A Review of Gold Pricing: Real Interest Rate and U.S. Dollar Index

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ABSTRACT

This paper explores key factors that could indicate the price of gold, with a specific focus on the real interest rate and the United States Dollar Index (USDX). By analyzing existing literature and historical events, this paper establishes the real interest rate as the primary driver of the price of gold and concludes that it could be used to predict future gold prices. As many existing studies purpose a negative relationship between the price of gold and USDX, this paper goes on to examine this relationship while considering the real interest rate. This paper purposes that the change in the U.S. real interest rate, relative to real interest rates in other countries, exhibits a positive correlation with the USDX. The real interest rate emerges as a key influencer for both the price of gold and USDX, potentially providing an explanatory framework for the relationship between the two. The finding of this paper is significant for researchers and investors seeking to predict future gold prices and study the relationship between the price of gold and USDX.

Introduction

Gold has been renowned as a noble metal that is rare, unreactive, and unique in appearance (Rowlatt, 2013). These unique characteristics have made gold scarce, durable, and irreplaceable, all of which are essential criteria of a currency. Thus, gold has historically served as a universal medium of exchange and a measure of value. It served as a currency before the paper money regime and later acted as the underlying asset for paper currency under the gold standard and the Bretton Woods system. During the gold standard, a country's currency was directly tied to a fixed quantity of gold. Subsequently, under the Bretton Woods system, gold retained its role as the basis of the U.S. dollar while other currencies were pegged to the dollar's value. The importance of gold during these money regimes has reinforced the authority of its value, making gold the most acclaimed precious metal.

The collapse of the Bretton Woods System in 1971 ended dollar convertibility to gold, thereby ending the fixed exchange rate regime from 1968 to 1973 (Bordo & Eichengreen, 1993). This event marked the end of gold's function as a money commodity (Nyiri, 1981), however, gave rise to gold's performance in the investment market. With established credibility as an ancient currency, gold has been perceived as a hedge against inflation and a store of value during times of crisis. An increase in expected inflation will encourage individuals to demand gold, aiming to preserve their purchasing power. Similarly, during times of crisis, individuals turn to gold due to insecurity about the government and the economy. To date, gold has become an important asset for investors to diversify their investment portfolio (Zainal & Mustaffa, 2015). The financial gold market is valued at approximately $5 trillion, encompassing 40% of the total gold supply. Previously, most individuals held physical gold bars or coins. But in recent times, investment in gold has been facilitated through exchange-traded funds (ETFs) that offer low-cost and liquid funds backed by physical gold. Investors could also purchase stocks of gold mining and associated companies. Development and innovation in the gold market have presented individuals with more convenient avenues for gold investment, making the gold market more accessible and popular.

Since individuals would want to optimize their investment in gold, it is imperative to identify potential factors that could indicate future gold prices. There have been a board literate that investigate the factors influencing the price of gold, including inflation (Beckmann & Czudaj, 2012; Chainani, 2016; Erb & Harvey, 2013), interest rate (Abdullah, 2013; Ling & Kueh, 2020; Wang & Chueh, 2013), U.S. dollar (Capie et al., 2005; Sjaastad, 2008; Tulley & Lucey, 2007), and gold as a safe haven asset (Bulut & Rizvanoghlu, 2019; Chkili, 2016; Gürgün & Ünalmış, 2014). However, existing research has tended to focus on the influence of a single factor rather than taking into account the interactions between multiple factors. Furthermore, divergent outcomes in various studies have left the conclusions ambiguous. This paper aims to contribute to the discussion by shedding light on the real interest rate and the U.S. dollar, two central factors that influence the price of gold. Real interest rates and the U.S. dollar are quantitative data that could be analyzed statistically. Thus, if correlations exist between the factors and the price of gold, investors will be able to make rational predictions about future gold prices and researchers will be able to initiate studies using this correlation. Through a review and evaluation of existing literature, this paper has concluded that (i) despite some limitations, there exists a relatively strong negative correlation between the real interest rate and the price of gold, (ii) the real interest rate could potentially explain the unstable correlation between the price of gold and the U.S. dollar. In the following, section 2 provides a comprehensive review of the relationship between real interest rate and the price of gold, section 3 discusses the relationship between the U.S. dollar and the price of gold, and section 4 concludes.

