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The Rise of Gold Financialization and its Safe Haven Role
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Abstract

Gold has always been considered the most safe haven asset in market turmoil. However, this role has appeared to disappear in recent years. Besides, the significant fluctuations in the level and volatility of gold prices have become increasingly evident over the past two decades, compared with a prolonged market stability period. These changes bring to question what has driven these developments. Understanding the transformation in the gold market can help assess gold's role in investment strategies and its revolving function in the global financial environment. This thesis aims first to assess gold market behaviour over the past 37 years and examine the role of gold during equity and bond market stress. Notably, investigating whether gold lost its appeal as a safe haven asset due to its own market instability. Second, it examines whether gold financialisation, through the introduction of gold ETF in the early 2000s, contributes to the observed volatility in the gold market. Next, it investigates the ramifications of gold ETF's onset on traditional gold roles and whether gold ETF supplanted gold's traditional roles. Then, it investigates if the co-integration between gold ETFs' holdings and gold spot prices exists. Last, it determines whether a causal relationship exists between gold ETFs' holdings and gold markets, i.e. whether gold ETFs' holdings cause gold prices.

The study first demonstrates that the gold market exhibits two distinct periods, each with differing market movements: a stable era followed by a highly volatile era, in which gold plays an insignificant role during the latter unstable period. Moreover, it exhibits a positive correlation in most high volatility periods of the S&P 500, again, especially during the unstable period. This implies that gold is losing (lost) its safe haven role during market stress. The outcome suggests that as the gold market encounters higher volatility periods, a more positive correlation is expected with the stock market in times of extreme stock market conditions. Second, the study establishes that the gold market exhibits a structural change around the onset of gold ETFs, in which gold spot volatility in the post-gold ETFs period is characterised by an unstable (highly volatile) era. Notably, the findings suggest that the changes in gold market volatility can be attributed to an increase in the rate of information flow to the gold spot market. The outcomes imply that the gold spot market is more efficient in the post-gold ETFs period. Yet, it is highly volatile. Third, The study finds that gold financialisation has altered the traditional roles of gold after the introduction of gold ETFs. In the post-ETF

state, gold's traditional hedging capability is shifted and weakened, and the safe haven role is lost. Moreover, the gold ETF shows better roles, playing a strong risk diversification role during normal times and a safe haven role at certain market thresholds. The outcomes suggest that gold ETF is a successful successor for gold, offering new options for mitigating market risks and implementing different investment strategies. Furthermore, the study finds that gold ETF holdings are co-integrated with gold prices, implying a long-run relationship exists. Besides, the findings show that gold ETFs' holdings significantly cause gold prices in the long run and, hence, may play an important role in gold price determination. This suggests that changes in gold ETFs' holdings (inflows and outflows), with limited gold production and high demand, may increasingly influence gold price dynamics and potentially substitute the traditional supply and demand forces in the gold market. These findings have important implications for investors, financial regulators and policymakers. Investors should be aware that the gold traditional roles seem to have waned, and adding gold to a portfolio may raise volatility without providing the expected protection. Gold is more likely to exhibit high volatility and co-movement with other financial markets. Investors should act with cautious hedging strategies to avoid taking on gold volatility risk and deterioration in hedging and safe haven roles, consequently destroying their portfolios. Besides, increasing gold market responsiveness after introducing gold ETFs requires additional attention and reassessment of gold's role in portfolio diversification. Investors may consider including gold ETFs in their investment and trading strategies as they offer more effective hedging and diversification strategies and risk management. Financial regulators need to pay attention to the potentially destabilising effects of financial innovations like ETFs on spot market volatility., i.e., recognising the link between information and volatility. Gold ETFs facilitate the acceleration of the assimilation of new information into gold prices, making the market more responsive and efficient but also more volatile. This indicates that further monitoring and regulation of financial innovations like ETF is needed to minimise detrimental effects. Regulators and policymakers need to monitor gold ETF activities to ensure transparency and promote accuracy and timely disclosure of vital information to market participants, leading to better market stability, portfolio and risk management decisions, and gold price forecasts. Understanding the impact of gold ETF leads to better anticipation and effective adaptation by regulators and

policymakers to future changes, not only for the gold market but also for other future innovations and markets.

Keywords: Gold, Safe haven, ICSS, Changing Point, DCC-GARCH, Gold ETF, Financialisation, volatility, GARCH, Engle-Granger, VECM

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Chapter 1: Introduction

The gold market has always been regarded as a cornerstone of financial markets, acting as a hedge against inflation, interest rate, exchange rate, and economic uncertainty, a safe haven during financial market turmoil, and a key component of diversified investment portfolios that assume gold market stability while ignoring possible shifts in gold market behaviour. However, following the beginning of gold financialisation marked by the introduction of gold Exchange-Traded Funds (ETFs) in the early 2000s, the gold market underwent substantial shifts in its structure and dynamics. The emergence of the new innovation investment vehicle, gold ETF, has fundamentally transformed gold trading, making it broadly accessible to institutional and individual investors alike. The significant increase in the level and volatility of gold prices over the past two decades, following a lengthy period of market stability, has shed light on what has driven these developments and their implications for the gold market. This transformation in the gold market motivates the interest in understanding how the financialisation of gold through gold ETFs has affected the traditional roles¹, as a hedge and safe haven, of gold in financial markets and influenced its price behaviour. What has commenced as a stable asset for mitigating risks appears to have evolved into a market driven by new and unconventional dynamics, prompting an in-depth investigation.

This study addresses critical questions about the impact of gold ETFs on the gold market. It explores how the gold ETF introduction affected gold's traditional roles and gold market volatility and whether a relationship exists between gold ETF holdings and gold prices. First, it demonstrates whether gold market behaviour has changed, whether this change is attributable to gold ETF inception, and whether gold's traditional roles as a hedge and safe haven asset have changed or, more likely, faded. Second, It explores whether gold market volatility exhibits a structural break along with the gold ETF inception and whether gold ETF has emerged as a new factor contributing to its underlying spot market volatility and instability. Next, it examines whether gold ETF supplanted gold's traditional roles as a hedge and safe haven asset. Last, it investigates whether gold ETF holdings contribute to gold market changes, whether

¹ Gold's traditional roles are the hedge and safe-haven roles. These terms will be used throughout the thesis interchangeably.

gold ETF holdings co-integrate with gold price movements, and whether gold prices respond to gold ETFs' holdings. Employing different advanced econometric methods such as changing point, rolling mean and standard deviation, Dynamic Conditional Correlation - GARCH (DCC-GARCH), Iterative Cumulative Sums of Squares (ICSS) Algorithm, and Generalized Autoregressive Conditional Heteroscedastic (GARCH) model, the study provides evidence of how the gold traditional roles and volatility have evolved in the pre-and post-ETF periods. Furthermore, using methods like co-integration tests and the Vector Error Correction Model (VECM) with the inclusion of an exogenous variable that accounts for external factors that may also affect gold price dynamics, the study provides significant evidence and understanding of the influence of gold ETF on the gold price dynamics, as well as enhances understanding of gold financialisation.

The novelty of this work stands in its ability to attempt to bridge several gaps in the existing literature and offer new insights into the implications of gold market financialisation. While previous studies have widely examined gold traditional roles and price drivers, there is scarce evidence of losing its traditional roles due to its market volatility, the emergence of gold ETF as a new factor contributing to gold volatility, and gold ETF mechanism and holdings deriving gold prices and the long-run co-integrating between gold ETFs' holdings and gold prices.

This thesis contributes to the field by demonstrating how gold ETFs have influenced gold market volatility, and have become a significant determinant of gold price dynamics, perhaps replacing the conventional supply and demand forces in the gold market with more financialised drivers. The findings have implications for stakeholders, underscoring the need to reevaluate the role of gold within investment strategies and its revolving function in the global financial system, monitoring gold ETF activities and ensuring transparency, accuracy and timely disclosure of vital information to market participants, thereby leading to better market stability, enhanced portfolio and risk management decisions, as well as provide a more accurate forecast of gold prices.

1.1 Background

Inter-market relations continuously elaborate, leading to higher correlations among assets and generating an equal need for alternative assets that mitigate risks

during market stress. In the financial markets, gold has been the most reliable safe haven asset for investors seeking shelter during times of uncertainty and market turbulence. Its appeal as a safe haven stems from its intrinsic store of value and its historical performance during stressful times. When financial markets plummet or economic and financial crises loom, gold has likely been the safe harbour for individuals and investors to park their money, believing it will retain or increase its value when everything else falters.

Early studies document gold's ability to enhance portfolio returns during market volatility while mitigating risks ([Jaffe \(1989\)](#); [Hillier et al. \(2006\)](#)). The work of [Baur and Lucey \(2010\)](#) is the first among others to rigorously test and confirm gold's dual role as a hedge against stocks on average market movements and a safe haven during extreme market conditions. According to [Baur and Lucey \(2010\)](#), a safe haven asset, like gold, is uncorrelated or negatively correlated with other assets or portfolios in times of stress, implying that its price tends to remain stable or increase when other assets, such as stocks, experience declining prices. Following [Baur and Lucey \(2010\)](#), several studies support the traditional roles of gold across different markets ([Reboredo \(2013b\)](#); [Bredin et al. \(2015\)](#); [Baur and McDermott \(2016\)](#); [Iqbal \(2017\)](#); [Bulut and Rizvanoglu \(2020\)](#); [Nguyen et al. \(2020\)](#); [Tiwari et al. \(2020a\)](#); [Triki and Maatoug \(2020\)](#)). Comparatively, [Baur and McDermott \(2010\)](#) extend the definition of Baur and Lucey for the safe haven asset by differentiating between strong and weak hedge and safe haven assets, enabling in-depth comparison between different potential safe haven assets across various markets. Neither [Baur and Lucey \(2010\)](#) nor [Baur and McDermott \(2010\)](#) safe haven definition takes into account the instability of the safe haven asset market itself. The safe haven literature examines gold market behaviour under flight-to-safety conditions, assuming the gold market is stable when other financial markets fluctuates. In most cases, gold's capability of being a hedge and safe haven in times of stress and uncertainty remained present and held for quite enough time. Yet, a close examination of gold behaviour in recent crises, including the global financial crisis and COVID-19 and their aftermath, has raised doubts about the sustained efficacy of gold traditional roles, specifically after 2005.

Figure 1.1 illustrates the historical trends in the gold market from 1975 to 2024, showing that gold prices were broadly stable for 25 years (1980 – 2005), with increases occasionally occurring in response to specific events, like macroeconomic

factors and equity market crashes, before returning to its average prices. This pattern is indicative of the role of gold safe havens and the stability of the gold market. On the other hand, the latter 19 years (2006 and 2024) were noticeable with surging prices and high volatility and instability in the gold market.

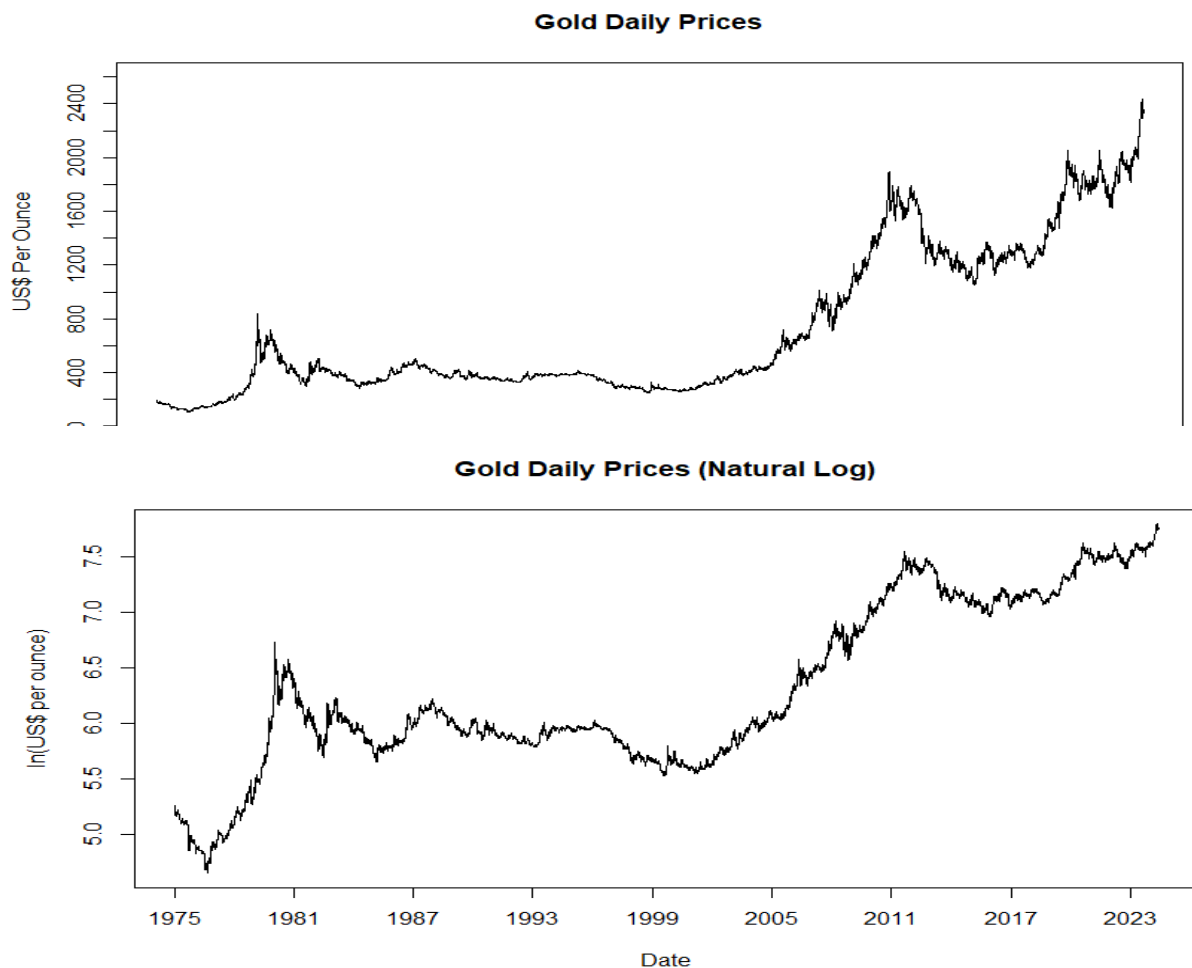


Figure 1.1 Shows the gold daily price movements from 1975 to 2024

Accordingly, the gold market exhibits two distinct eras: a stable period and a high volatility period, each with unique roles and price behaviour. The recent fluctuations in the gold market raise doubts about the persistent effectiveness of these roles, as volatility and instability in the gold market increased after 2005. The high fluctuations in the gold market suggest a potential shift or, more likely, diminishing in its traditional roles.

Furthermore, the two aforementioned periods represent/indicate a structural break in the dynamics of the gold market, which raises questions about what has

driven these developments. It is well documented that gold price variations tend to be dominated by different market conditions and macroeconomic variables such as interest rate, inflation, exchange rate, economic uncertainty, and financial market turmoil ([Baur and Lucey \(2010\)](#), [Ghosh et al. \(2004\)](#), [Capie et al. \(2005\)](#), [Levin et al. \(2006\)](#), [Beckmann and Czudaj \(2013\)](#), [Baur and Smales \(2018\)](#)). Besides, gold market volatility is intimately linked to information about adverse events such as uncertain economic conditions, financial market movements, geopolitical tensions, macroeconomic variables, and macroeconomic policy changes ([Christie-David et al. \(2000\)](#), [Cai et al. \(2001\)](#)). However, these elements have always remained present and occur occasionally, which would not cause daily fluctuations. One would not notice significant deviations in gold volatility if these were the only factors driving gold price fluctuations. The changes in gold market volatility may perhaps coincide with the beginning of gold financialisation through the introduction of gold ETFs in the early 2000s. As the chairman of the World Gold Council (WGC) stated, “With the fundamentals of the gold market outlook improving and some fresh new investment product ideas for gold in the pipeline, the future for gold is as bright as I have seen it for some time.” Chris Thompson, 2002². The First gold ETF was launched and traded on the Australian Stock Exchange in March 2003, followed by, with the help of the World Gold Council, the largest First US gold ETF (GLD) in November 2004, traded on the New York Stock Exchange (NYSE).

