determinant of the gold price. Academic literature is in general lacking research in this area, as unemployment is deemed an insignificant determinant of gold price. Commonsense would expect unemployment to influence the gold price in a negative manner, as the rise in unemployment would leave less disposable income to be invested in gold. However, the historic data shows otherwise. [40] conduct one of the few research projects on the topic, concentrating on the period of the global financial crisis of 2007–2009 and its effect on the gold price in the U.S. The authors discover a strong positive, elastic and statistically significant influence of unemployment on the gold price.

1.9 The GDP per Capita in the US (GDPPC)

The GDP per capita is not among the most investigated determinants of gold price. In general, an increase in the GDP directly leads to an increased purchasing power, of both households and investment capabilities by firms. Therefore, it is expected to find some positive relationship between GDP and the gold price. [41] and [42] conduct research on this relationship and find a positive relationship between the two variables. However, not all academic research yields the same result. [43] and [44] support a statistically significant negative impact of GDP on the gold price. For periods of sharp economic recessions this is actually the case, as an announcement of the start of an economic recession is likely to massively rush investors to start selling their stock portfolios and buy gold as a safe haven. Both hypotheses will be tested if they hold true of the context of the U.S. market, both the 2008–2010 and the Covid-19 crisis, and the period of economic growth in between.

1.10 The price of silver ETF's (SILVER)

Silver is often considered a substitute commodity for gold. Some investors have seen it as a cheaper alternative to gold and a hedge against various risks. [45] discover a positive, statistically significant influence of silver on gold prices. [46] manage to prove the opposite: a significant negative effect of silver prices on gold. [47] find no statistically significant impact of the silver price on gold.

1.11 Money Supply M2 in the US (M2MS)

The money supply in an economy is another defining factor for the prices of all commodities and investment instruments. High money supply is likely to fuel inflation and assent an upward pressure on the prices of all commodities. [48] describe the complex relationship between money supply and the gold price in the context of different economic conditions. They do not establish a clear, one-way relationship between money supply and the gold price.

1.12 The Economic Policy Uncertainty Index for United States (USEPUCIN)

The U.S. Economic Policy Uncertainty Index is an indicator of the level of uncertainty associated with the economic policy decisions by the U.S. government [49]. Previous research indicates a statistically significant, positive impact of USEPUIN on the gold price in the U.S. [50] discover a close, positive, significant impact of the index on the gold price. In this respect gold acts as a distinct safe haven against economic uncertainty.

1.13 3-Month Treasury Bill Secondary Market Rate (DTB)

This relationship has been studied extensively in the corporate finance literature. [51] found significant negative impact on gold by the rising yield on the 3-moth treasury bills. In this instance the securities act as a substitute of gold for the investors – as the T-bill yield rises, the opportunity cost of investing in gold increases.

2. Methodology

The regression model seeks to establish an OLS line that optimally characterizes the relationship between determinants and the dependent variable while mitigating issues such as multicollinearity, homoscedasticity, non-normal distribution, and autocorrelation in the error terms. As the initial data sample is characterized by autocorrelated and heteroscedastic residuals, the Newey-West covariance method will be applied. According to [52], [53], [54], [55] the resulting linear equation is more reliable and accurate. The t-statistic is used to test the significance of the parameters. The Fisher test is performed to evaluate the statistical significance of the entire regression, while Durbin-Watson value is used to test for the 1st degree of autocorrelation, along with the Lagrange Multiplier statistic for the higher order [56].[4]

[4] Following the single regression models, a combined model of all independent variables is constructed. It is enhanced by eliminating regressors, which do not contribute to the reliability of the model by increasing its predictive capability. Then the combined model is tested for multicollinearity. Independent variables causing extreme muliticollinearity are removed accordingly. Finally, we test the autocorrelation, normality, and heteroscedasticity of the residuals. If the model is not robust, and due to a structural break, a shorter sample, including the last five years is extracted and used for the final estimation.

3. Results

The following 14 equations are using the HAC (Newey-West) estimator. This method is selected due to the strong autocorrelation.[5] Y is defined to be the Gold Price, x_t is the independent variable, β_0 is the vertical intercept, β_1 is the slope of the regression, and ε is the error term.