Real Interest Rate

According to Fisher's equation, the real interest rate is defined as the nominal interest rate minus the inflation rate (Fisher, 1896). The nominal interest rate represents the actual payments investors received for interest-bearing securities such as bonds. As the investment matures over time, its real value might be eroded by inflation. Adjusted for inflation, the real interest rate represents the actual yield, measured by purchasing power, of interest-bearing assets. For most investors, an easy way to observe the real interest rate is to track the rate of return of Treasury Inflation-Protected Securities (TIPS). First issued in 1997, TIPS is designed to protect investors against inflation. The principal invested in TIPS is returned at its inflated value, which reflects the original purchasing power. Additionally, the interest paid would be based on the inflated value instead of the original principle (DePrince & Ford, 1998). Because TIPS are securities in which coupon and principal payments are linked to price levels, information about yields on TIPS could provide insights into the real interest rate and inflation expectation (D'Amico et al., 2018).

Since TIPS is viewed as an estimation of the real interest rate, researchers have used TIPS data to study the correlation between the real interest rate and the price of gold. Erb and Harvey (2013) conducted a regression analysis on the real price of gold in U.S. dollars and the real yield of a 10-year TIPS. Their analysis covered the period from the inception of TIPS trading in 1997 until 2013. The results revealed a relatively strong negative correlation of -0.82 between the two variables. However, when a similar analysis was performed on the real yield of the Barclays U.K. Government Inflation-Linked bond index and the U.K. real price of gold starting from the early 1980s, the correlation falls to -0.31, a relatively weak negative correlation. These results suggest that the correlation between TIPS and the price of gold might be limited to the U.S. only and possibly restricted to the past two decades. This paper presents useful data about the correlation between TIPS and the price of gold, however, does not conclude whether there exists a causal relationship between these two variables.

Using the logarithms of real gold price and the U.S. 10-year TIPS yield from April 11, 2007, to October 31, 2013, Lu and Fang (2013) performed a similar regression analysis and found an R-value of -0.9095. The logarithmic transformation was employed to show the percent changes in gold prices relative to the real yield of TIPS. The strong negative correlation presents in this study confirms the result of Erb and Harvey (2013), further supporting the existence of a robust correlation between TIPS and the price of gold in the past two decades.

This correlation is further proven by Cooray et al. (2019), who conducted a study using the Markov Switching Vector Error Correction Model (MS-VECM) to examine the time-varying dynamic relationship between real interest

rates and gold prices. This study used real interest rate data obtained by subtracting the Consumer Price Index (CPI) inflation rate from the nominal interest rates on 10-year government bonds, which provides a more accurate representation of the real interest rate than the real yield of TIPS. Spanning the period from 1975 to 2016, the study found that there exists a negative and significant relationship between the change in the lagged value of real interest rates and the change in the lagged value of gold prices in the short run across the G7 countries (US, UK, Germany, Canada, Japan, France, Italy).

Thus far, this section has reviewed key studies that have evident a negative correlation between the real interest rate and the price of gold, it is now necessary to provide some possible explanations for this correlation. In the following pages, two possible explanations (i) the opportunity cost of holding gold and (ii) gold as an inflation hedge is presented. Additionally, the limitations of such relationship are also discussed at the end of this section.

The Opportunity Cost

Opportunity cost represents the potential benefit an individual foregoes when choosing one alternative over another due to limited resources. In the investment market, opportunity cost is an important concept for individuals to make rational decisions. When faced with two investment options, the opportunity cost is the benefit an individual gives up by choosing one over the other. Thus, if the opportunity cost of an investment is relatively high, individuals are less inclined to invest in it.