Unlike traditional gold trading, gold financialisation has brought about innovations like gold-backed Exchange Traded Funds (ETFs) that allow investors to gain exposure to gold prices without physically owning, storing, and insuring the metal. It is suggested that the increase in price volatility of an asset is likely witnessed with the introduction of new financial instruments ([Lee and Ohk \(1992\)](#); [Bae et al. \(2004\)](#); [Arisoy \(2008\)](#)). With the introduction of paper gold, which securitises gold by converting physical gold into financial claims, the gold ETFs simplify and broaden access to gold investments. Consequently, as the demand for gold ETF shares expands, additional physical gold must be secured by gold ETFs to back those shares to be issued, thus increasing gold demand, price, liquidity, and perhaps volatility. Ever since, the number

² <https://www.gold.org/news-and-events/press-releases/new-ceo>

of gold ETFs and their holdings have grown substantially. Figure 1.2 shows a positive correlation between gold prices and amounts of gold owned by the gold ETFs.

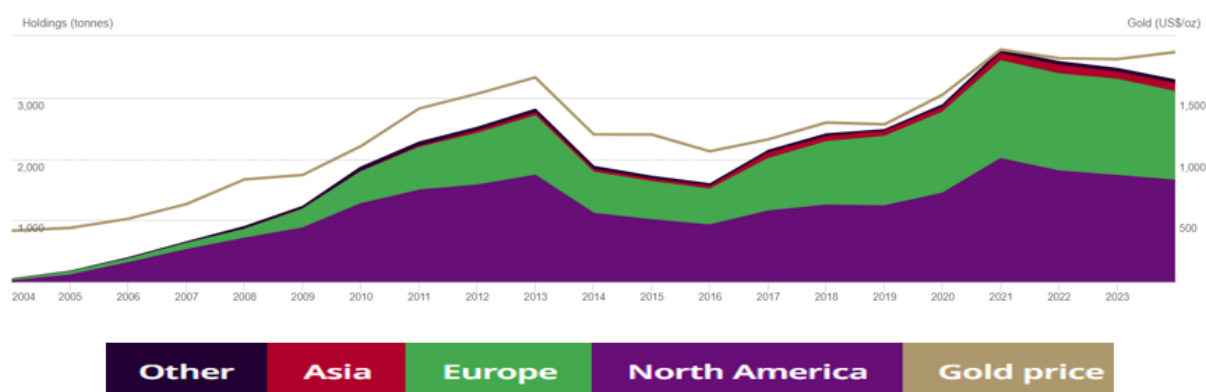


Figure 1.2 Shows the gold ETF increment holdings (Tonnes) by region from 2004 to 2023, World Gold Council.

In the same way, gold ETFs might accelerate the gold market response to gold-related news, escalating the flow of information to the gold spot market, which leads to increased volatility and market efficiency. Hence, the structural change in gold market volatility could be largely attributable to the new financial investment vehicle, gold ETF.

Additionally, the recent development in the gold market and increased market volatility following the introduction of gold ETFs raises questions about the impact of gold ETFs on the traditional roles of gold, i.e. whether gold ETFs influence the effectiveness of hedging and safe haven properties of gold and whether gold ETF supplanted physical gold's traditional roles. Likewise, in Figure 1.2, the positive correlation between gold prices and amounts of gold owned by the gold ETFs suggests a co-movement between gold prices and gold ETFs' holdings. Figure 1.2 illustrates that the increase (decrease) in gold holdings by gold ETFs aligns with the increase (decrease) in gold prices over time. For instance, the substantial increase in gold holdings between 2004 and 2013 aligns with the gold price surging, and the sharp fall in gold ETFs' holdings between 2013 and 2014 aligns with the gold price plummeting. Hence, this encourages investigating whether gold ETF investment demand (holdings) contributes to the gold market changes, i.e. whether gold ETF holdings co-integrate with gold prices and whether gold ETFs' holdings cause gold price movements.

Gold Exchange-Traded Fund (ETF) works as an investment fund, pooling gold, dividing ownership of this gold into shares for trading, and tracks the price of its

underlying single asset, gold, and can be viewed as the most directly linked investment vehicle with gold prices and successful investment instruments for gold. Building on the mechanism of gold-backed exchange-traded funds, the growing number of gold ETFs and their sizes (holdings) have greatly impacted the demand for gold. [Baur \(2013a\)](#) notes that introducing gold ETFs leads to a structural demand shift by increasing investment demand and the rising number of gold ETFs. Figure 1.3 shows that the number of gold ETFs has grown substantially along with its holdings. As the popularity and number of gold ETFs increase and the demand for gold ETF shares expands, additional physical gold must be secured by the existing and new gold ETFs, leading to increased gold investment demand and prices.

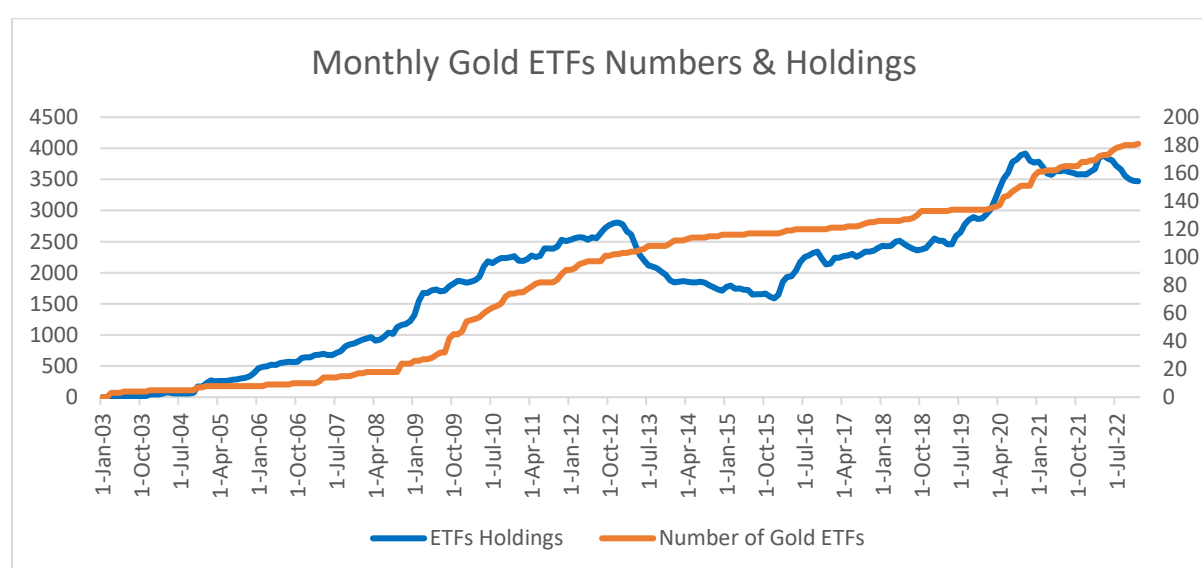


Figure 1.3 shows the monthly accumulated number of gold ETFs & holdings (Tonnes) from 2003 to 2022.

Figure 1.4 demonstrates that the changes in gold investment demand (holdings) by gold ETFs correspond to fluctuations in gold prices over time. An increase in gold investments by these ETFs is associated with rising gold prices, while a decrease in holdings aligns with falling prices. This view is supported by [Durham \(2013\)](#), who notes that the increase in investment demand could explain the gold price sensitivity given the limited gold production. Hence, the presence of a co-movement relationship between gold ETFs' holdings and gold prices may suggest, with limited gold production and high demand, an increased influence on gold price dynamics and potentially substitute the traditional supply and demand forces in the gold market.

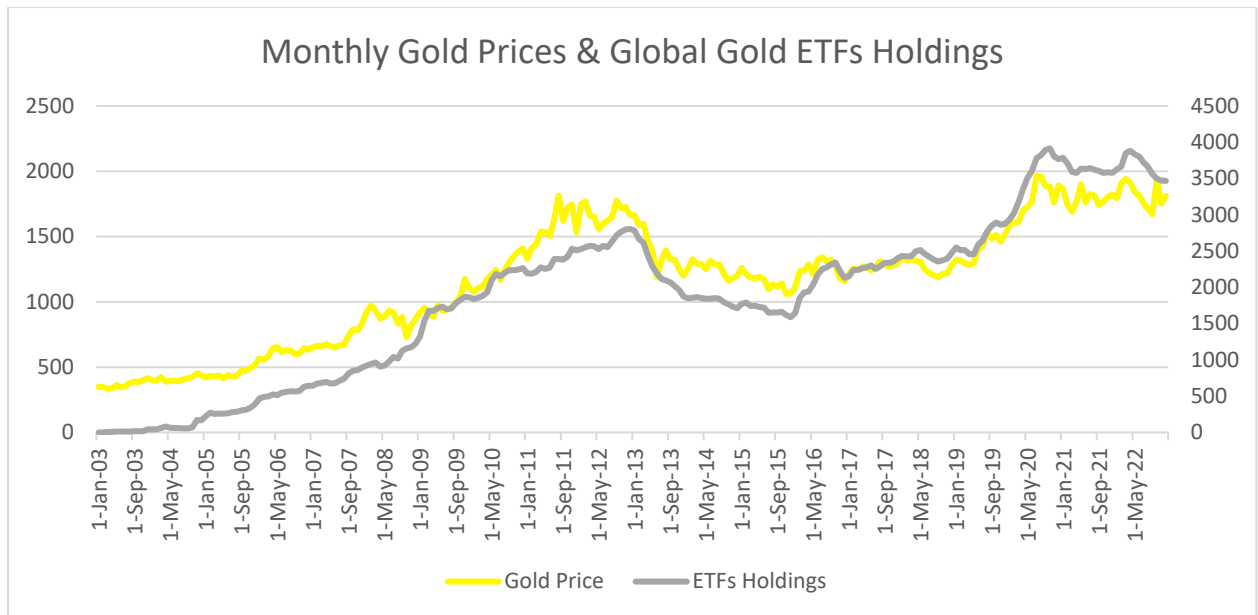


Figure 1.4 shows the monthly gold prices and Gold ETF holdings from 2003 to 2023.

The remainder of this thesis is structured as follows. Chapter 2 addresses the gold market changes, demonstrating the instability within the gold market that began in 2005 and examining its effect on traditional gold roles. Chapter 3 Addresses the gold financialisation effect on gold market volatility, exploring whether gold market volatility exhibits a structural break along with the gold ETF inception and whether gold ETF has emerged as a new factor contributing to gold spot market volatility and instability. Chapter 4 addresses gold ETF impact on the gold market, investigating whether co-integration exists between gold ETF investment demand (holdings) and gold prices, and whether a causal relationship runs from gold ETFs' holdings to gold prices. Chapter 5 gives concluding remarks.

Chapter 2: Gold Volatility and Safe Haven Role

Abstract

For decades, gold has been considered the most safe haven of assets in times of market turmoil. However, this role has appeared to disappear in recent years. This study aims to assess gold market behaviour over the past 37 years and examine the role of gold (and other precious metals) during equity and bond market stress. Notably, investigating whether gold lost its appeal as a safe haven asset due to its own market instability. The study demonstrates that the gold market exhibits two distinct periods characterised by differing market movements: a stable era followed by an unstable (highly volatile) era. Gold plays an insignificant role during the latter unstable period. Moreover, it exhibits a positive correlation in most high volatility periods of the S&P 500, again, especially during the unstable period. This implies that gold is losing (lost) its safe haven role during market stress. The outcome suggests that as the gold market encounters higher volatility periods, we anticipate a more positive correlation with the stock market in times of extreme stock market conditions. These findings have important implications for hedging, diversification, and investors seeking shelter in times of market stress since it is more likely for gold to exhibit high volatility and co-movement with other financial markets.

Keywords: Gold, Safe Haven, Volatility, ICSS, Changing Point, Rolling Mean, GARCH, DCC-GARCH

2.1 Introduction

Gold has been regarded as the most reliable safe haven asset for investors seeking shelter during times of uncertainty and market turbulence. Its appeal as a safe haven stems from its intrinsic store of value and its historical performance during times of uncertainty. When financial markets plummet or economic and financial crises loom, gold has often been a safe resort that individuals and investors turn to, believing it will retain or increase its value when everything else falters. Yet, is that still the case? The recent crises, including the global financial crisis and COVID-19, and its aftermath have underscored the viability of gold's safe haven role.

Apart from [Baur \(2012\)](#) and [Chang et al. \(2021\)](#), there is a lack of papers examining the effect of gold market volatility on gold's safe haven role during losses and financial market crises. Besides, the literature commonly assumes gold market stability, ignoring possible changes in gold market behaviour. [Baur et al. \(2022\)](#) argue that high asset volatility can diminish the asset's risk-diversifying or risk-hedging capabilities.

This study extends the literature on gold safe haven by focusing on gold market volatility's effect on the traditional roles of gold. In this framework, the objective of this study is twofold: First, it aims to assess gold market behaviour, focusing on whether a structural break exists. Second, it examines if gold lost its hedging and safe haven roles.

Findings reveal two distinct, stable and volatile, periods in gold market behaviour during which gold's hedging and safe-haven properties deteriorate. Mainly, in the high-volatility period of the gold market, gold shows a positive correlation with the S&P 500, especially during extreme market conditions, i.e. gold behaves more like a risky asset. The positive relationship during periods when both gold and stock/bond markets are under stress suggests a co-falling across these markets. The findings challenge the prevailing definition of the safe haven, which assumes a negative correlation with risky assets, specifically during crises, and provoke the assumption of the stabilizing role gold may offer in the financial system by mitigating losses in the face of extreme market downturns.

Given that gold is becoming highly volatile, aligns and acts more like other risky financial markets, these findings have important implications for hedging,

diversification, and protecting investors seeking safe investments, especially in times of market stress. If gold happens to lose its appeal as a safe haven, it could reshape investment strategies and risk management practices across the markets.

Inter-market relations have generally increased, leading to higher correlations among assets, generating an equally increased need for alternative assets that provide shelter in times of market stress. Media, analysts, and investors suggest that gold is the best asset offering protection in times of financial market instability. Gold shows its capability of being a hedge and safe haven in times of stress and uncertainty for quite enough time. This view of gold is a cornerstone of financial discourse.

Early studies, such as [Jaffe \(1989\)](#) and [Hillier et al. \(2006\)](#), underscore gold ability to enhance portfolio returns while mitigating risk, particularly during periods of market volatility. The work of [Baur and Lucey \(2010\)](#) rigorously tests and confirms gold's dual role as a hedge against stocks on average and a safe haven during extreme market conditions. [Baur and Lucey \(2010\)](#) define a safe haven asset as an uncorrelated asset or negatively correlated with other assets or portfolios in times of stress. They specifically identify gold as a safe haven asset as it demonstrates this characteristic, implying that its price tends to remain stable or increase when other assets, such as stocks, experience declining prices. Comparatively, [Baur and McDermott \(2010\)](#) extend the definition of Baur and Lucey for the safe haven asset by differentiating between strong and weak hedge and safe haven asset. This distinction enables the comparison between different potential safe haven assets and assesses the benefit of safe haven assets to different financial markets.

However, the definition of a safe haven asset does not account for the instability of the safe haven asset itself. In practice, Moving capitals in times of stress into another risky and volatile market is an irrational decision. The safe haven literature examines gold market behaviour under flight-to-safety conditions, assuming that the gold market is stable when broader financial market volatility increases. However, the study finds that the gold market fluctuates significantly and behaves more like risky assets in the nineteen years after 2005, compromising this assumption and its appeal as a safe-haven asset.