3.1 The COMEX Gold ETF Price and the US Consumer Price Index (CPI)

According to the regression, $Y_t=20.10889–630.7758x_t+\varepsilon_t$,[6] there is a negative relationship between the US CPI index and the gold price. The t-stat supports the statistical significance of the slope.[7] Proceeding to F-test, where H_0 (Null hypothesis): The model is not statistically significant, and H_1 (Alternative hypothesis): The model is statistically significant, the F-stat is 25.54161 is greater than F-critical (1.4294), as the p-value is 0.000001, so H_0 can be rejected at α=0.01. Therefore the entire equation is statistically significant. In the selected series of observations, the level of inflation has a negative impact on gold price. The coefficient of determination, which shows the amount of the explained variability, is 0.1306. This means that 13.06% of the variability in gold futures price is explained by the level of inflation.

3.2 Gold ETF Futures Price and the Nominal Broad US Dollar Index

There is a negative relationship between the US Dollar index and the US COMEX gold price according to $Y_t=40.55438–0.206885x_t+\varepsilon_t$. Both β_0 and β_1 alone are statistically significant, as well as the entire equation, according to the F-test. In the selected series of observations, the US Dollar exchange rate index has a negative impact on gold price.

3.3 Gold Price and the NYSE Wilshire 5000 Index

There is a negative relationship between Wilshire 5000 and the COMEX gold futures price based on $Y_t=24.52527-0.054658x_t+\varepsilon_t$. Both β_0 and β_1 alone are statistically significant, as well as the entire equation. A drop in the stock index has a positive impact on the gold futures price, as gold is a low-risk alternative to corporate stock. In this respect the result meets the initial expectation for an inverse relationship between the stock market and the gold price. It is also supported that the relationship is statistically significant.

3.4 Gold Price and the Federal Funds Effective Rate, or the Interest Rate

There is a negative relationship between the federal funds interest rate and the COMEX gold futures price according to $Y_t=20.66980–2.931271x_t+\varepsilon_t$. Both β_0 and β_1 alone are statistically significant, as well as the entire equation. The interest rate has a negative, statistically significant impact on gold futures price.

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[5] Illustrated diagrams are available upon request. The detailed hypothesis definition and testing procedure is described in section 3.1 and later repeated in a similar way through 3.14.

[6] Note that Y_t and U_t are the estimated values. This holds from 3.1-3.14.

[7] The absolute value of t-stat is 14.40883, which is greater than t-critical (2.6049) at α=0.01, H_0 may be rejected. Therefore, β_0 is statistically significant (the same result can be obtained from the P-value, which is 0.0000). To test the statistical significance of the slope β_1 the following two hypotheses are defined: H_0 (Null hypothesis), where $\beta_1=0$, or the slope value is not statistically significant. H_1 (or Alternative hypothesis) holds that $\beta_1\neq0$, or the slope value is statistically significant.The absolute value of t-stat is 1.934321, which is less than t-critical (2.6049) at α=0.01, H_0 cannot be rejected. Therefore, β_1 is not statistically significant (the same result can be obtained from the P-value, which is 0.0547). β_0 is statistically significant, while β_1 is not. This, however, does not indicate if the entire equation is statistically significant or not.

3.5 Gold Price and the Spot Crude Oil Price, Texas Intermediate (TXI)

There is a positive relationship between the oil price and the gold futures price based on Y_t= 17.54828+0.019967x_t+ε_t. Only β_0 alone is statistically significant, while β_1 is not. The entire equation is not statistically significant either. Consequently, the oil price standalone is a weak determinant of gold futures price.

3.6 Gold Price and the Moody's AAA Corporate Bond Yield (DAAA)

There is a positive relationship between the corporate bond AAA yield (DAAA) and the COMEX futures gold price based on Y_t=4.495332+3.642741x_t+ε_t. While β_0 and β_1 are statistically significant, the entire equation is statistically significant too. The coefficient of determination is 0.204, meaning that 20.4% of the variability in S&P500 is explained by the level of employment.

3.7 COMEX Gold Futures Price and the Fixed 30-Year US Mortgage Rate

There is a positive relationship between the 30-year mortgage rate and the COMEX gold futures price based on Y_t=4.252586+3.560897x_t+ε_t. Both β_0 and β_1 are not statistically significant, but the entire equation is statistically significant. The 30-year US mortgage has a positive impact on gold futures price.

3.8 Gold Price and the Unemployment Rate (UR)

Both β_0 and β_1 alone are statistically significant, as well as the entire equation: Y_t=9.952961+ 1.415049x_t+ε_t. The level of unemployment has a positive impact on gold futures price.