Gold and U.S. Treasuries are viewed as alternative assets since they are both regarded as safe-heaven assets in an investment portfolio (Chainani, 2016). However, the key distinction lies in the fact that U.S. Treasuries provide yields while gold does not. Hence, for investors, the opportunity cost of holding gold instead of interest-bearing treasuries is the real interest rate (Ghosh et al., 2004). In a market where investors make rational decisions, the real interest rate will primarily determine the asset demand for gold. Falling real yields makes financial assets less attractive and makes the opportunity cost of holding gold lower (Abdullah, 2013). As a result, individuals become more inclined to hold gold, leading to an increase in its price. On the other hand, when the real interest rate is high, the gold price may soften as individuals sell gold to allocate funds to other interest-bearing investments (Chainani, 2016). As individuals flee from the gold market, demand for gold will decrease which results in a lower price. The concept of opportunity cost explains the relationship between the real interest rate and the price of gold by comparing the benefit of holding gold and interest-bearing investments. The next part of this section will explain this relationship in terms of the inflation-hedging ability of gold.

Hedge Against Inflation

Inflation affects both the real interest rate and the gold price. Thus, the correlation between the two variables could be attributed to their common response to inflation.

Fisher proposes that the real interest rate is independent of monetary measures (the nominal interest rate and inflation) known as the Fisher Hypothesis (Fisher, 1896). According to this hypothesis, the nominal interest rate adjusts to accommodate any changes in inflation, ensuring that the real interest rate remains unchanged. This hypothesis, however, creates many debates and various studies have been conducted to test its accuracy. Mishkin (1991) used the Monte Carlo simulation and the cointegration test and found that although there is evidence of the Fisher Hypothesis in the long run, there is no evidence of a short-run Fisher Hypothesis. Laatsch and Klein (2003) also utilized a cointegration test to examine the Fisher Hypothesis using data from August 1997 through July 2001. Their study, using data across four years, demonstrated that the nominal interest adjusts on a one-for-one basis with the change in expected inflation, supporting Fisher's hypothesis in the long run. However, as Fisher's Hypothesis does not hold in the short run, the nominal interest rate would not account for changes in inflation. Therefore, the real interest rate would decrease as inflation rises in the short run, eroding the yields of investment.

The history of gold has demonstrated maintenance of value during periods of crisis, such as war. Gold is known for its performance as an inflation hedge in times of unstable money regimes and economic uncertainty. Countries and central banks hold gold as a source of trust, an indicator of economic health, and insurance against economic crashes. Gold has long been perceived as an effective hedge against inflation. While the actual hedging ability of gold remains uncertain (Chainani, 2016; Erb & Harvey, 2013; Wang et al., 2011), the belief in its ability continues to induce individuals to purchase gold during high inflation. When inflation is high or inflation expectations are elevated, individuals will flee to purchase gold. The increase in demand for gold consequently leads to an increase in the gold price. Thus, inflation is positively associated with the price of gold.

The trend of inflation could explain the correlation between the real interest rate and the price of gold. An increase in inflation will simultaneously cause the price of gold to increase and the real interest rate to decrease. This explanation, however, does not provide a comprehensive account since the inflation and gold price does not adjust on a one-on-one basis in the short run, the momentum of such adjustment varies depending on government policies and market regime (Wang et al., 2011).

Limitation

There are three major limitations to the correlation between the gold price and the real interest rate. Firstly, this correlation did not appear before the 2000s (Barsky et al., 2021). Prior to the 2000s, inflation expectations have remained high and varied greatly which is the primary driver of gold prices. Since 2001, however, the long-term inflation expectations have remained relatively stable at around 2-3%, making the unprecedentedly low real interest rate the main driving force behind gold prices. Additionally, the development and innovation in the bond market since the 2000s provide alternative assets to gold, which allows individuals to compare and contrast the opportunity cost of each asset. Therefore, the real interest rate has become an important factor in determining the demand for gold after the 2000s. The absence of the correlation prior to the 2000s indicates that the negative relationship between gold and real interest rate requires pre-existing conditions such as a financialized economy and a stable money regime.