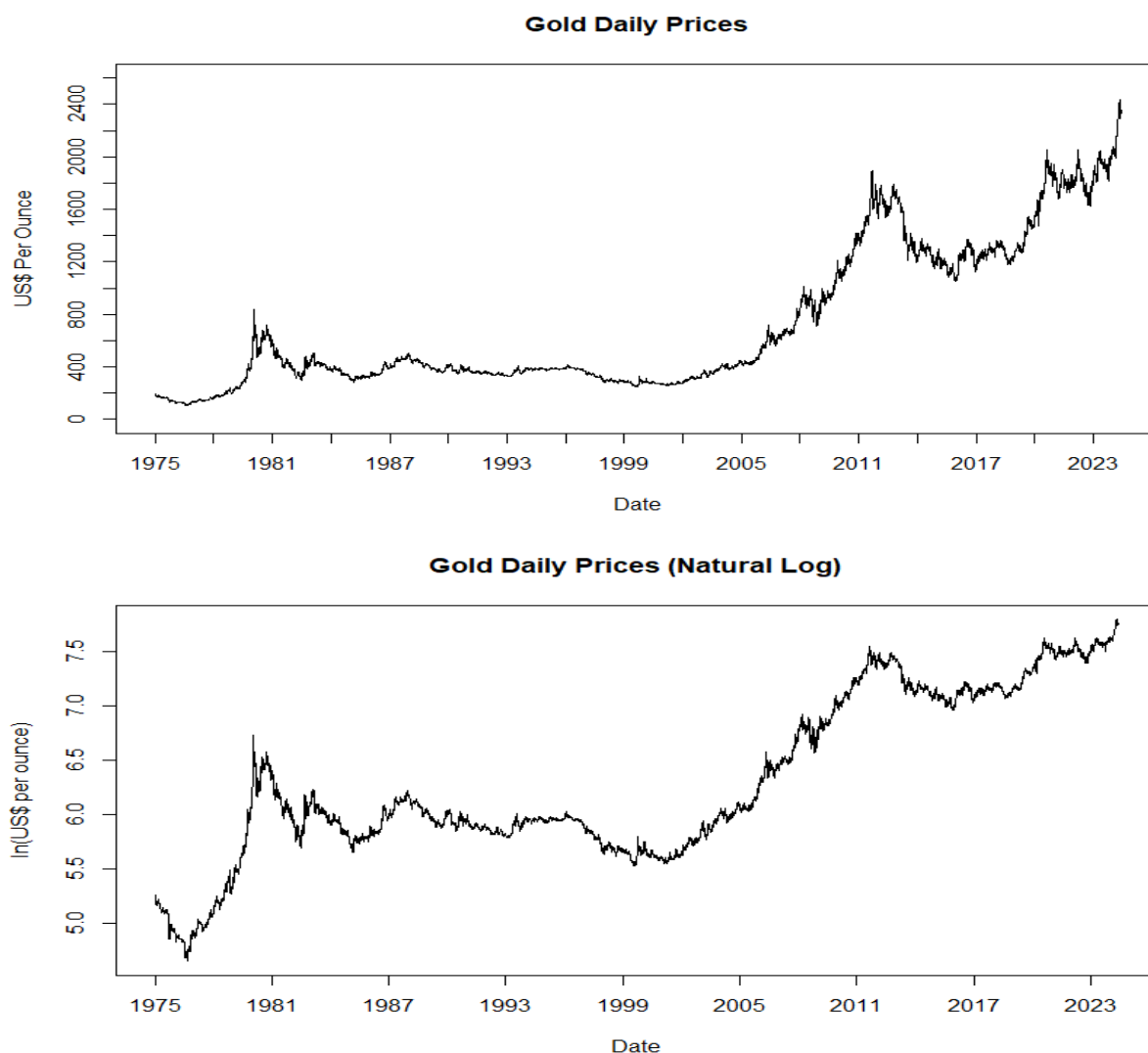


Figure 2.1 Shows the gold daily price movements from 1975 to 2024

A close examination of gold behaviour recently raised doubts about the sustained efficacy of its traditional roles. Figure 2.1 illustrates the historical trends in the gold market from 1975 to 2024³, showing that gold prices were broadly stable for 25 years (1980 – 2005)⁴, with increases occasionally occurring in response to certain events, like macroeconomic factors and equity market crashes, before returning to its average prices. This pattern is indicative of its safe haven role and the stability of the gold market.

³ We have earlier data but do not use this in the formal analysis due the effects from the oil price shocks.

⁴ There was a higher volatility period in the second half of the 1970s associated with the OPEC oil price shocks.

On the other hand, the latter 19 years (2006 and 2024) were noticeable with surging prices and high volatility and instability in the gold market. For example, the gold price surged by 52% during the financial crisis between July 2007 to February 2009. Furthermore, the market fell by 29% during 2008, including a sharp fall of 21% in October alone, before recovering by February 2009. Despite signs of economic recovery and improved financial market performance, gold initially expected to retreat and retain its value at the time when the crisis began as the crisis unfolded. However, it continued to rise alongside equity markets in periods beyond the global financial crisis and showed high market volatility.

Moreover, gold has behaved differently recently across the COVID-19 pandemic crisis. During this event, both gold and stock markets exhibited an uptrend movement in 2019. Despite the significant fall in equity markets at the beginning of 2020 as the concerns about the spread of Coronavirus increased, the gold market response was weak, and the gold price fell slightly on different occasions. Even more, when equity markets entered a bear market as the World Health Organization (WHO) declared the COVID-19 pandemic on March 11, the gold market fell as well. Additionally, following the equity market's recovery and entering a bull market on March 16, the gold market exhibited a similar upward trend. Both equity and gold markets peaked in August 2020 before they fell together.

Accordingly, one can notice that the gold market exhibits two distinct eras: a stable period and a high volatility period, each with its unique roles and price behaviour. The evidence of high fluctuations in the gold market suggests a potential shift in its traditional roles. The literature on the ability of gold to provide a safe haven in times of financial market stress presents a mixed picture and inconsistent roles. For instance, gold is a strong safe haven in developed markets but a weak safe haven for the US, France, Germany, UK, and European markets ([Baur and McDermott \(2010\)](#); [Coudert and Raymond \(2011\)](#); [Hood and Malik \(2013\)](#)). It also plays a relatively small role as a safe haven in emerging markets and is more likely considered a hedge or diversifier ([Ibrahim \(2012\)](#); [Ghazali et al. \(2013\)](#); [Seetharam and Bodington \(2015\)](#); [Robiyanto \(2018\)](#)). Other work argues that it always acts as a hedge, negatively correlated, for stock market risks, and this does not change during market falls ([He et al. \(2018\)](#)), or that it is, on average, a hedge and a safe haven during crises, but not during economic contractions ([Bredin et al. \(2015\)](#)). In a similar vein, [Choudhry et al.](#)

[\(2015\)](#) argue that it acts as a hedge in an economic crisis and as a safe haven in a financial crisis. However, both economic and financial crises cause market drops and increase uncertainty, in which investors seek safe haven assets to reduce their losses and protect their capital. Alternatively, others show an insignificant relation with stock markets in general ([Kopyl and Lee \(2016\)](#); [Choudhry et al. \(2015\)](#)), while exhibiting a positive correlation with S&P 500 at the peak of the global financial crisis ([Hood and Malik \(2013\)](#)). Equally, gold's role in periods of market turmoil and shocks in US and European markets faded after 2013 ([Klein \(2017\)](#)). Others document a change in the safe haven role, while gold shows a safe haven role during only the first stage of the COVID-19 pandemic ([Akhtaruzzaman et al. \(2020\)](#); [Ji et al. \(2020\)](#)), and this role weakened during the pandemic ([Cheema et al. \(2020\)](#); [Tarchella et al. \(2024\)](#)). Moreover, [Umar et al. \(2023\)](#) reveal that gold does not demonstrate a consistent safe haven role.

Overall, gold exhibited stability for quite a long time before 2005, during which its traditional roles as a hedge and safe haven emerged. However, recent fluctuations in the gold market raise doubts about the persistent effectiveness of these roles as volatility and instability in the gold market increased after 2005. The existing literature on gold's safe haven remains debatable, and the instability within the gold market needs to be addressed.

2.1.1 Study Focus

Considering recent gold price fluctuations, there remains a notable gap in the literature concerning the exact role of gold during financial market downturns, leaving the debate regarding gold's safe haven status ongoing. Despite increasing volatility in the gold market, limited research directly addresses the effect of gold market volatility on gold's safe haven role in periods of losses in financial markets, with notable exceptions being [Baur \(2012\)](#) and [Chang et al. \(2021\)](#). [Baur \(2012\)](#) suggests that gold volatility demonstrates an inverted asymmetric reaction to positive and negative shocks, and this effect is connected to the safe haven property of gold and may be related to contagion effects. [Chang et al. \(2021\)](#) further observe that gold serves as a safe haven in high volatility regime of the gold market but loses this role in low volatility regime.

This study aims to assess gold market behaviour over the last 37 years, examine gold's viability as a safe haven, and investigate whether gold has lost its ability to act

as a safe-haven asset due to market instability. The sample period spans from January 1987 to May 2024, covering several major crises (Black Monday in the 1987, the early 1990s recession, the dotcom crisis, the stock market crash of 2002, the global financial crisis in 2008, European Sovereign debt crisis, COVID-19 pandemic). This study moves the argument about gold as a safe haven asset forward by demonstrating how gold's role has faded over this period.

This study contributes to the existing literature by empirically examining and comparing gold market responses to extreme losses in stock and bond markets, focusing on whether gold has lost its safe haven role. The study compares two different periods: gold's reaction before and after 2005, arguing that this represents a break in the dynamics of the gold market. The analysis finds that, before 2005, gold demonstrated better safe haven properties during crises. However, after 2005, in most cases, it does not. Notably, gold becomes positively correlated with stocks in most post-2005 crises. These findings indicate that gold is losing its appeal as a safe haven in response to stock market stress. This result has important practical implications as it suggests that investors should be cautious when adding gold to their portfolios as a means to manage risk. For risk-averse investors, gold is believed to provide stability, reduce portfolio volatility, and provide protection in times of market stress. Therefore, realising changes in gold volatility and its safe haven role will reshape their investment decisions.

The rest of the chapter is structured as follows. Section 2 summarizes the main findings in the literature on gold roles. Section 3 introduces the data and describes the methodology used to test whether gold (and other precious metals) act as a hedge or safe haven for stocks and bonds and to explain gold market volatility. Section 4 provides gold market analysis, descriptive statistics, and empirical analysis and discusses the empirical results. Section 5 gives concluding remarks.

2.2 Literature Review

This section covers the literature about gold safe haven property, long-term gold roles, dependency and time variation structure between gold and other assets, Gold roles during uncertainty and political tension, and, more importantly, the Insignificant safe haven role and gold market volatility effect.

2.2.1 Safe Haven Property

Financial market interdependency has been growing steadily in recent decades. The need for an asset that could stabilize financial markets and reduce investors' losses during market turmoil and crashes has also increased. For quite a long time, financial media suggested that gold is an asset that could serve this purpose. Gold has been considered a safe haven in times of stress and uncertainty: "As gold's unquenchable beauty like the sun, people have turned to it to protect themselves against the darkness ahead" ([Bernstein, 2012: p1](#)). [Kaul and Sapp \(2006: p.761\)](#) define a safe-haven asset as an "ideal venue to park money during periods of uncertainty". As a commodity, gold shows that it is an asset that has no relationship with other types of financial assets. Thus, it is desirable for every investor or portfolio manager due to its risk-diversifiable property.

According to [Baur and Lucey \(2010\)](#) a safe haven is "an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market stress or turmoil". For an asset to qualify as a safe haven, its negative correlation with the other asset must remain negative in times of stress. A safe haven asset serves a distinct function beyond that of a hedge or diversifier. It is not necessarily that a safe haven asset can also function as a hedge and vice versa. As per [Baur and Lucey \(2010\)](#) definitions, a hedge (diversifier) is an asset that is uncorrelated or negatively (positively, not perfectly) correlated with another asset or portfolio on average. [Baur and Lucey \(2010\)](#) empirically show that for a short period, about 15 trading days, gold is a safe haven for stocks in the US, UK, and Germany only in extreme market shocks.

[Baur and Lucey \(2010\)](#) review of the literature concludes that relevant studies about gold as a safe haven prior to their study were scarce. Prior studies primarily focused on the financial characteristics of gold and the influence of macroeconomic variables on the gold market ([Sherman, 1982](#); [Lucey and Tully, 2003](#); [Faff and Hillier, 2004](#); [Capie et al., 2005](#); [Faugere and Van Erbach, 2005](#); [Hillier et al., 2006](#); [Tully and Lucey, 2007](#)). One study explicitly examined the role of gold as a hedge to the US dollar ([Capie et al., 2005](#)).

2.2.2 Long-Term Analysis of Gold Roles

In extreme market conditions, investors seek a safe haven asset, i.e. preserves value and protects wealth. In their investigation of investors with short and long-term

investment horizons between 1980 and 2013, [Bredin et al. \(2015\)](#) reveal that gold, on average, exhibits a hedge property and serves as a safe haven during crises, not during economic contractions for periods up to one year in three major markets (US, UK, Germany). Similarly, considering a long span of data from 1970 to 2013, [Baur and McDermott \(2016\)](#) report that gold functions as a strong, though short-lived (1 to 15 days), safe haven in response to large shocks. Nonetheless, reviewing earlier published papers and beyond the safe haven definition, [He et al. \(2018\)](#) conclude that gold consistently acts as a hedge, negatively correlated with equity market risks, and this relationship does not change even during market falls. Despite this, gold did not serve as either a hedge or safe haven during recent market crashes in 2018 and 2020. The persistent existence of a negative relationship between gold and equity, both in normal market conditions and during extreme market shocks, implies that “The safe have characteristic of gold is simply that it always remains a hedge” ([He et al., 2018: P.4](#)).

Contrary to [He et al. \(2018\)](#), [Boubaker et al. \(2020\)](#), in their investigation of gold over seven & a half centuries, present evidence that gold acts as a reliable safe haven when a crisis occurs. Moreover, gold serves as a robust safe haven during global crises when the gold market is bullish. Supporting this, [Iqbal \(2017\)](#) shows that gold can hedge and provide a safe haven role against adverse movement of stock price, commodities price inflation, and exchange rate risk regardless of whether the gold market is in a bullish or bearish condition.

2.2.3 Gold Role in Developed and Emerging Markets

Building on the work of [Baur and Lucey \(2010\)](#), [Baur and McDermott \(2010\)](#) extend the definition of a hedge as “A strong (weak) hedge is an asset that is negatively correlated (uncorrelated) with another asset or portfolio on average” while a safe haven as “A strong (weak) safe haven is an asset that is negatively correlated (uncorrelated) with another asset or portfolio in certain periods only, e.g. in times of falling stock markets”. The authors analyze the data from 1979 to 2009 and conclude that gold serves as both a strong hedge and safe haven asset for major European stock markets and the US but not for Australia, Canada, Japan or large emerging markets such as the BRIC countries (Brazil, Russia, India, and China). Besides, [Coudert and Raymond \(2011\)](#) find a weak safe haven role for gold, showing zero

correlation with stocks in the short run during recessions. However, it plays a strong safe haven role during bear stock markets for the US and G7 (Canada, France, Germany, Italy, Japan, UK, and US) collectively and weak safe haven for France, Germany, UK, and Europe separately. They also show that generally, gold is a hedge in the short run for all markets and only in the long run for (France, UK, US). Also, [Hood and Malik \(2013\)](#) show that gold serves as a hedge but a weak safe haven for the US stock market.