3.9 Gold Price and the GDP per Capita in the US (GDPPC)

There is a slight negative relationship between the level of employment and S&P500 (Y_t=78.69300–0.001104x_t+ε_t). Both β_0 and β_1 alone are statistically significant, together with the entire equation. The GDP per capita has an inverse effect on gold futures prices.

3.10 Gold ETF Price and the Price of Silver ETF's

β_0 is statistically significant, while β_1 is not (Y_t=20,651.91–0.081224x_t+ε_t). The entire equation is not statistically significant either. The silver ETF price is a weak determinant of the gold ETF's and cannot be used to reliably predict it.

3.11 Gold Price and the Money Supply M2

There is a slight negative relationship between the M2 Money Supply and the price of gold ETF's ($Y = 27.01 – 0.00623 * x_t + \varepsilon$). β_0 is statistically significant, while β_1 is not statistically significant. The entire equation is statistically insignificant. The M2 Money supply is a strong determinant of the gold ETF's price.

3.12 Gold Price and the Economic Policy Uncertainty Index for United States

Both the intercept β_0 and the slope β_1 of the equation are statistically significant, along with the equation: Y_t=13.59+0.0412x_t+ε_t. The USEPUCIN is a strong determinant of the gold ETF's.

3.13 Gold Price and the 3-Month Treasury bill Secondary Market Rate, Discount Basis

β_0 and β_1 are statistically significant. The equation, $Y_t=20.7087–3.1714x_t+\varepsilon_t$, is significant. The 3-Month Treasury bill is a strong determinant of the gold ETF's price.

3.14 Statistics of the Combined Model with all independent variables included

All independent variables considered so far will be combined into a single predictive equation and their significance will be tested in the multiple regression model. The equation used is:

$$Y_t=\beta_0+\beta_1x_{1t}+\beta_2x_{2t}+\beta_3x_{3t}+\beta_4x_{4t}+\beta_5x_{5t}+\beta_6x_{6t}+\beta_7x_{7t}+\beta_8x_{8t}+\beta_9x_{9t}+\beta_{10}x_{10t}+\beta_{11}x_{11t}+\beta_{12}x_{12t}+\beta_{13}x_{13t}+\varepsilon_t$$

The combined model results in the following equation:

$$Y_t=43.46–214.88CPI_t–0.47USD\_IND_t–0.13WILL500_t+13.98FFER_t–0.12OIL_t–1.67DAAA_t+ 8.31MORTGAGE30US_t–1.09UNRATE_t–0.0008GDPPAP_t–0.10SILVER_t+0.0003M2SL_t+ 0.04USEPUCIN_t–18.3DTB3_t$$

The intercept of the equation β_0 is not statistically significant. The same is valid for the slopes of the variables CPI, USD_ID, WILL5000, OIL, DAAA, UNRATE, GDPPCAP, and SILVER; by eliminating them from the equation its predictive power (R^2) is not significantly decrease. CPI, US Dollar nominal broad index, Wilshire 5000 stock index, AAA corporate bond yield, unemployment rate, and U.S. GDP per capita, which are statistically significant in a single regression model, are no longer significant. The combined regression model, including all determinants, will further be tested for multicollinearity,[8] normal distribution,[9] heteroscedasticity,[10] and serial correlation (first level and higher)[11] of the residuals. Based on the results the model is enhanced.

[8] Multicollinearity is defined as a high degree of correlation between the determinants, or explanatory variables [60]. For a model to be a reliable predictor, extreme collinearity between its determinants, or independent variables must be eliminated. Such collinearity is defined for any centered VIF values > 10. The following regressors cause multicollinearity in the model: M2 Money Supply, Wilshire5000 stock index,AAA corporate bond yield, GDP Per capita, silver price and 3-Month Treasury bill. Removing them for the equation resolves the multicollinearity problem. The predictive power of the new equation ($R^{2)}$ is slightly up from 0.6523 to 0.6564. The F-statistic (44.76639) is still above the F-critical. Retesting for multicollinearity, there are no longer extreme collinearity cases with the determinants.

[9] The Jarque-Bera test defines for a certain distribution its level of resemblance to a normal distribution [57]. The J-B value for the gold price is 7.640629, which is less than the critical value, at α=0.01, therefore H_0 cannot be rejected. The gold price residual values are normally distributed. This is also confirmed by the Probability, which is greater than 1%.

[10] The Breusch-Pagan-Godfrey test is used to test the residuals for heteroscedasticity. A reliable model would have homoscedastic residuals, indicating that no significant determinant of the dependent variable was omitted. The probability for Chi-square<1%, therefore H_0 can be rejected, and the residuals are heteroscedastic.