Another limitation lies in the lack of accurate real-time measurements for real interest rates. Despite TIPS yields are commonly used as an estimation of real interest rate, they often misrepresent the real-time real interest rate. In the early years, TIPS yields appeared to overestimate the real interest rate, possibly due to their novelty and limited liquidity. This indicates that the use of TIPS as a measure of real interest rate may lead to inaccurate results and conclusions in research and analysis. Other techniques mostly rely on estimating inflation expectations by subtracting them from nominal yields. While these techniques may be more accurate than TIPS yields, estimating inflation expectations using surveys or assuming rational expectations can introduce errors (Levin et al., 2010). Moreover, such estimations do not capture daily fluctuations in real interest rates, limiting their usefulness to historical studies rather than real-time analysis. On a positive note, the liquidity premium component of TIPS yields has decreased significantly in recent years, suggesting that TIPS yields are becoming more aligned with real interest rates (D'Amico et al., 2018).

Lastly, insecurity about the current paper money system can potentially drive up gold prices regardless of real interest rate movements. During times of war and systemic risk, individuals tend to prefer physical and tangible assets such as gold as they face the risk of hyperinflation and failure of paper currency (Chainani, 2016). The COVID-19 pandemic, for example, caused widespread shutdowns, increased unemployment rates, and a significant decrease in GDP output. The uncertainty about the economy during the pandemic led to a significant surge in gold demand that spiked gold prices to a historical high of $2,300. While gold prices decreased after their highest price as the global economy recovered, they rose again in 2022 due to the Russia-Ukraine conflict. The conflict had highly impacted the energy and food resources and soared the oil prices. Panic and fear among individuals once again propelled gold prices, exceeding $2,000.

To conclude this section, a review of existing literature reveals a strong negative correlation between the real interest rate and gold prices. This relationship can be explained by (i) the real interest is the opportunity of holding gold and (ii) the inverse impact of inflation on the real interest rate and gold prices. Despite the strong correlation, this relationship has three main limitations: (i) the relationship only emerged after the 2000s, (ii) the real interest rate is challenging to observe in real-time, and (iii) an unstable currency regime can lead to a markup of gold prices regardless of the real interest rate. The following section explores the relationship between gold and the U.S. dollar by utilizing the correlation between the real interest rate and gold prices.

U.S. Dollar

Previous studies have established a negative correlation between the U.S. dollar and the price of gold (Chainani, 2016; Tulley & Lucey, 2007; Wang & Chueh, 2013). However, many have found this relationship to be unstable. Capie et al. (2005), utilizing various econometric modeling, found that despite gold has served as a hedge against the U.S. dollar, the extent of its hedging ability has varied widely. This suggests that the relationship between gold prices and the U.S. dollar is unstable. Huang & Wang (2010) employed the Unit Root Test and Cointegration Test to analyze the relationship between gold prices and the U.S. Dollar Index. They found that although there is a negative correlation between gold prices and the U.S. Dollar Index, no cointegration relationship exists between the two factors, meaning the spread between them is not stationary in the long term. The presence of correlation without a cointegration relationship suggests the possibility of a third factor that influences both gold prices and the U.S. Dollar. Huang and Wang take oil prices into account as a potential third factor but did not find a cointegration relationship involving all three factors.

This paper aims to contribute to the discussion by proposing a potential third factor for the relationship between gold prices and the U.S. Dollar, namely the real interest rate. The following discussion argues how the real interest rate could explain the correlation between gold prices and the U.S. dollar.