Furthermore, [Beckmann et al. \(2015\)](#) examine data from 18 individual economies and five regional indices in developed and emerging markets, confirming that gold's hedge and safe haven properties exist. Still, it depends on the specific economic environment under observation. More recently, [Bulut and Rizvanoglu \(2020\)](#) revisited [Baur and McDermott \(2010\)](#) study, confirming a similar point that gold possesses a strong safe haven for developed countries. Contrary to [Baur and McDermott \(2010\)](#), [Bulut and Rizvanoglu \(2020\)](#) find that gold is a hedge for all 34 emerging and developing countries, including BRIC, and a safe haven for some emerging markets. However, [Bekiros et al. \(2017\)](#) find a different conclusion, showing that gold plays only a diversifier role for stock markets in BRICS countries (Brazil, Russia, India, China, and South Africa).

Further studies have specifically investigated the gold properties against emerging equity markets. [Dee et al. \(2013\)](#) find gold is neither a hedge nor a safe haven against stock and inflation in China. In contrast, by considering domestic and foreign investors in 28 emerging financial markets, [Gürgün and Ünalmış \(2014\)](#) conclude that while gold acts as a hedge and safe haven for domestic investors in most emerging markets, it serves as a safe haven for both domestic and for foreign investors during global financial crises 2008. Evidence from Malaysia and South Africa also shows gold's role as a hedge and diversifier and a relatively small role as a safe haven during market turbulence ([Ibrahim, 2012](#); [Ghazali et al., 2013](#); [Seetharam and Bodington, 2015](#); [Robiyanto, 2018](#)). Conversely, [Iqbal \(2017\)](#) finds that gold is more of a safe haven than a hedge in two emerging markets (Pakistan and India).

2.2.4 Dependency and Time Variation Structure Between Gold and Other Assets

Several studies have provided an in-depth analysis of dependency structure and whether gold is a hedge and safe haven against equity markets, fixed assets markets,

oil markets, currencies, and exchange rates. [Ciner et al. \(2013\)](#) examine time variation in conditional correlation dependencies using DCC-GARCH to determine when gold, stocks, bonds, oil, and exchange rates serve as a hedge against each other in a portfolio and whether the dependencies, using quantile regression, differ during extreme price movements to act as a safe haven. The conditional correlation analysis suggests that while gold shows a hedge function for equities and dollars, it has a relatively low relation with bonds. The safe haven analysis indicates that gold is not a safe haven for equities but continues to be a safe haven for currency declines. It is a safe haven against the US and UK exchange rate, which refers to its monetary asset role. Moreover, results showed that gold could act as a safe haven for bonds. Equally, [Śmiech and Papież \(2017\)](#) confirm gold to function as a safe haven in the turmoil market for equity is time-varying.

Furthermore, many studies have confirmed the effectiveness of gold's ability to act as a hedge and safe haven against the US dollar. As quoted in the US dollar, gold relatively reflects the strength of the currency linked to the US dollar. [Joy \(2011\)](#) examines gold's capability to act as a hedge or safe haven against 16 US dollar exchange-rate pairings and concludes that it is an effective hedge but a weak safe haven. Similarly, empirical evidence reported by [Reboredo and Rivera-Castro \(2014\)](#) shows that gold is a poor safe haven and successful hedge against seven major US dollar exchange-rate pairings [Australian Dollar (AUD), Canadian dollar (CAD), euro (EUR), pound sterling (GBP), Japanese yen (JPY), Norwegian krone (NOK) and Swiss franc (CHF)]. [Reboredo \(2013b\)](#) proves that gold is an effective hedge for USD exchange rate movements and a safe haven in extreme conditions, thus confirming gold's diversification capability and downside risk reduction. Furthermore, gold proves to be a hedge and safe haven not only for the US dollar but also for other currencies in which it is quoted. Similarly, [Pukthuanthong and Roll \(2011\)](#) empirically showed a negative relationship between the gold price quoted in Euro, Pound, and Yen and the depreciation of these currencies. Research by [Qureshi et al. \(2018\)](#) examines gold and rupee exchange rate relation in a gold consuming country (Pakistan), finding that gold acts as a short-run hedge and a safe haven for Pakistan exchange rate depreciation against a set of currencies [US dollar, euro, UAE dirham, and Saudi riyal]. Likewise, [Iqbal \(2017\)](#) indicates that gold is a hedge and safe haven for currency depreciation in India and Pakistan. Recently, [Nguyen et al. \(2020\)](#) show that gold acts as a hedge for

USD, EUR, and JPY on average and a safe haven only for dollars and euros in turmoil periods.

Although few studies explicitly investigate gold and oil dependency in recent years, [Ciner et al. \(2013\)](#) find that gold is not a hedge against oil price movements. Similarly, [Reboredo \(2013a\)](#) and [Śmiech and Papież \(2017\)](#) find a positive correlation between gold and oil, which reduces the opportunity for gold to hedge for the oil market on average. However, it is a safe haven in extreme oil price movements. Nevertheless, [Tiwari et al. \(2020a\)](#) find that gold is a hedge only for the short and medium term and is a safe haven in extreme market conditions against oil price movements. Additionally, in their comparison between bitcoin and gold against oil price movements, [Selmi et al. \(2018\)](#) find that the role of gold to serve as a hedge, diversifier, and safe haven is sensitive to gold's market conditions (bear, normal, bull) and degrees of oil price movements.

2.2.5 Gold Roles During Uncertainty and Political Tension

Few studies have investigated the role of gold as a safe haven asset in periods of market uncertainty and geopolitical risks. Financial and economic crises heavily contribute to uncertainty, in which investors tend to move to other markets to reduce their losses and protect their capital. [Baur and McDermott \(2012\)](#) examine the effect of uncertainty caused by financial crises on gold and bonds to act as a safe haven. They show that both assets act as a safe haven for the equity markets in periods of extreme market shocks, but they differ in their response time. Their results show a strong, immediate, and persistent response to act as a safe haven following extreme shocks. According to [Apak et al. \(2012\)](#), gold prices gain value in times of uncertainty. Likewise, [Triki and Maatoug \(2020\)](#), in a period of political tension, show that gold volatility negatively correlates with stock market volatility, which indicates the hedge property of gold. In extreme political events, gold appears to be a safe haven.

Additionally, the outbreak of the COVID-19 pandemic affects several industrial sectors, international trades, and individuals, which causes instability in the economic and financial markets around the world. The rapid spread of the virus forces governments to impose strict restrictions and precautions to contain the virus internally, imposing lockdowns. On the other side, international travel was banned for more than a year. These procedures and other measurements have led to a global

crisis and vague expectations about the future. The pandemic has caused significant losses in financial markets, and like other crises, investors seek safe assets to protect their investments. [Cheema et al. \(2020\)](#) compare the performance of safe haven assets against developed and emerging equity markets during the COVID-19 pandemic, finding that gold lost its property as its price moved in conjunction with all equity markets. [Akhtaruzzaman et al. \(2020\)](#) examine the impact of uncertainty set off by the COVID-19 pandemic on gold properties, finding that gold has lost its safe haven property at some point amid the pandemic. They show that gold negatively correlates with equity indices in the first period of the COVID-19 pandemic crisis (December 31, 2019–March 16, 2020), while it acts as a hedge in the second period (March 17, 2020–April 24, 2020). Moreover, [Ji et al. \(2020\)](#) investigate whether the ability of the candidates' safe haven assets (Gold, bitcoin, oil, currencies) remains valid, finding that only gold has held its role in market turmoil between December 2019 and March 2020. Similarly, [Baur and Dimpfl \(2020\)](#) propose a safe haven index (SHI) which includes Gold, US and German government bonds, major currencies, and bitcoin along with other assets that could act similarly, examining whether it demonstrates positive returns and high volatility in crisis periods. They note that safe haven index (SHI) fell at the beginning of the COVID-19 crisis, and the safe haven assets did not function as expected. Similarly, [Choudhury et al. \(2022\)](#) find that gold is a weak safe haven during COVID-19. [Echaust and Just \(2022\)](#) compare gold roles during COVID-19 and GFC and find that gold is not a good shelter against stock market drops during COVID-19 but is a significant safe haven during the Global Financial Crisis (GFC), decreasing the extreme downside risk. However, [Drake \(2022\)](#) notes that gold safe haven role is not supported in both the 2007–09 financial crisis and during COVID-19. [Tarchella et al. \(2024\)](#) note that gold demonstrated a weak safe haven role at the start of the COVID-19 outbreak, showing a positive correlation pattern with G7 equity markets. It is a more promising diversifier under all market conditions. Similarly, [Le Thi Thuy et al. \(2024\)](#) find that while gold traditionally serves as a strong safe haven, its effectiveness is inconsistent in certain crises, losing its role, particularly during the COVID-19 pandemic, and restoring it during Russia-Ukraine conflict in the Netherlands, US and Germany markets. In the same vein, other studies further highlight that gold effectiveness can vary depending on the nature of the crisis and market conditions ([Ryan et al. \(2024\)](#); [Feder-Sempach et al. \(2024\)](#))

2.2.6 Insignificant Safe Haven and Gold Market Volatility Effect

Further studies investigate whether gold lost its safe haven property. [Lucey and Li \(2015\)](#) study the safe haven property of the four precious metals (Gold, silver, platinum, and palladium) and show that gold exhibits a safe haven role against equity market decline most of the time. However, other precious metals individually and collectively act as a safe haven in times when gold does not. Extending the study and analysis of 32 assets, including commodities, bonds, currencies, and alternative assets, during the severe financial crisis between 1964 and 2014, [Kopyl and Lee \(2016\)](#) find that gold statistically insignificantly correlated with the equity market.

Similarly, [Choudhry et al. \(2015\)](#) provide statistical evidence that gold was not a safe haven during the last global financial crisis (2008) by investigating the nonlinear causality between gold and three major equity markets (US, UK, Japan). Nevertheless, it serves as a hedge in times of stability for stock market volatility. Likewise, [Hood and Malik \(2013\)](#) show that gold exhibits a positive correlation with the S&P 500 at the peak of the global financial crisis when the Lehman Brothers collapsed. Interestingly, [Klein \(2017\)](#) shows that gold's role in periods of market turmoil and shocks in the US and European markets faded after 2013. Besides, [Shahzad et al. \(2020\)](#) find that gold does not act as a safe haven for stock and bond markets of G7 countries due to the significant positive impact spillover from the stock and bond markets to gold returns during bearish market conditions. [Umar et al. \(2023\)](#) indicate that gold, unlike other assets, cannot be considered a consistent safe haven asset regardless of the level of global risk aversion.

Additionally, the literature assumes that the gold market remains stable most of the time and only activates in times of stress and turbulence in financial markets. However, the volatility in the gold market has increased significantly in the last 15 years (2005 – 2020) compared to the gold market history since 1975. The literature shows two strands of studying gold market volatility. Few studies investigate whether gold price volatility affects the price of the equity markets. The analysis of the causal relation between gold price volatility and stock market prices shows evidence that gold prices cause equity market returns and vice versa in India ([P.K. Mishra \(2010\)](#), [Bhunja and Das \(2012\)](#)). [Filiz YILDIZ CONTUK \(2013\)](#) shows that gold returns and stock market returns are affected by each other and by their own shocks in Turkey. [Gokmenoglu and](#)

[Fazlollahi \(2015a\)](#) find that gold volatility impacts the S&P500 index in the long run but not in the short run.

On the other hand, the study of gold market volatility's effect on gold's traditional safe haven role is scarce. [Baur \(2012\)](#) investigates the effects of gold price volatility on the safe haven role of gold during equity market turmoil and crashes. [Baur \(2012\)](#) analyzes volatility asymmetry and its effect on portfolio diversification and whether increases in gold volatility in times of financial crisis would compromise the effectiveness of gold safe haven property. The author suggests that, due to its safe haven role, increasing gold prices are interpreted by investors as an indication of the uncertainty of economic and financial conditions. This perception, in turn, leads to increased gold price volatility as investors react to these conditions. The author shows that gold exhibits an inverted asymmetric (positive shocks increase volatility more than negative shocks) reaction, which can positively enhance the effectiveness of gold as a hedge or safe haven. However, the strength of this effect depends on the correlation between gold and other assets. "An analysis of this effect for portfolios including equity and gold shows that the increased volatility of gold complements the beneficial negative correlation of gold and equity markets in periods of market turmoil or financial crisis and enhances the safe-haven property of gold" ([Baur, 2012: P. 37](#)). Besides, [Chiarella et al. \(2016\)](#) and [Todorova \(2017\)](#) confirm and discuss the implications of inverted asymmetric volatility in the gold futures market. [Chang et al. \(2021\)](#) further investigate gold's role as a safe haven across different volatility periods, considering different gold market volatility regimes in the United States, the United Kingdom, Germany, Australia, and Japan from 2002 to 2018. The authors find that in the low volatility period of the gold market, gold has no hedging ability with most equity markets during all subsample periods around Global Financial Crisis (the pre-crisis period, crisis period and post-crisis period). In contrast, gold hedging capability existed in the high volatility regime of the gold market, but only before (pre-crisis) the Global Financial Crisis. Yet, gold failed to provide hedging role after financial crisis. On the other hand, in the low volatility period, gold lacks the safe-haven ability against stocks across most countries at different subsample periods. However, gold retained its ability in the high gold market volatility period. [Chang et al. \(2021\)](#) conclude that gold market volatility regimes highly influence gold hedging and safe-haven properties.

To conclude this section, the literature on gold as a hedge and safe haven asset is enormous but fragmented, producing inconsistent findings shaped by differing market scopes, asset classes, time periods, and methodologies (see Table 5.2, Appendix 1). Foundational work by [Baur and Lucey \(2010\)](#) and Baur and McDermott [Baur and McDermott \(2010\)](#) (2010) defined and empirically validated the distinction between hedge and safe haven assets, framing gold as a strong safe haven during extreme market shocks. However, these and following studies assume gold's market stability and do not account for potential structural changes in gold market behavior over time.

While papers like [Hood and Malik \(2013\)](#) or [Kopyl and Lee \(2016\)](#) question gold's consistency as a safe haven, they do not attribute this inconsistency to gold's own volatility — a central hypothesis of the present study. Other work, like [Baur \(2012\)](#), introduces the notion of inverted asymmetric volatility, suggesting that volatility itself may enhance or erode safe haven status. Yet, it does not account for gold's own market instability. [Cheng et al. \(2020\)](#) analyze volatility regimes but retain a predefined segmentation, thereby missing a formal framework for detecting regime shifts. Recent literature on safe haven performance during COVID-19 (e.g., [Cheema et al. \(2020\)](#); [Echaust and Just \(2022\)](#)) provides event-based findings and highlights gold's diminished role but again without account for gold's market structural changes.

This study diverges significantly and contributes to literature in both scope and method, builds a comprehensive framework and adds novel empirical evidence. Using a 37-year data window and a data-driven structural break analysis, this work identifies a distinct regime change in 2005, marking a shift from a stable to a volatile gold market. Prior literature often treats market volatility as an external condition (e.g., stock market stress) affecting gold. This study uniquely argues that gold's own volatility undermines its safe haven function, a proposition largely unexplored and here addressed over a formal framework and systematic testing. This study extends the scope of analysis to cover most major crises from Black Monday to COVID-19, offering more chronological and cross-crisis Analysis than most previous works. Unlike previous studies that broadly test safe haven properties with stability assumption of the market, this research endogenously segments the gold market using a change-point detection approach, quantifies regime-specific behavior, and applies GARCH, DCC-GARCH, and ICSS methodologies to capture volatility clustering, dynamic correlation, and

gradual changes in gold's safe haven properties, a methodological enhancement over previous work, offering a more wide-ranging and robust framework than those relying on single-model estimations.

2.3 Methodology

This section introduces the research questions and discusses methods used to evaluate gold market behaviour changes, highlights gold market volatility, and examines whether gold remains a safe haven and whether gold market volatility affects gold's safe haven capability.