[11] A reliable prediction model is not expected to contain autocorrelation, or serial correlation in the different correlation orders. The orders or correlation may be tested with different tests . The Durbin – Watson test is used to test for 1st order of correlation. The Serial Correlation LM test (Lagrange – Multiplier) is used for testing of higher (>1) orders of correlation. Both of them will be applied to the current model. For the residuals to be homoscedastic, the DW value has to be in the range. 1.5< DW<2.5. The DW is 0.57, meaning that H_0 may be rejected. There is a strong positive 1st order serial correlation in the model. Moving to LM, the prob. of Chi-square<5%, therefore H_0 can be rejected. Based on LM and DW tests for autocorrelation, and the BPG for heteroscedasticity, the model is suffering from statistically significant heteroskedasticity and positive serial correlation of the residuals. To address these two issues, the Newey-West covariance method has been used conveniently for managing such data sets. Furthermore, an alternative model will be proposed based on the last five years of observations (Nov-2017 to Oct-2022).

3.15 Summary of the Results of the data from 2008 to 2022 at α=0.01

Table 1. Summary of the results

Independent Variable	T-test for Intercept Abs. Value/ Statistical Significance	T-test for Slope Abs. Value/ Statistical Significance	F-test for Equation / Statistical Significance	Relationship Of the Determinant to the Gold Price	Coefficient of Determination as a %
CPI	36.66 / Pass	5.05 / Pass	25.54 / Pass	Negative	13.06%
USD Nom. Board	8.43 / Pass	4.51 / Pass	20.35/ Pass	Negative	10.69%
NYSE Wilshire 5000	23.36 / Pass	5.97 / Pass	35.66 / Pass	Negative	17.34%
Fed. Funds Eff. Rate	32.03 / Pass	4.29 / Pass	18.40 / Pass	Negative	9.76%
Crude Oil Price	10.25 / Pass	0.88 / Fail	0.77 / Fail	Negative	0.45%
Moody's AAA bond Yield	2.00 / Fail	6.60 / Pass	43.57 / Pass	Negative	20.40%
Fixed 30-yr Mortgage Rate	1.59 / Fail	5.58 / Pass	31.16 / Pass	Positive	15.49%
Unemployment Rate	6.99 / Pass	6.72 / Pass	45.21 / Pass	Negative	21.01%
GDP per Capita	9.64 / Pass	7.32 / Pass	53.65 / Pass	Negative	23.99%
Silver ETF Price	11.99 / Pass	1.03 / Fail	1.05 / Fail	Negative	0.62%
M2 Money Supply	15.92 / Pass	4.96 / Pass	24.59 / Pass	Positive	12.64%
US Economic Policy Uncertainty Index	13.60 / Pass	0.04 / Pass	37.67 / Pass	Positive	18.14%
3-Month T- Bill Second. Market Rate	20.71 / Pass	-3.17 / Pass	23.47 / Pass	Negative	12.13%
Model with All Determinants	43.45 / Fail	N/A	32.40 / Pass	N/A	72.72%
Enhanced Model	29.16 / Fail	N/A	44.77 / Pass	N/A	65.64%

Source: Authors' calculations

3.16 Alternative model, based on the latest 5 years (November 2017 to October 2022)

Within the 15 years between 2008 and 2022 the domestic economic conditions in the U.S. changed drastically several times, leading to sudden shifts in the selected independent variables and spillovers between them.[12] In summary, this period included the global financial crisis of 2007–2009, the European sovereign debt crisis of 2012–2013, the following economic recovery, the Covid-19 pandemic downturn, and the subsequent period. In an attempt to propose a more robust and reliable model, a new regression is built based on the same determinants and their data points from the last 5 years.

Starting with all dependent variables, and eliminating the ones causing multicollinearity, a regression model is derived, which may be defined by the following expression:

$$Y_t=-12.44–1.63DTB3_t+0.30SILVER_t–1.25UN_t+0.15US\_IND_t+0.06USEPU_t+ 1.22MORTG30US_t$$

[12] The strong positive serial correlation and heteroscedasticity of the residuals do not contribute to its robustness and predictability power. Despite the usage of the Newey-West regression, its ability to account for 65.4% of the gold price variability, coupled with high autocorrelation and heteroscedasticity of the residual terms raise questions on its potential to reliably forecast the gold prices in the future. One of its shortcomings, leading to its high residuals positive autocorrelation and heteroscedasticity is the sheer length of the period, for which data is being collected.