Discussion

The most common method to measure the value of a currency is through exchange rates. The U.S. Dollar Index (USDX) is a relative measure of the value of the U.S. Dollar relative to a basket of foreign currencies including the Euro, Swiss franc, Japanese yen, Canadian dollar, British pound, and Swedish krona. In this paper, the value of the U.S. dollar and the U.S. Dollar Index (USDX) are used interchangeably.

Several economic theories provide insights into the determinants of exchange rates. The Theory of Purchasing Power Parity states are influenced by the relative purchasing power of each currency, under the influence of inflation. The Balance of Payments Theory of Exchange Rate suggests that exchange rates are determined by the demand and supply of the currency. For example, a higher real interest rate in a country tends to attract investors to purchase financial assets within that country. In order to invest locally, foreign investors must purchase the country's currency. The increase in demand for the currency will subsequently lead to higher exchange rates. Considering these theories together, exchange rates reflect the comparison of economic strength between countries, which is under the influence of economic growth, trade activities, monetary policy, fiscal policy, capital flow, etc. The economic strength of a country is hard to measure quantitatively, yet there are key data that could indicate a country's economic strength.

Bernanke & Blinder (1992) propose that the real interest rate is predictive of the future economy since it reflects the future movements of real macroeconomic variables. The nominal interest rate, which is based on the federal funds rate, is informative about monetary policy and economic growth. Inflation expectations offer insights into government debt and fiscal policy. The interest rate of a country indicates future capital flows. Containing all this information, the real interest rate is a strong indicator of a country's economic strength.

Comparing the real interest rates across different countries allows individuals to compare the economic strength of those countries. The difference in economic strength between countries impacts exchange rates. As USDX is a measurement of exchange rates between the United States and other countries, it exhibits a positive correlation with the difference between the real interest rates of the United States and the real interest rates of countries in the rest of the world (ROW). This is different from gold prices which directly correlate with the U.S. real interest rate. Despite the U.S. real interest rate might be decreasing, as long as it remains higher than the ROW real interest rates, the value of the U.S. dollar will appreciate, resulting in a higher USDX.

The following table illustrates four possible scenarios according to different economic cycles and international interaction between the United States and other countries.

Table 1. Relationship between gold prices and USDX

1. Gold Price and USDX negatively correlated	3. Gold Price and USDX positively correlated
U.S. Real Interest Rate +[1] Gold Price -[2] U.S. Real Interest Rates relative to ROW + USDX +	U.S. Real Interest Rate + Gold Price - U.S. Real Interest Rates relative to ROW - USDX -
2. Gold Price and USDX negatively correlated	4. Gold Price and USDX positively correlated
U.S. Real Interest Rate - Gold Price + U.S. Real Interest Rates relative to ROW - USDX -	U.S. Real Interest Rate - Gold Price + U.S. Real Interest Rates relative to ROW + USDX +

[1] Increases

[2] Decreases

The first two scenarios where gold price and USDX are negatively correlated are the most common observed cases. Scenario 1 represents an economic upswing in the United States. The increase in the U.S. real interest rate signals a decrease in the gold price. The rise in the U.S. real interest rate relative to the ROW real interest rates indicates an appreciation of USDX. This scenario occurs when U.S. economic strength grows faster than other countries. Scenario 2, on the other hand, indicates an economic downswing in the United States. The U.S. real interest rate decreased and remains weak compared to other countries. This creates uncertainty in the U.S. economy which leads to an increase in gold prices and depreciation of USDX.