2.3.1 Data

The data consists of daily closing spot prices for gold, silver, platinum, palladium, bonds (10-year US Treasuries), and stocks (S&P 500)⁵. All precious metals prices are measured in US dollars per troy ounce. The data used is obtained from Refinitiv Workspace. The data sample covers 37 years from January 5, 1987 to May 31, 2024 leading to a sample size of 9760 daily observations⁶. As shown in **Error! Reference source not found.**, the gold market appears to exhibit two different states of behaviour: a stable period (January 1987 to December 2005) and a high volatility period (January 2006 to May 2024). Thus, the sample splits into previously mentioned periods, allowing for further comparison of gold market behaviour and gold responses to stock and bonds market stress.

The daily returns for gold and other precious metals, bonds and S&P500 were computed based on the daily closing price (P_t), where the return Ri_t is defined by $[(P_t / P_{t-1}) - 1]$. All time series returns were tested for unit root through the Augmented Dickey-Fuller test⁷, with the null hypothesis of the existing unit root being rejected at a 5% significant level (p-value < 0.05). Thus, all series returns are stationary, meaning

⁵ The thesis considered U.S. markets due to global influence of the U.S. economy and its capital markets. It hosts some of the largest and most liquid financial markets in the world, serving as a benchmark for global financial trends. Besides, U.S. financial data provides a solid basis for empirical analysis due to its availability, accessibility, reliability and credibility. Hence, it allows the drawing of well-supported conclusions and facilitates comparison with existing literature.

⁶ As can be seen in, for example, Figure 2.1, we have earlier data but do not use this in the formal analysis due the effects from the oil price shocks (again, as can be observed in Figure 2.1).

⁷ See appendix 1 for test results.

their statistical properties remain constant over time, which is necessary to generate unbiased and reliable results.

2.3.2 Research Aims and Hypotheses

On the subject of safe haven property, Baur and Lucy (2010) were the first to explicitly examine and show evidence of gold's hedge and safe haven properties in relation to bond and equity markets. Following their work, numerous researchers expanded the investigation in different directions, resulting in inconsistent findings, as shown in the previous section. Notably, most of these studies focused on gold roles during either the early or part of the latter era or in both eras of the gold market, assuming market stability. However, the gold market price movements in the latter era, as shown in Figure 2.1, have raised questions about gold market volatility and its effects on gold's traditional roles as a hedge and safe haven.

Hence, the study seeks to:

- 1- Investigate whether gold market behaviour changes.
- 2- Examine gold viability as a hedge and safe haven.
- 3- Evaluate whether gold volatility affects gold's appeal as a safe haven.

2.3.3 Is There a Break in the Gold Market?

As shown in Figure 2.1, the gold market exerts two different states of behaviour: a stable period (1987 to 2005), in which the gold market occasionally responds to market conditions, and a high volatility period (2006 to 2020) characterised by price surging and high volatility and instability in the gold market. The high volatility period of the gold market covers major crises, including the global financial crisis, the eurozone debt crisis, several stock market crashes, and ending with the recent economic turmoil caused by the COVID-19 pandemic. Based on this background, the first hypothesis investigates whether gold market behaviour changes.

Hypothesis 1: The gold market exhibited a shift in the early 2000s, and the market behaviour changed.

To establish whether the gold market nature exhibits two distinct behaviours and justify dividing the sample period, the study first explores whether a statistical changing point exists in the gold market. Then, it measures if the mean of gold return remains stable over the entire sample period and highlights the difference between

the two subsamples. Last, it illustrates if there is a change in the level of volatility within gold returns over the full sample and subsample periods.

2.3.3.1 Changing Point Approach

From a theoretical perspective, the changing point in gold market prices is driven by the fact that the gold market behaviour has changed around the mid-2000s. Figure 2.1 reveals that the gold price was broadly stable (the price line in the chart is almost flat) for 25 years (1980 – 2005), increasing only in response to stock market crashes, before returning to its average price. In this context, the term stable period is used to describe this period where the price line remains almost flat. In contrast, in the latter 19 years (2006 and 2024) gold prices began to rise gradually following the dotcom crash and a period of historically low interest rates, with noticeably high volatility and instability in the gold market. This indicates that the gold market exhibits two distinct eras: a stable period and a high volatility period, each with its unique roles and price behaviour.

Given this background, to establish whether the gold market exhibits two distinct behaviours and justify dividing the sample period, the study investigates whether such a break exists statistically. To consider whether there is a change (break) point in the data, we follow the procedure in [Killick et al. \(2012\)](#) and [Killick and Eckley \(2014\)](#).

The changing point approach identifies structural breaks in a dataset to understand how the data may have changed over time. It is a point in the data series where there is a sudden significant change in the underlying statistical properties of the data that allows split series into two or more segments, each with its own statistical properties (e.g., mean, variance, etc.). The approach uses different search algorithms (BinSeg, AMOC, PELT) to identify the location of one or more change points within a time series. The main difference between these algorithms is in the number of changepoints they can detect. While PELT (Pruned Exact Linear Time) allows for the detection of multiple changepoints, BINSEG (Binary Segmentation) and AMOC (At Most One Changepoint) detect one changepoint. The choice between algorithms largely depends on the nature of the data and the specific requirements of the analysis. For this study, the AMOC is considered, and for robust results, BINSEG is also considered.

In particular, detecting changes in the characteristics of time series data can be accomplished by comparing statistical properties across the data. Shifts in the mean value are one notable example of such changes and can be identified when the data can be segmented into different constant segments with different mean values. Another example is a change in variance, where the mean value of the data remains constant while having multiple segments with distinct variance values. These changes can be interpreted as sudden fluctuations in the time series data, providing valuable insight into its behaviour.

To consider whether there is a changing (break) point in the data, let's denote the observations as $X = \{x_1, x_2, \dots, x_n\}$ and the segment of this dataset from point i to j as $X_{ij} = \{x_i, \dots, x_j\}$

For each segment X_{ij} , the mean and variance are defined as follows:

$$M_{ij} = \frac{1}{j-i+1} \sum_{k=i}^j x_k$$

$$V_{ij} = \frac{1}{j-i+1} \sum_{k=i}^j (x_k - M_{ij})^2$$

Then, the cost function for each segment X_{ij} , based on the likelihood of the normal distribution, can be expressed as follows:

$$C(i, j) = -\log \left[\frac{1}{(2\pi V_{ij})^{(j-i+1)/2}} \exp \left(-\frac{1}{2V_{ij}} \sum_{k=i}^j (x_k - M_{ij})^2 \right) \right]$$

After computing the cost for each segment X_{ij} , the total cost for the dataset X segmented at each position i is the sum of the cost of all segments. Then, if the total cost is less than the cost of considering the whole data set as one segment, it implies one or more change points. The approach helps find a single change point, which infers to the first observation in the new data segment by considering the mean and variance of data.

2.3.3.2 Rolling Mean Approach

To further illustrate the changing nature of the gold market, the rolling average return is calculated. The rolling means computing the gold average return over a fixed window (24 periods). Then, as the window rolls ahead through the sample by a given increment (one period or one observation at a time) each time, it yields individual statistics (average) for each window. Thus, the rolling mean creates a series of averages (means) from each rolling window subset of the entire sample to smooth out fluctuations and highlight trends. If the computed means remained constant and not widely different over the full sample, it would bear out gold returns stability. Hence, the division of the whole period into specified two eras cannot be constructed. However, suppose the computed means change at some point. In that case, the model will validate that gold return exerts different behaviours and justify dividing the entire period into a stable and highly volatile period.

To consider whether the mean of the gold return time series (G_t) remains constant over a sample from $t = 1, \dots, T$, the rolling window calculation is given for windows $t = n, \dots, T$, where n denotes the window size (a subset of the sample):

$$\hat{\mu}_t(n) = \frac{1}{n} \sum_{i=0}^{n-1} G_{t-i}$$

To provide a clearer illustration, the calculations were undertaken with re-sampled monthly data and so the window size covers 24 months, where the daily return would be noisy and not clearly reflect the changes.

2.3.3.3 GARCH (volatility) Model

As a further exercise in understanding gold behaviour, the Generalized Auto Regressive Conditional Heteroskedasticity GARCH (1,1) model for daily gold returns is estimated over the two sample periods. The GARCH model, a volatility estimator, captures the significant fluctuation and low variation in a financial time series like gold. This is largely illustrative but serves to highlight the change in the level of volatility within gold returns over the full sample period.

The model requires a few checks and procedures before it can be run. First, find gold time series returns. Second, select the significant lag in gold returns by plotting ACF (Autocorrelation function). Next, check whether the gold return is stationary, i.e. the unit root test, Augmented Dicky-Fuller (ADF) test, rejects the null

hypothesis of existing unit root. If the test fails to reject the nonstationarity of gold return, the time series must be transformed to stationary by differencing. The gold return series appears to be stationary as the P-value⁸ of the unit root test is less than 0.05, meaning that the series has a constant mean, variance, and no seasonality over time.

Afterwards, the mean equation, Autoregressive Integrated Moving Average (ARMA), is specified as follows:

$$\hat{R}_t = \varphi_0 + \sum_{i=1}^p \varphi_i \hat{R}_{t-i} + \sum_{i=1}^q \theta_i \hat{\varepsilon}_{t-i}$$

According to Akaike information criteria (AIC) and Bayesian information criterion (BIC), ARMA (1,1) provides the best fit for the model. Then, the residuals from the mean model are tested to ensure no serial correlation between residuals and follow a normal distribution. Using the Ljung-Box test to assess the null hypothesis (H_0) of there is no serial correlation, the null hypothesis is accepted, as the p-value⁹ exceeds 0.05., indicating that the residuals are normally distributed.

Subsequently, the ARCH effect, or conditional heteroskedasticity, is examined using the Ljung-Box test on squared residuals. The null hypothesis H_0 : there is no ARCH effect, is rejected as the p-value¹⁰ is less than 0.05, indicating the ARCH effect is statistically significant. Hence, volatility should be modelled. The presence of the ARCH effect implies that the variance of the error term is not constant, which requires the use of the GARCH model to capture the time-varying volatility. The GARCH (1,1), commonly found to be the best fit in many cases for modelling volatility in time series, model is applied.

GARCH(p,q) model given as below:

$$\sigma_t^2 = \omega + \sum_{i=1}^m \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^s \beta_i \sigma_{t-i}^2$$

GARCH is an ARMA model where AR(p) portion models the variance of the error term (ε_{t-i}) and MA(q) portion models the variance of the process (σ_{t-j}). To model the current volatility, not only the previous volatility of the error term (ε_{t-i}) is taken into

⁸ See appendix 1 for test results.

⁹ See appendix 1 for test results.

¹⁰ See appendix 1 for test results

account, but also the value of the volatility (σ_{t-j}) from previous times is considered in the model.

2.3.4 Is Gold a Safe Haven?

Suppose the formal tests and the illustrative of gold volatility highlight the view that the behaviour of the gold market experienced a shift in the early 2000s. In that case, the change in the gold market behaviour (volatility) may affect the gold's ability to act as a safe haven asset. Accordingly, the second hypothesis is developed to examine gold viability as a safe haven.

Hypothesis 2: Gold remains a hedge and safe haven asset in the volatility period.

2.3.4.1 Hedge and Safe Haven Approach

In this section, the approach considers whether gold remains a safe haven asset over the extensive period from January 1987 to May 2024, which included multiple periods of market stress and crashes. The study follows the definition of [Baur and Lucey \(2010\)](#) and [Baur and McDermott \(2010\)](#) in considering both strong and weak safe haven and hedge. A strong (weak) safe haven is an asset negatively correlated (uncorrelated) with stock returns on days of extremely negative returns. A strong (weak) hedge is an asset that is negatively correlated (uncorrelated) with stock returns on average. Furthermore, the econometric analysis follows the [Baur and Lucey \(2010\)](#) approach to test for safe haven and hedge properties by specifying the regression model as given:

$$R_{gold,t} = a + b_t R_{stock,t} + e_t \quad (1)$$

$$b_t = c_0 + c_1 D(R_{stock,q10}) + c_2 D(R_{stock,q5}) + c_3 D(R_{stock,q1}) \quad (2)$$

$$h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} \quad (3)$$

where the return (R) of the potential safe haven asset, such as gold, depends on the changes in the stock or bond market. Additionally, we assume that the relation between gold (or other safe haven asset) and the stock or bond market is not constant and is influenced by certain extreme conditions in the stock market. More specifically, equation (1) models the relation between gold (or other asset) and stock or bond return. The parameters to be estimated are (α) and (b_t), with the error term is given by (e_t). The parameter (b_t) is modelled as a dynamic process given by equation (2). Here, the parameters c_1 , c_2 and c_3 measure the effect of extreme events captured by the

dummy variables denoted as $D(\dots)$ that are equal to one if the stock or bond market crosses a threshold given by the 10%, 5% and 1% quantile of the return distribution. Equation (3) is a standard GARCH equation.

Of particular interest, if one of the parameters c_1 , c_2 or c_3 is significantly different from zero, then there is evidence of a relation between gold and extreme movements in the stock or bond market ([Baur and Lucey \(2010\)](#)). If the parameters in equation (2) are zero or negative, the gold (or alternative asset) acts as a safe haven for that market. However, gold would serve as a hedge for the market if the parameter c_0 is zero or negative and the sum of the parameters c_1 , c_2 and c_3 are not jointly positive exceeding the value of c_0 .

2.3.5 Has Gold Safe Haven's Behaviour Changed?

This section further evaluates whether gold volatility affects gold's appeal as a safe haven asset. Financial assets are quite correlated in today's markets, and the correlation is usually dynamic. The relationship between assets changes based on certain events or market movements where more or less relationships would occur. The conditional correlation between assets may not exist if a particular event or effect causes an asset to be volatile while not affecting other assets. However, if an event affects both assets, a certain correlation can exist between the two assets. For instance, If the stock market suffers from high volatility due to an event or movement, the gold market would experience high volatility if the two assets were positively correlated or low volatility if they were negatively correlated.

2.3.5.1 Dynamic Conditional Correlation - GARCH (DCC-GARCH)

In further seeking to understand the changing role of gold as a safe haven asset, the gold time-varying co-movements with stocks and bonds is considered by estimating a DCC-GARCH model, which captures the dynamic conditional correlation between the series. Notably, the model captures the persistence and clustering of volatility alongside time-varying correlations. Again, the model serves to illustrate the change in the conditional correlation between gold and stock and bond market returns over the full sample period. It underlines whether the negative relation remains as initially expected, being a safe haven, or changes during the high volatility period.

While the Dynamic Conditional Correlation (DCC) part of the model accounts for the time-varying correlation, capturing the changing relationship between assets

during financial stress or crisis, the GARCH part accounts for volatility, capturing the clustering of volatility over time of each individual's time series. Once each asset's volatility is modelled, the DCC model then estimates the time-varying correlation between assets. Hence, the DCC-GARCH model helps understand how gold, S&P 500, and Bonds co-move, especially in periods of market volatility.

2.3.5.2 Iterative Cumulative Sums of Squares (ICSS) Algorithm

To further consider if gold is losing its safe haven appeal, the iterative cumulative sums of squares (ICSS) algorithm of [Inclan and Tiao \(1994\)](#), which is designed to detect multiple breaks in volatility, is applied. First, the most significant periods of volatility of S&P500 returns for the entire period are identified. Second, the corresponding market conditions for these periods are defined. Then, the mean (average daily returns) and standard deviation (risk) for the precious metals and stocks are calculated for each volatility period. Last, the regression equation (1) was applied to explore the correlations between precious metals and the S&P 500 during these periods. The study focuses only on ten volatility periods corresponding to major significant crises, with the first five occurring during the stable period of the sample and the latter five in the high volatility period. For comparative analysis, the study focuses on gold's performance and its correlation with the S&P 500 during these periods. Accordingly, the third hypothesis is developed.

Hypothesis 3: Gold lost its appeal as a hedge and safe haven during the high volatility period.

2.4 Empirical analysis & Discussion

This section first provides data descriptive statistics. Then, it presents the gold market analysis, where the results of the changing point approach, rolling mean approach, and the GARCH model illustrations are addressed. Last, it presents the safe haven analysis, the DCC-GARCH model illustration, and the ICSS model, which address the changes and loss of gold's role as a safe haven asset.