The F-stat for the equation is 66.72, greater than F-critical=1.8459, therefore the equation is stat. significant. The R^2 is 0.883, accounting for 88.30% of the variability in the gold price.[13]

In conclusion, the above model based on 60 monthly data points during the last 5 years has yielded: F-stat(66.72)>F-critical(1.85), thus the equation is stat. significant; the model contains no extreme multicollinearity; residuals are normally distributed (JB p=0.79); residuals are homoscedastic, and have neither 1st or higher level of autocorrelation (based on DW and LM stat).

4. Discussion of the results

Based on our research the following holds for the period between 2008 and 2022:

The regression model built on the 15 years of monthly observations has strong positive autocorrelation of its residual terms, as there is also evidence for heteroscedasticity. This is why a second model, based on the last 5 years of observations (2017-2022) is proposed. This shortcoming of the initial model is mainly resulting from the long, 15-year period of observations, which covers different states of the U.S. economy: going from a global recession to recovery, through the Covid-19 lock-down and the period following afterwards.

Negative, statistically significant relationship between the US CPI index and the Comex ETF gold price. This result is somewhat unexpected, given that high inflation should trigger investors to seek a safe haven in assets such as gold, exerting an upward pressure on its price. Looking closely at the results, two effects may be observed, which refute this hypothesis. First, the data series covers the entire 2008–2009 recession, characterized by increasing unemployment and gold prices and falling inflation, defying the positive relationship between CPI and gold. Secondly, the pandemic and post-Covid-19 period is characterized by another phenomenon: high inflation triggered by increased money supply, and stable, in some periods even decreasing gold prices. Gold is no longer seen as a safe haven for inflation. Summarizing both observations, it could be supported, that during periods of recession, characterized by increasing unemployment and gold prices and gold and falling inflation, there is a statistically significant inverse relationship between CPI and the US gold futures prices.

Negative, statistically significant relationship between the nominal broad US dollar index and the gold futures price at a=0.01 level. In this study the USD acts as a substitute of gold for safe haven during times of economic depression. This conclusion is especially valid for the post-Covid period, when unexpectedly the bear stock market was coupled with declining gold price and appreciating US dollar. In the post-covid era, bear market is not coupled with high gold prices, like in the crisis of 2008-2009. The declining stock market is matched with appreciating US dollar, which even surpassed the Euro for certain periods in 2022. USD appears to be a safe haven for investors, probably replacing gold. However, more data points are needed in the post-covid period to fully justify such a hypothesis and certainly further research.

Negative, statistically significant relationship between the Interest Rates and the gold price at a=0.01 level. The increasing interest rates impose a negative pressure on the gold price. This call is due to the combined effect of two events. First, higher interest on the savings accounts would incentivize the businesses and households to hold more money in savings accounts and invest less in gold. Secondly, the recession of 2008–2009 was characterized by an increase in the gold price, seen as safe haven at the time, and declining interest rates, trying to stimulate the economy.

[13] Testing for multicollinearity, no extreme multicollinearity is found in the model. The J-B test for normal distribution of the residual terms yields the result: JB=0.4590, which is less than the critical value, at α=0.01, therefore H_0 cannot be rejected. Thus, the residuals are normally distributed. The heteroscedasticity test of the residuals (Breusch-Pagan-Godfrey) indicates that residuals are homoscedastic; prob. for Chi-square < 1%, therefore H_0 cannot be rejected. The LM test shows no evidence of 2nd or higher level of serial correlation of the residuals too.

Negative, statistically significant relationship between the crude oil price and the gold price at a=0.01 level. Such a statement is not valid when the crude oil price is analyzed as a standalone determinant on the gold price. However, when put in a model together with other determinants, the oil price becomes significant, contributing to the robustness of the model.

Positive, statistically significant relationship between the fixed 30-year mortgage rate and the gold price at a=0.01 level. The mortgage rate is a statistically significant determinant of the gold price both standalone and in combination with other variables. As the mortgage rate goes higher, the cost of purchasing real estate becomes higher. Real estate needs to be treated as an investment substitute for gold. Since it becomes costlier to invest in real estate, the demand for gold should increase, putting an upward pressure on its price.