The next two scenarios where gold price and USDX are positively correlated occur less frequently. Scenario 3 arises during phases of global economic recovery when most countries' economies are growing. Despite the U.S. real interest rate increases, it is increasing at a slower rate than the rates in other countries. As a result, both the price of gold and USDX decreases. One example of scenario 3 occurred during the post-pandemic recovery period from September to November 2020. The global economy was recovering and individual countries were imposing policies to stimulate their economies. The recovery in the United States relied heavily on the expansionary fiscal and monetary policy imposed in the summer of 2020. However, from September to November, no further expansionary policy updates occurred due to budget constraints. This resulted in a slowdown of economic recovery in the United States. While the U.S. real interest rate was still growing which led to a decrease in gold prices, the United States economy was recovering at a slower speed than other countries which indicated a depreciation of USDX. The overall result was the gold price and USDX depreciated simultaneously reflecting a positive correlation. Scenario 4 emerges during global economic slowdowns or recessions. The U.S. economy exhibits greater resilience during such downturns, resulting in a stronger economic position compared to other countries. This strength leads to an appreciation of the U.S. dollar while the economic downturn stimulates gold prices, resulting in a positive correlation between gold prices and the U.S. dollar. One instance of scenario 4 is the European Sovereign Debt Crisis. The collapse of financial institutions

and high government debts caused the reputation and confidence of the euro to be threatened. This triggered an economic downturn as Europe is one of the global centers of trade and investments. Individuals eagerly sought gold due to its independence from paper currencies, causing the demand for gold to increase significantly which drove up gold prices. During this time, the United States was in a recovery phase following the Global Financial Crisis of 2008, however, slowed down due to the impact of the European Sovereign Debt Crisis. Despite this slowdown, the United States was not at the center of the crisis, and the U.S. dollar and bonds were considered as safe-haven assets against the crisis. As a result, the U.S. economy was declining at a rate slower than other countries. Thus, the U.S. dollar appreciates which causes a positive correlation between the gold price and the U.S. dollar.

This section began by describing the negative correlation between the price of gold and the U.S. dollar and highlighting the instability of this correlation. It went on to suggest that the real interest rate could potentially explain the relationship between gold prices and the U.S. dollar. The discussion in this section proposes that (i) the U.S. real interest rate is negatively correlated with the price of gold and (ii) the change in the U.S. real interest rate relative to the ROW real interest rate is positively correlated with the U.S. dollar. The change in the U.S. real interest rate and the ROW real interest rate will consequently affect the price of gold and the U.S. dollar, resulting in different relationships.

Conclusion

This paper set out to examine the relationship between the price of gold, the real interest rate, and the U.S. Dollar Index (USDX). Drawing on existing literature and statistical analysis, this paper has identified the real interest rate as the major influencer for the price of gold. Despite certain limitations, a strong and consistent negative correlation between the price of gold and the real interest rate has been observed. Utilizing historical events as evidence and logical reasoning, this paper further proposes that changes in the U.S. real interest rate relative to real interest rates in other countries are positively correlated with the USDX. These findings suggest that the real interest rate influences both the price of gold and the USDX, providing a potential explanation for the fluctuating negative correlation between these two factors. Changes in the real interest rate will subsequently affect the price of gold and USDX which leads to varying relationships in different scenarios.

The findings and suggestions of this paper will be of interest to researchers and investors who attempt to investigate factors that could indicate the price of gold and make rational predictions about future gold prices. Furthermore, this paper has gone some way toward enhancing the understanding of the correlation between the price of gold and the U.S. dollar by bringing the real interest rate into light.

The main limitation of this study was the paucity of technical forms of data collection and statistical analysis. Therefore, it is not possible to firmly conclude that the real interest rate could explain the unstable correlation between the price of gold and USDX. Despite its exploratory nature, this paper provides insight into the relationship between the price of gold, the real interest rate, and the U.S. dollar by utilizing the results of previous literature and historical events as evidence to support its claim. The aim of this paper is to propose potential new approaches to gold pricing for future researchers and encourage further discussion on this topic. Considerably more work will need to be done to determine whether the relationship between the real interest rate and the U.S. dollar is well grounded. Subsequent studies could build upon this paper as a foundation for hypotheses and conduct data analysis and statistical modeling to delve deeper into this subject matter.

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