2.4.1 Data Descriptive statistics

Table 2.1 presents descriptive statistics for daily returns of gold, silver, platinum, palladium, bonds (10-year US Treasuries), and stocks (S&P 500). The average daily return of gold is lower than that of silver, stocks, and palladium, while platinum and bonds have the lowest average return. The standard deviation of gold

and bonds is the lowest compared to other assets, with gold higher. Minimum and maximum return values also represent this finding. Gold and bonds exhibited lower negative values (-0.096, -0.028) than other variables and lower positive values (0.076, 0.041). As such, bonds display the lowest average daily return and standard deviations across all assets, which is arguably consistent with the usual risk-return trade-off. Palladium is the riskiest asset, with a standard deviation higher than that of stocks, but it yields a similar return to the stock market (although slightly higher). All data exhibit high kurtosis value except bonds, which implies high volatility and a high probability of extreme returns.

Table 2.1 Descriptive Statistics

Variable	Mean	Std. Dev.	Minimum	Maximum	Skewness	kurtosis
Gold	0.0002248	0.009494	-0.09663	0.07661	-0.23246	7.1030
Silver	0.0003250	0.017204	-0.21078	0.14642	-0.41747	7.9069
Platinum	0.0001766	0.014240	-0.15867	0.12443	-0.36358	7.1737
Palladium	0.0004169	0.020378	-0.16355	0.18485	-0.02202	7.1695
S&P 500	0.0003750	0.011436	-0.20467	0.11580	-0.77347	20.632
Bond	0.0000196	0.004598	-0.02834	0.04144	0.02104	3.4247

Note: the table presents a statistic of daily returns observation (9755) of all variables in US dollars from January,5 1987 to May 31, 2024

2.4.2 Gold Market Analysis

The analysis examines the gold market's behaviour over the 37 years (1987 to 2024), highlighting how gold responded to various market conditions and crises, emphasizing whether a statistical break exists in the gold market, i.e. there is a change in the mean and variance within the gold market, thus supporting the division of the series into stable and high volatility periods.

Figure 2.1 shows that the gold market appears to exhibit two distinct states of behaviour: a stable period (January 1987 to December 2005)¹¹ and a high volatility period (January 2006 to December 2020), with the change occurring around the end of 2005 and the beginning of 2006. To confirm, the study statistically investigated whether a structural break exists, allowing for a robust comparative analysis of gold behaviour across these two periods. These periods are illustrated in Figure 2.2 below, where the result indicates that the turning point, employing the changing point approach, in gold market behaviour occurred in late December 2005.

¹¹As can be seen in, for example, Figure 1.1, we have earlier data but do not use this in the formal analysis due the effects from the oil price shocks (again, as can be observed in Figure 1.1).

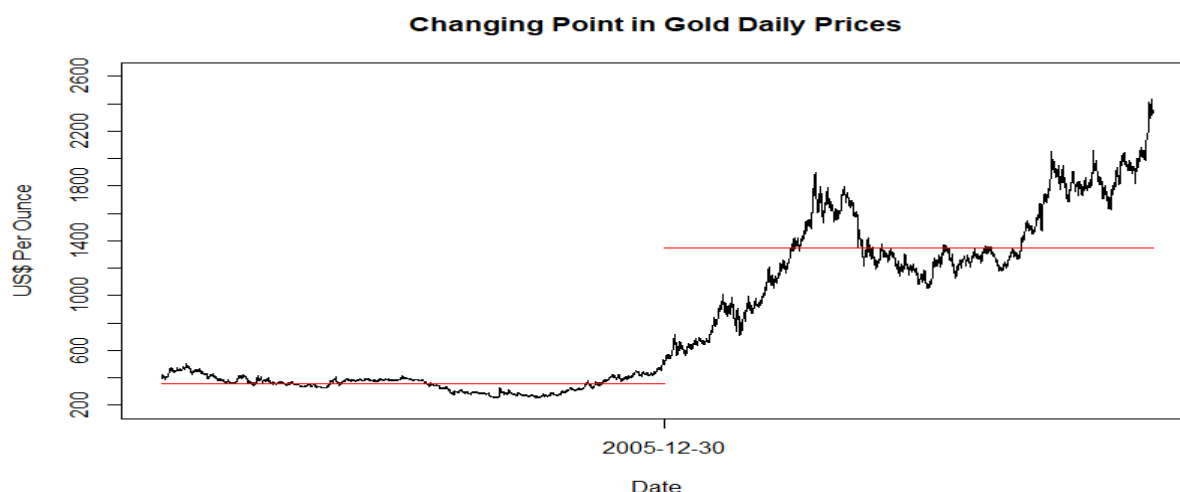


Figure 2.2 Shows the gold prices from 1987 to 2024 and the date of the detected changepoint in data

Table 2.2 shows the result of the change point test using the AMOC and BinSeg algorithm to identify the location of the breakpoint in data. Both algorithms locate the same breakpoint. The identified location, 4658, corresponds to December 30, 2005 according to the data sample period.

Table 2.2 Changing point test results

Created Using changepoint version 2.2.4		
Changepoint type:	Change in mean and variance	Change in mean and variance
Method of analysis:	AMOC	BinSeg
Test Statistic:	Normal	Normal
Type of penalty:	MBIC with value, 27.55876	MBIC with value, 36.74501
Minimum Segment Length:	2	2
Maximum no. of cpts:	1	1.5
Changepoint Locations:	4958	4958

Further analysis for robustness results, the PELT (Pruned Exact Linear Time) algorithm, which allows for the detection of multiple changepoints, is applied. Table 5.1 (see Appendix 1) and Figure 2.3 Changing points detected by the PELT algorithm. Figure 2.3 shows several breaks correspond to major events in financial markets, where break number 11 reinforce the previous results. Figure 2.3 highlights the key points in time when the statistical properties of gold prices changed significantly. Each break is annotated with its corresponding date labels to help identify when these regime changes occurred, making it easier to relate them to historical context.

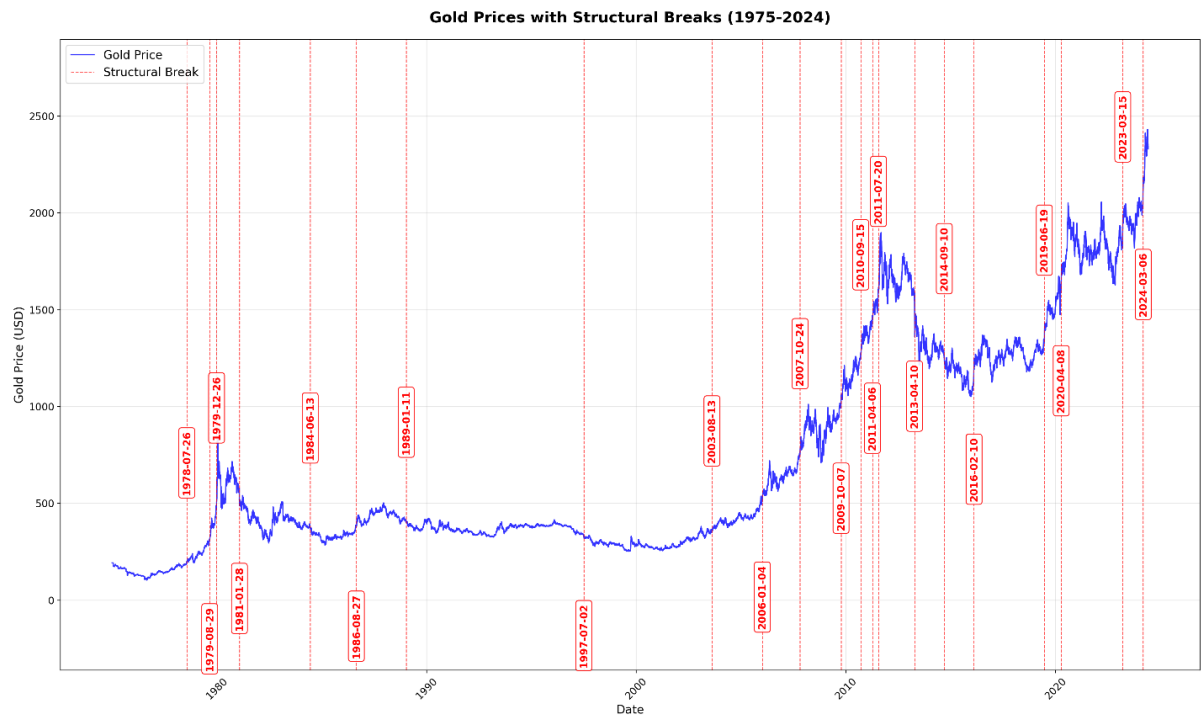


Figure 2.3 Changing points detected by the PELT algorithm

To further illustrate the changing nature of the gold market, the calculated rolling average return, which takes into account whether the mean of the gold return remains stable or exhibits shifts, would justify dividing the sample period. Figure 2.4 presents the rolling average return over the full sample period, while Figure 2.5 and Figure 2.6 present the same but for the sub-sample periods.

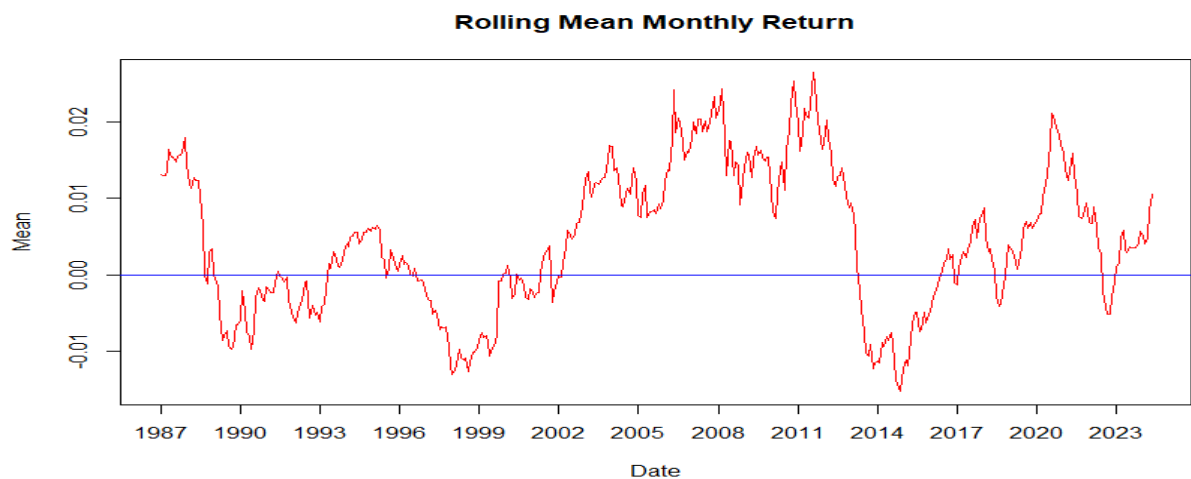


Figure 2.4 Shows the gold monthly rolling mean from 1987 to 2024

As can be observed, the first part of the sample reveals a relatively stable mean value. This contrasts with the second part of the sample, where the mean experiences

more dramatic fluctuations. This, although largely an illustrative exercise, further demonstrates the changing behaviour of the gold market.

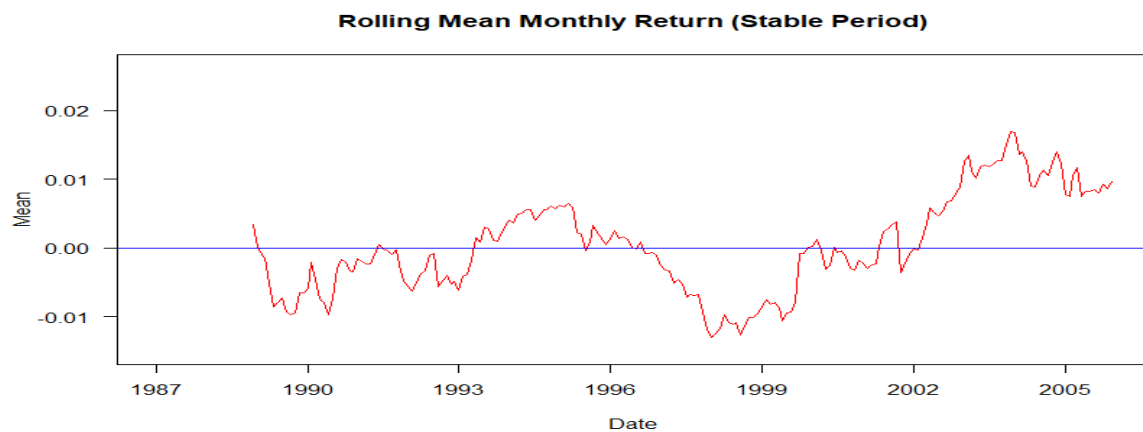


Figure 2.5 Shows the gold monthly rolling mean from 1987 to 2005

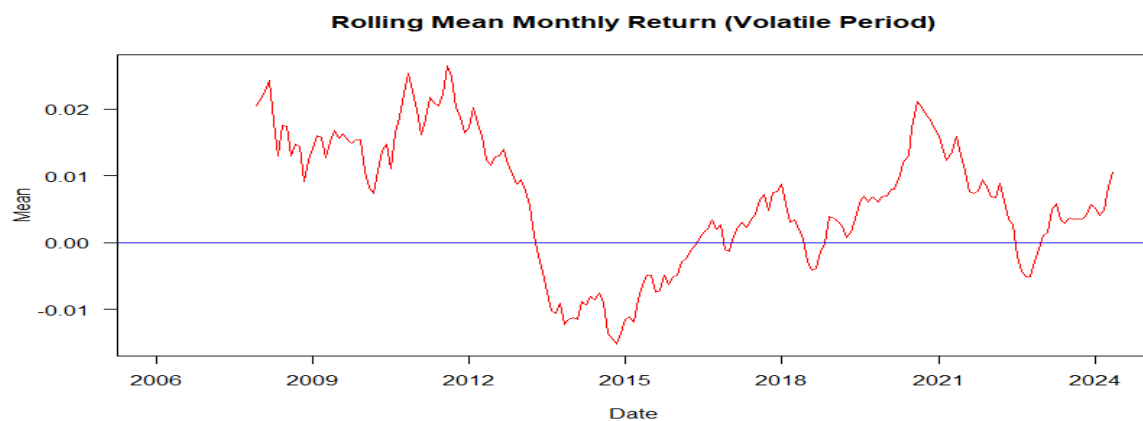


Figure 2.6 Shows the gold monthly rolling mean from 2006 to 2024

Further comparative analysis of gold behaviour across these two periods can be observed in Figure 2.1. Gold was stable from the 1987 to December 2005. To provide a brief overview, over the period from the late-1980s to 2005, the price fluctuated at \$400. It plays a safe haven role in response to equity market crashes (Black Monday, Asian Financial crisis, Dot-Com bubble) and all economic recessions until the end of 2005, showing a rational and stable behaviour in dealing with market fluctuations and economic cycle/conditions during this period. However, from 2006 to 2024, gold prices surged to historic highs, exhibiting significant volatility. During this latter period, gold prices began to rise gradually following the dotcom crash and a period of (then historically) low interest rates. This period is marked by instability in the gold market.

During the global financial crisis (GFC) of 2008, gold fluctuated around \$900, peaking at \$1000 before sharply dropping by 25% between July and September 2008, with notable fluctuations attributed to different policy actions. Although the recession officially ended in June 2009 and stock markets recovered, gold prices did not decline as expected, maintaining their average before rising to \$1200 in December 2009, possibly driven by the eurozone crisis. Gold continued to fluctuate between \$1150 and \$1250 and reached a record high of \$1895 during a period of falling stock markets between May and September 2011. This represents a doubling of the gold price from \$900 at the beginning of this period.