There is a positive, statistically significant relationship between the M2 (Money Supply) and the gold price at a=0.01 level. The relationship of money supply to inflation (CPI) was tested for Granger causality. *The M2 Granger causes inflation (p=0.0018),* or less than 0.01. The opposite statement is not valid, as the index is 0.0291. Although being statistically significant as a standalone determinant, the M2 was dropped from the model as it was causing extreme collinearity in combination with the other variables.

There is a negative, statistically significant relationships between the NYSE Wilshire5000 Index and DAAA on one hand, and the gold price at the level of confidence a=0.1. At a=0.01 they are not statistically significant. The Wilshire5000 index and the Moddy's AAA bond yield are statistically significant as standalone determinants but yield extreme collinearity in combination with the other variables, thus not contributing to the robustness of the overall model.

When combined together with the other determinants, there is no statistically significant relationship between the Unemployment rate, GDP per Capita, and the Silver ETF's. This finding suggests that even though some determinants prove to be statistically significant, as standalone independent variables, when put together with other variables, they may become redundant and only make the model more cumbersome, without bringing incremental value to it.

The Crude oil price becomes statistically significant to the gold price when put in a model with multiple determinants, without being statistically significant alone. This call suggests that some regressors may be statistically insignificant, but when combined with other, they become significant and contribute to the model's robustness.

Some variables cause extreme collinearity in the model and need to be excluded. Despite being statistically significant as standalone variables, Wilshire5000 and the M2 (Money Supply) cause extreme collinearity in the model. This is why they were excluded, even though they were increasing the coefficient of determination (R^2) in the combined model.

The model based on the last 5-year's observations is robust, statistically significant, with higher predicting power than the initial model based on 15 years (2008–2022). Both models contain no extreme multicollinearity of the determinants and normal distribution of the residual terms, but the latter, unlike the former, is not characterized with strong positive serial correlation and heteroscedasticity of the error terms and thus it can be perceived as a robust one.

5. Conclusion

It is a rather challenging endeavor to establish a multiple regression model for the gold price prediction, based on domestic economic and financial data from a lengthy time span, such as the last 15 years, starting from the GFC. The domestic economic conditions in the U.S. during that time were dominated by different circumstances, such as the international financial crisis of 2007–2009, the European sovereign debt crisis, the recovery period after 2013, the Covid–

19 crisis and the post-covid period of yet unstudied overflows between the various economic KPI's.

The resulting enhanced model, although free of multicollinearity and with normal distribution of the residual values, still possesses a high degree of positive autocorrelation and heteroscedasticity of its residual terms. In this model, several determinants proved to be statistically significant for gold price. They include CPI, the nominal broad USD index, Federal Funds interest rate, crude oil price, U.S. 30-year fixed mortgage rate, U.S. unemployment rate, and U.S. Economic Policy Uncertainty index. The CPI, dollar exchange rate, interest rate, oil price, and unemployment rate have a negative, statistically significant effect on the gold price, while the fixed 30-year fixed mortgage rate and U.S. E.P.U. index exert a positive influence on the COMEX gold price. Using the Newey-West regression methodology, and using the OLS method, an alternative model to forecast the COMEX gold ETF futures was proposed, based only on the last 5 years of observations. The new model which used DTB3, SILVER, UNRATE, USD_IND, USEPUCIN, and MORTGAGE30US as regressors, proved to be more reliable, as its predictability power is 88.30%, as opposed to 65.64% of the original enhanced model, based on 15 years of observations (2008–2022). The U.S. exchange rate, unemployment rate, 3-month Treasury bills rate, fixed 30-year mortgage rate, and U.S. Economic Policy Uncertainty Index play a significant role in determining the gold price. The USD exchange rate, 30-year fixed mortgage rate, U.S. E.P.U. index and the silver price have a positive effect on gold: their increase lead to an increase in the gold price. The unemployment rate and the 3-month Treasury bill yields have an adverse effect on the gold price. Furthermore, unlike the original regression model, the latter one is free from serial correlation and heteroscedasticity of its residual terms. Relationships and interconnections between the gold price and macroeconomic factors that may have been valid 10 or 15 years ago, may not hold true anymore, and may well be a burden to the model.

This analysis does not dive deeply into the linkages between the determinants of gold price, especially after the Covid–19 economic downturns, caused by the lockdowns and restrictions. A valuable example of such study is the work by [3], focusing on the dynamic linkages and overflows between the economic and financial factors, determining the gold price in the U.S. Further analysis, based on more data points and a deeper level of granularity may reveal more valuable linkages between the domestic factors, determining the COMEX gold ETF price.

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