Following its peak in September 2011, gold experienced a sharp 15.5% drop in just 20 days, ending the year with a 19% decrease to close at \$1531. Another significant decline of 31% occurred between October 2012 and July 2013, due to greater stability in financial markets that encouraged investors to switch to higher-yielding assets. In May 2019, gold surged by 19% but later plummeted by 21% in 14 days in March 2020 before gradually climbing to a new high of \$2067 in August 2020. Despite the significant fall in stock markets at the beginning of 2020 in response to increased COVID-19 concerns, the gold market response was weak and fell along with stock markets. Similarly, as stocks rebounded and entered a bull run in later 2020, gold followed suit, peaking in August 2020 before declining.

To conclude, during this second period, the gold market has experienced dramatic shifts in response to market events both negatively and positively. Besides, the price volatility in the second period is high compared to the early period of gold market behaviour. This view can be observed in Figure 2.7, where the estimated GARCH(1,1) model illustration for daily gold returns over the two sample periods showed that gold exhibits low volatility in the first period and higher volatility in the second period, with more frequent spikes in volatility.

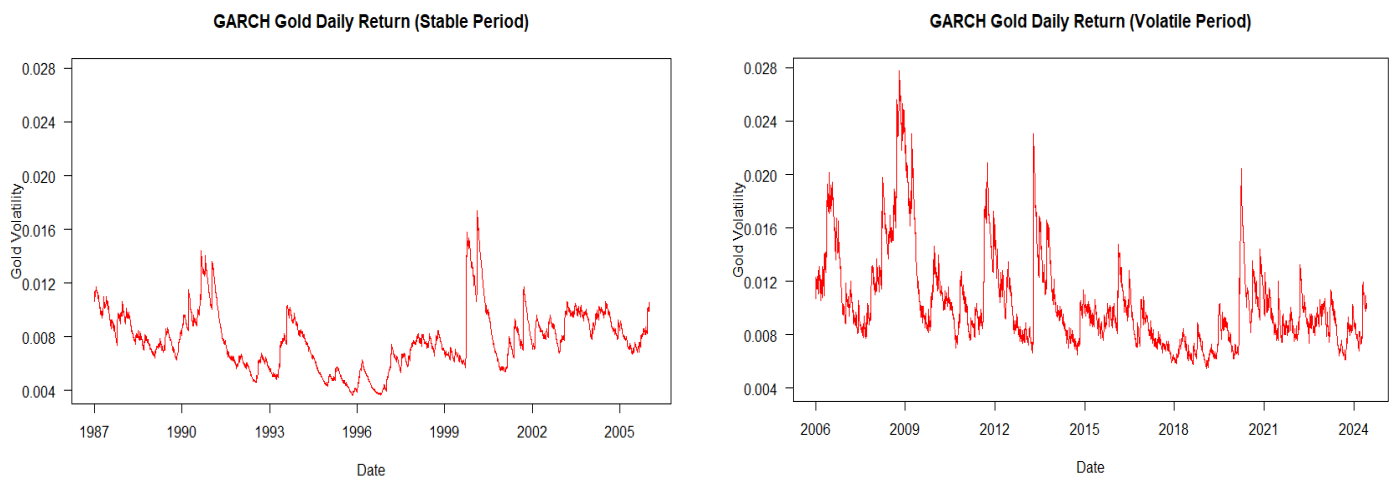


Figure 2.7 Shows the gold volatility from 1987 to 2005 and 2006 to 2024

The high volatility period of the gold market covers major crises, including the global financial crisis, the eurozone debt crisis, several stock market crashes, and ending with the recent economic turmoil caused by the COVID-19 pandemic. Again, this is largely illustrative but serves to highlight the change in the level of volatility within gold returns over the full sample period.

Overall, with respect to the first hypothesis, both the formal tests and the illustrative figures highlight the view that the behaviour of the gold market has experienced a shift in the early 2000s, and this may affect its ability to act as a safe haven asset.

2.4.3 Safe haven analysis

This section examines whether gold remains a hedge and safe haven asset over the extensive period from January 1987 to May 2024, as well as subsample periods (1987 to 2005) and (2006 to 2024). The study focuses on the change in gold market behaviour as addressed previously, and Tables 2.3, 2.4, and 2.5 present the estimation results of the regression model for the full sample and the first (stable) and second (volatile) sub-samples, respectively, given by equations (1), (2), and (3).

As noted, the tables contain the estimates of c_0 (hedge) and the values for c_0 , c_1 , c_2 , and c_3 , which capture extreme market conditions at 10% (sum of c_0 and c_1), 5% (sum of c_0 , c_1 , and c_2), and 1% (sum of c_0 , c_1 , c_2 , and c_3) thresholds. While gold is the main safe haven asset of interest, the role of silver, platinum, and palladium is also

considered. Equally, although stocks are the usual asset to be protected, bonds are also considered.

Table 2.3 presents the results for the full sample from January 1987 to May 2024. The coefficient estimates for the average (c_0) effect of stocks on gold, silver, platinum, and palladium are -0.030 , 0.0233 , 0.0798 , and 0.1221 , respectively, with statistically significant only for platinum and palladium. The insignificant negative coefficient between gold and stocks suggests, at best, a weak hedge, while silver has an insignificant positive correlation, implying a diversifying effect. Platinum and palladium appeared to co-move by having a significant positive relation. As such, this implies that platinum and palladium cannot be used for hedging but for diversifying purposes. The same coefficient estimates for the average effect of bonds on gold, silver, platinum, and palladium are 0.1126 , -0.0570 , -0.1181 , and -0.1380 , respectively, with only statistical significance for gold, platinum, and palladium. For the significant coefficients, the positive coefficient suggests a strong diversifying role for bonds, while the negative coefficient implies a strong hedge of platinum for bonds.

We now consider the coefficients designed to capture safe haven behaviour across different percentile cut-offs, i.e., c_1 , c_2 , and c_3 , respectively. As observed, there are no significant results at each of the 10%, 5%, and 1% extreme negative return levels. This implies that these markets have no relation with extremely negative stock and bond returns. As argued in ([Baur and Lucey, 2010](#)), what matters is the joint effect between c_0 and each of c_1 , c_2 , and c_3 . Thus, gold continues to have a negative relation (-0.0108) with stocks, but is insignificant, consistent with a safe haven effect, or hedge at a minimum. Silver, platinum, and palladium only act as diversifiers. For bonds, each of platinum and palladium has a joint negative or safe haven effect, while gold and silver separately have a joint positive relation, which is perhaps more consistent with hedging behaviour.¹²

The reported results are broadly in agreement with [Kopyl and Lee \(2016\)](#), who show that gold insignificantly correlates with the stock market in periods of severe financial crisis between 1964 and 2014 and shows a strong hedge role on average. Additionally, they also note that gold is not a hedge for the bond market, while other

¹² A question arises with regard to insignificant coefficients. Notably, should the estimated value be treated as zero or taken as reported. The main discussion assumes the former, as the values are statistically indistinguishable from zero, however, if we allow the latter, the safe haven and hedge properties are weakened.

precious metals show a strong hedging role on average. It is encouraging to compare the results with those of [Ciner et al. \(2013\)](#), who find a relatively low relation between gold and bonds on average.

Table 2.3 Hedge and safe haven assessment (Entire period 1987 - 2024)

Regression results of Safe Haven analysis				
	Coefficient	Std. Error	t-ratio	p-value
Panel 1: Gold				
S&P 500				
Hedge	-0.0300	0.0258	-1.164	0.2445
Safe Haven quantiles				
0.1	0.0013	0.0475	0.0266	0.9788
0.05	-0.0020	0.0474	-0.0420	0.9665
0.01	0.0199	0.0613	0.3247	0.7454
Bond				
Hedge	0.1126***	0.0411	2.740	0.0062
Safe Haven quantiles				
0.1	-0.0080	0.0804	-0.0991	0.9211
0.05	0.0544	0.0985	0.5518	0.5811
0.01	-0.1047	0.1040	-1.007	0.3140
Panel 2: Silver				
S&P 500				
Hedge	0.0233	0.0390	0.5972	0.5504
Safe Haven quantiles				
0.1	0.0543	0.0809	0.6717	0.5018
0.05	0.0273	0.0787	0.3472	0.7284
0.01	0.0541	0.1125	0.4815	0.6301
Bond				
Hedge	-0.0570	0.0792	-0.7196	0.4718
Safe Haven quantiles				
0.1	0.0536	0.1447	0.3702	0.7112
0.05	0.0456	0.1784	0.2557	0.7982
0.01	-0.0350	0.1807	-0.1939	0.8463
Panel 3: Platinum				
S&P 500				
Hedge	0.0798***	0.0280	2.852	0.0043
Safe Haven quantiles				
0.1	-0.0104	0.0612	-0.1692	0.8657
0.05	-0.0623	0.0657	-0.9484	0.3429
0.01	0.1462	0.1044	1.4010	0.1612
Bond				
Hedge	-0.1181**	0.0543	-2.176	0.0296
Safe Haven quantiles				
0.1	0.1266	0.1146	1.1050	0.2693
0.05	-0.0794	0.1391	-0.5707	0.5682
0.01	0.0093	0.1427	0.0649	0.9483
Panel 4: Palladium				
S&P 500				
Hedge	0.1221***	0.0417	2.925	0.0035
Safe Haven quantiles				
0.1	0.0340	0.0903	0.3754	0.7073
0.05	-0.0783	0.0913	-0.8577	0.3911
0.01	0.1586	0.1355	1.1710	0.2416

Bond				
Hedge	-0.1380*	0.0722	-1.910	0.0562
Safe Haven quantiles				
0.1	-0.0036	0.1551	-0.0235	0.9812
0.05	0.1049	0.2001	0.5242	0.6002
0.01	-0.2111	0.2104	-1.004	0.3155

Notes: This table presents estimation results for the models in Eqs. (1)-(3). Hedge represents the parameter c_0 . Quantiles 0.1, 0.05, and 0.01 mean in extreme market conditions. *, **, and *** mean statistically significant at 10%, 5%, and 1%, respectively.

Table 2.4 presents the estimation results for gold and the other asset's role as a hedge or safe haven asset for the stable period between 1987 and 2005. Considering first the stock, the coefficient estimates for the average effect for gold, silver, platinum, and palladium are -0.0825, -0.1383, -0.0118, and 0.0046, respectively, with the estimates for gold and silver being significant. The results suggest that all precious metals act as a hedge for stocks, with gold and silver as a strong hedge, and palladium, with no statistical correlation, has a weaker hedging role. Examining the effects of extreme market movements presents a more mixed picture. At the 10% level, the coefficients are positive and significant for gold, silver, and platinum but not palladium. Moreover, the combined coefficient magnitudes of c_0 and c_1 are positive, implying that as the stock market falls, so do the respective metals. At the 5% level, the coefficients again become negative and are significant only for gold and platinum. This supports safe haven behaviour for gold and platinum and potential safe haven or hedging behaviour for the remaining two.¹³ At the 1% level, all the coefficients are statistically insignificant and negative, except for platinum. Moreover, the values are small and do not change the previous conclusion. Furthermore, the joint effect of c_0 and c_1 , c_2 , and c_3 for all metals remains negative with stocks, consistent with a safe haven effect. Thus, over this sample period, there is greater evidence of safe haven behaviour by gold and the other precious metals series for stocks.

Table 2.4 Hedge and safe haven assessment (Early era 1987 - 2005)

Regression results of Safe Haven analysis				
Panel 1: Gold				
S&P 500				
	Coefficient	Std. Error	t-ratio	p-value
Hedge	-0.0825***	0.0180	-4.575	<0.0001
Safe Haven quantiles				
0.1	0.1028**	0.0510	2.017	0.0438
0.05	-0.1043*	0.0551	-1.894	0.0583
0.01	-0.0048	0.0491	-0.0978	0.9221

¹³ As above, this depends on whether we treat insignificant coefficients as zero or take the numerical value.

Bond				
Hedge	−0.0660	0.0440	−1.505	0.1323
Safe Haven quantiles				
0.1	−0.0702	0.1037	−0.6764	0.4988
0.05	−0.0078	0.1115	−0.0702	0.9440
0.01	0.1119	0.0980	1.141	0.2540
Panel 2: Silver				
S&P 500				
Hedge	−0.1383***	0.0312	−4.448	<0.0001
Safe Haven quantiles				
0.1	0.1676**	0.0807	2.078	0.0377
0.05	−0.0780	0.0953	−0.8165	0.4142
0.01	−0.0038	0.0925	−0.0410	0.9673
Bond				
Hedge	−0.2120**	0.0953	−2.225	0.0261
Safe Haven quantiles				
0.1	−0.0383	0.1787	−0.2142	0.8304
0.05	−0.1875	0.2170	−0.8642	0.3875
0.01	0.3687*	0.2204	1.673	0.0944
Panel 3: Platinum				
S&P 500				
Hedge	−0.0118	0.0300	−0.3938	0.6938
Safe Haven quantiles				
0.1	0.1443*	0.0760	1.905	0.0569
0.05	−0.2039**	0.0874	−2.332	0.0197
0.01	0.0037	0.0780	0.0478	0.9618
Bond				
Hedge	−0.1670**	0.0680	−2.397	0.0166
Safe Haven quantiles				
0.1	0.1775	0.1340	1.325	0.1854
0.05	−0.3380**	0.1511	−2.237	0.0253
0.01	0.1582	0.1540	1.027	0.3044
Panel 4: Palladium				
S&P 500				
Hedge	0.0046	0.0421	0.1087	0.9134
Safe Haven quantiles				
0.1	0.0986	0.1011	0.9752	0.3295
0.05	−0.0972	0.1192	−0.8153	0.4149
0.01	−0.0296	0.1086	−0.2722	0.7855
Bond				
Hedge	0.0015	0.0877	0.0167	0.9867
Safe Haven quantiles				
0.1	−0.1645	0.1913	−0.8598	0.3899
0.05	−0.1095	0.2280	−0.4802	0.6311
0.01	−0.3218	0.2399	−1.341	0.1799

Notes: This table presents estimation results for the models in Eqs. (1)-(3). Hedge represents the parameter c_0 . Quantiles 0.1, 0.05, and 0.01 mean in extreme market conditions. *, **, and *** mean statistically significant at 10%, 5%, and 1%, respectively.

Turning to the bond market, on average (c_0), the coefficients are negative, with values of −0.0660, −0.2120, −0.1670, respectively for gold, silver, platinum and positive for palladium (0.0015), and statistically significant for silver and platinum. This

implies strong hedging behaviour for these two assets and weaker hedging (no correlation) for gold and palladium. For the extreme bond returns, the coefficients are predominantly statistically insignificant and negative, which continues to imply hedging and even safe haven behaviour. As with stocks, the results here are generally more supportive of gold and the other precious metals acting as a safe haven.

Table 2.5 presents the estimation results for the role of gold and other assets as a hedge and safe haven asset for the volatile period between 2006 – 2024. Here emerges a different picture to Table 2.3, with much less evidence of the metals acting as a safe haven or hedge and instead resembling assets that can be part of a diversified portfolio but with a typically positive relation. Considering stocks, the average relation given by c_0 reveals a positive and significant effect for silver, platinum and palladium, indicating assets with diversifying behaviour only. The relation with gold is also positive but statistically insignificant, suggesting, at best, a hedging role. For the 10% level (c_1), all the coefficients are negative but insignificant, except for platinum is significant. Nonetheless, this continues to imply hedging and even safe haven behaviour. However, all the coefficients are again positive for the 5% level (c_2) and insignificant, except for silver is significant. At the 1% level (c_3), all coefficients are insignificant and are negative for gold and silver and positive for platinum and palladium. If we consider all the estimated coefficients as reported, the summed effect is positive for all assets, implying no hedge or safe haven role.

The situation for bonds is broadly similar but arguably shows even less evidence of a safe haven effect. For the c_0 coefficient, this is positive and significant for gold and silver, and negative and insignificant for platinum and palladium. Thus, gold and silver can be described as diversifying assets and the rest as potential hedging assets. For each of the extreme return cut-offs (c_1 , c_2 , and c_3), these are all statistically insignificant and thus could imply some safe haven behaviour (i.e., no correlation), thus would seem to be a weak relation. Moreover, the sum of the coefficients, ignoring significance, is positive for each asset, which would negate any hedge or safe haven role.

Table 2.5 Hedge and safe haven assessment (Volatile era 2006 - 2024)

Regression results of Safe Haven analysis				
	Coefficient	Std. Error	t-ratio	p-value
Panel 1: Gold				
S&P 500				
Hedge	0.0445	0.0454	0.9806	0.3268
Safe Haven quantiles				
0.1	-0.0853	0.0752	-1.135	0.2566
0.05	0.1204	0.0748	1.608	0.1078
0.01	-0.0392	0.1000	-0.3920	0.6951
Bond				
Hedge	0.3181***	0.0631	5.043	<0.0001
Safe Haven quantiles				
0.1	0.0847	0.1242	0.6821	0.4952
0.05	0.0456	0.1567	0.2929	0.7696
0.01	-0.2730	0.1791	-1.524	0.1275
Panel 2: Silver				
S&P 500				
Hedge	0.2104***	0.0660	3.197	0.0014
Safe Haven quantiles				
0.1	-0.1494	0.1250	-1.195	0.2323
0.05	0.2813**	0.1145	2.458	0.0140
0.01	-0.0496	0.1532	-0.3248	0.7454
Bond				
Hedge	0.2280**	0.1018	2.241	0.0251
Safe Haven quantiles				
0.1	0.1070	0.2289	0.4677	0.6401
0.05	0.2353	0.2729	0.8622	0.3886
0.01	-0.3814	0.2697	-1.414	0.1574
Panel 3: Platinum				
S&P 500				
Hedge	0.1762***	0.0433	4.071	<0.0001
Safe Haven quantiles				
0.1	-0.1564*	0.0856	-1.826	0.0679
0.05	0.1405	0.0917	1.533	0.1254
0.01	0.1198	0.1408	0.8506	0.3950
Bond				
Hedge	-0.0021	0.0688	-0.0309	0.9753
Safe Haven quantiles				
0.1	0.0880	0.1811	0.4858	0.6271
0.05	0.1220	0.2239	0.5451	0.5857
0.01	-0.0834	0.2326	-0.3586	0.7199
Panel 4: Palladium				
S&P 500				
Hedge	0.2302***	0.0699	3.295	0.0010
Safe Haven quantiles				
0.1	-0.1070	0.1315	-0.8143	0.4155
0.05	0.1112	0.1291	0.8609	0.3893
0.01	0.1550	0.1760	0.8811	0.3783
Bond				
Hedge	-0.1453	0.1056	-1.376	0.1687

Safe Haven quantiles				
0.1	−0.0247	0.2464	−0.1004	0.9200
0.05	0.4000	0.3107	1.287	0.1980
0.01	0.0122	0.3328	0.0365	0.9709

Notes: This table presents estimation results for the models in Eqs. (1)-(3). Hedge represents the parameter α . Quantiles 0.1, 0.05, and 0.01 mean in extreme market conditions. *, **, and *** mean statistically significant at 10%, 5%, and 1%, respectively.

By taking the results in their entirety over both the full sample and the two sub-samples, one can consider whether a significant negative relation or no relation exists between stocks and bonds as the invested assets and gold, silver, platinum, and palladium as the potential safe assets. A significant negative (no) relation would provide strong (weak) evidence of hedging or safe haven behaviour. A positive relation implies that while the asset may offer some diversification benefit, it nonetheless moves in the same direction as the invested asset. Over the full sample, there is evidence that gold, on average, acts as a hedge for stocks and a diversifier for bonds. There is weak evidence for silver to act as a hedge on average for stocks and bonds. For platinum and palladium, both appear to act as a diversifier for stocks and a hedge for bonds, with evidence of a strong diversifying role with stocks and a hedging role with bonds. When we consider the sub-sample periods, a change in behaviour is noted. In the first sub-sample, there is greater evidence that gold, silver, and platinum act as a hedge on average and a safe haven with extreme falls for both stocks and bonds. The effect for gold and silver is stronger for stocks, while silver and platinum have a stronger effect for bonds. For the second sub-sample, however, the evidence indicates that each of these assets is more likely to act as a diversifier for stocks and bonds. This finding is not consistent with the literature that suggests that gold plays a fundamental role as a safe haven in high-volatility periods ([Chang et al. \(2021\)](#)).

Further evidence of the changing role of gold as a safe haven asset is captured by the DCC-GARCH model in Figure 2.8. As illustrated, the correlation between gold with stocks and bonds remained negative prior to 2000 (consistent with its hedging or safe haven role), but it fluctuated between positive and negative regimes after 2000. This implies that while gold could be a hedge or safe haven for stocks and bonds before 2000, it is less likely to be after 2000. Therefore, with respect to the second hypothesis, “gold remains a hedge and safe haven asset in the volatility period” is rejected.

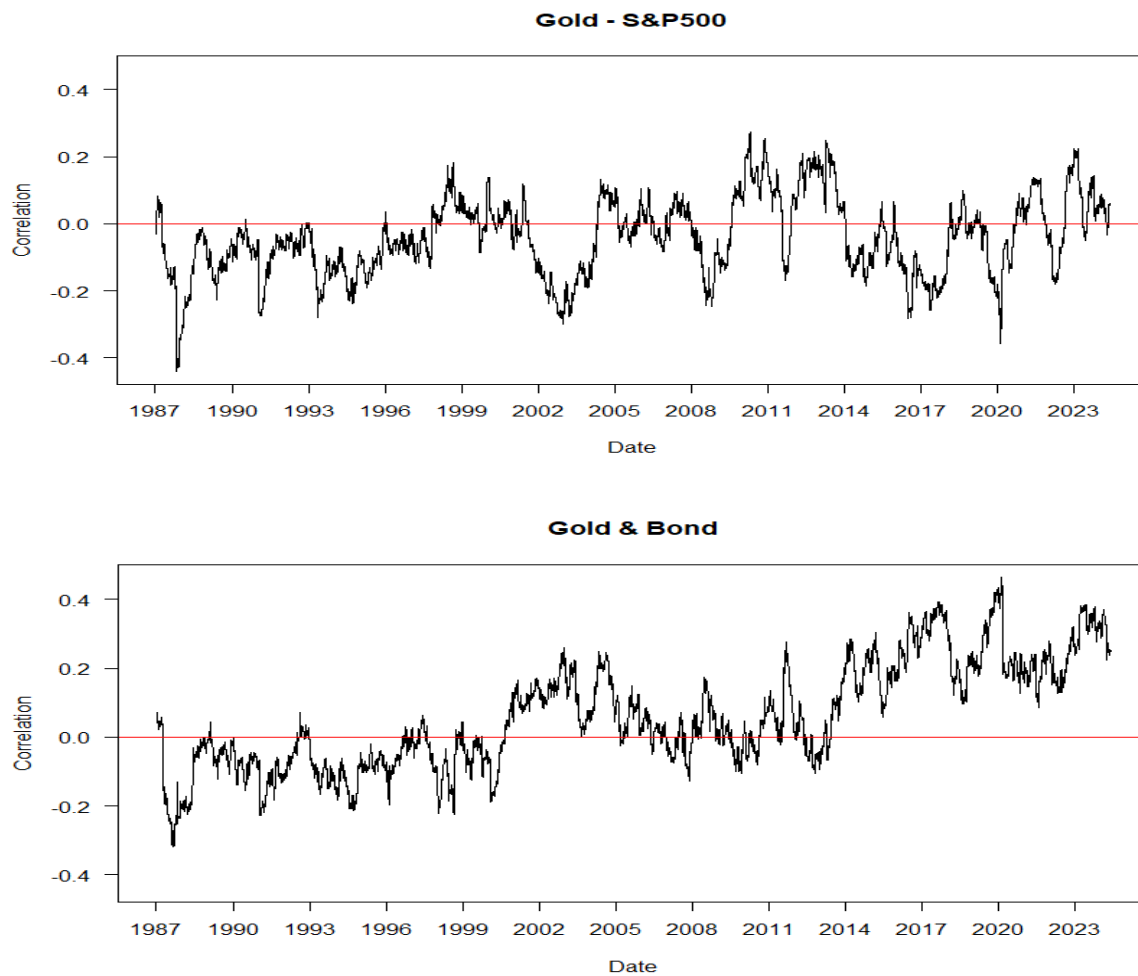


Figure 2.8 Shows the returns correlation between gold, S&P500, and bond markets

2.4.4 Evidence of Losing Safe Haven Role

One can notice from the previous analysis that gold safe haven role is fading during a volatile period. A possible explanation for this is the high volatility of the gold market, which acts like a risky asset. This view is illustrated in Figure 2.9 below and also supported by [Coudert and Raymond \(2011\)](#), who note that gold is a risky investment during crises, and [Baur et al. \(2022\)](#), who indicate that high volatility can diminish the risk-hedging capabilities. The gold market volatility exhibits similar fluctuations to the riskiest market, the S&P 500, and even exceeds at some points.

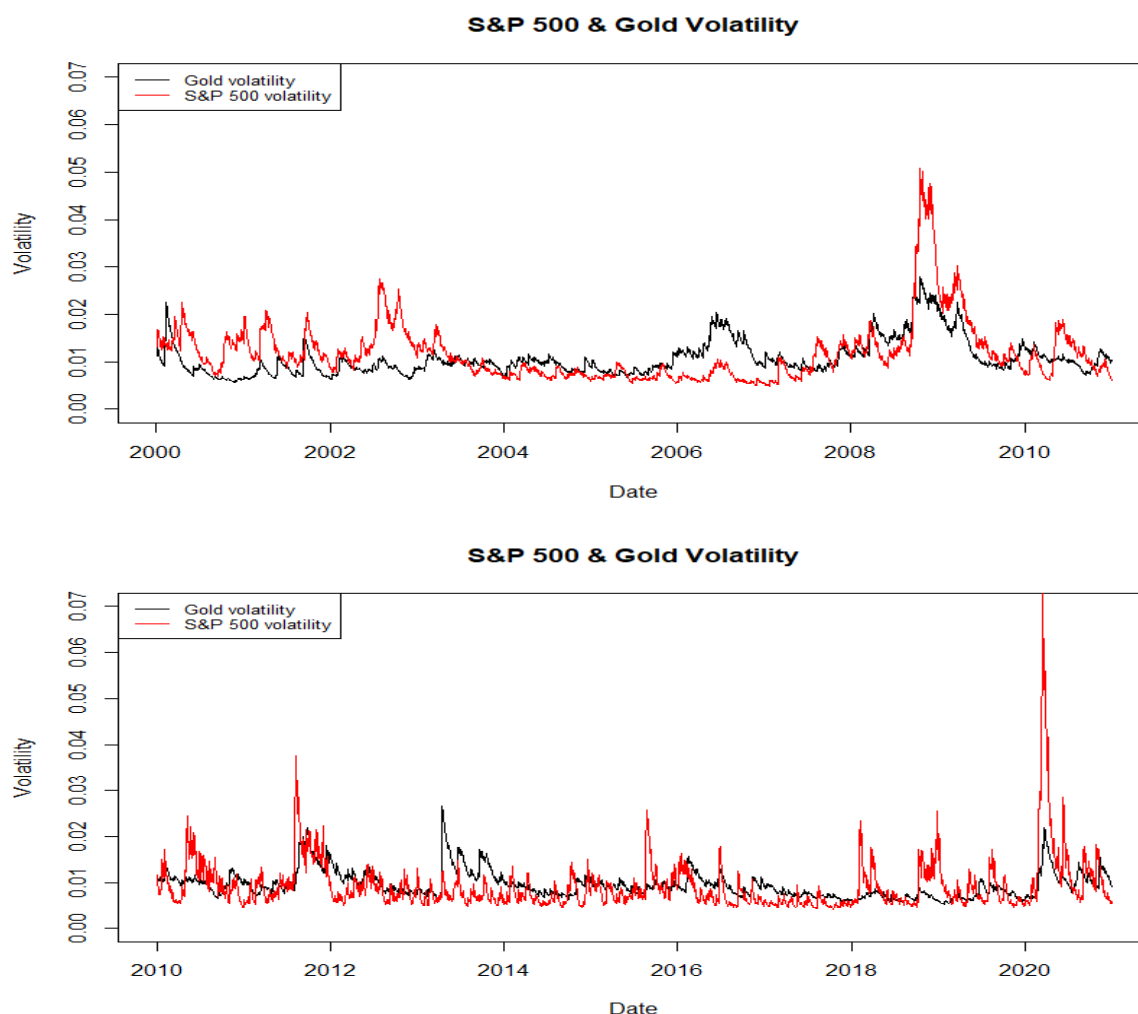


Figure 2.9 Shows gold and S&P500 volatility in the volatility period

In the same vein, further analysis using the Iterative Cumulative Sums of Squares (ICSS) algorithm revealed that gold lost its appeal as a safe haven during the volatile period. As shown in Table 2.6, the approach identifies a finer set of sub-sample regimes that define a series of crisis events. Of particular interest is the correlation between stocks and gold. The results indicate that gold exhibits safe haven properties with a negative correlation with stocks during all the high volatility periods in the stable sub-sample period. This suggests that even as stocks experience increased volatility, gold retains its safe haven role. These findings are consistent with both the analysis in the previous section (2.5.3) and Figure 2.8, which shows a consistently negative conditional correlation between gold and the S&P 500 during the stable period.

In the volatile sub-sample, the most volatile periods for stocks correspond to the recent global financial crisis and the COVID-19 pandemic crisis, noted in the fifth and tenth periods, respectively. During these periods, the stock return standard deviation is notably high at 4.67% and 5.23%, with average daily returns of -0.63% and -0.71%. Here, we can see that gold exhibits a positive correlation with stocks, indicating a departure from its safe haven role. The work of [Hood and Malik \(2013\)](#), [Choudhry et al. \(2015\)](#), and [Echaust and Just \(2022\)](#) supports these findings, finding that gold exhibits a positive correlation with the S&P 500 at the peak of the Global Financial Crisis (GFC), provide statistical evidence that gold was not a safe haven during the Global Financial Crisis (GFC), is not a good shelter against stock market drops during COVID-19.

Moreover, during this period, gold only shows a negative correlation with stocks in two periods (the sixth and ninth). Again, Figure 2.8 supports this observation, with the dynamic conditional correlation fluctuating between positive and negative values for gold and stocks. As the negative correlation diminishes and becomes positive, this undermines gold's role as a safe haven asset and suggests it exhibits similar behaviour to stocks and can only act as a diversifier.

1 Table 2.6: Relationship between Gold and precious metals with S&P 500 at different volatility periods

Crisis in each volatility period	Entire sample period	Black Monday in USA	Early 90 Recession, Iraq invaded Kuwait	Early 90 Recession	Stock Market Downturn 2002 following Sept 11 Attack	Financial Crisis 2007-2008	European Sovereign Debt Crisis	Markets Down from May 2011 - October 2011	Stock Market Selloff	Cryptocurrency Crash	Stock and Oil Markets Crash by Covid-19 & Economic Lockdown
Stable Period						Volatile Period					
Starting Date	1/12/1987	10/14/1987	8/2/1990	11/13/1990	6/17/2002	9/15/2008	4/27/2010	8/24/2011	8/19/2015	10/10/2018	2/24/2020
Ending Date	12/31/2020	10/27/1987	11/13/1990	12/31/1991	10/18/2002	12/3/2008	6/11/2010	12/21/2011	3/2/2016	1/7/2019	4/7/2020
Volatility Period	All	1	2	3	4	5	6	7	8	9	10
Mean											
S&P 500	0.03%	-2.99%	-0.02%	-0.15%	-0.15%	-0.63%	-0.31%	0.08%	-0.04%	-0.19%	-0.71%
Gold	0.02%	0.34%	0.08%	-0.03%	-0.03%	0.06%	0.18%	-0.18%	0.07%	0.13%	0.02%
Silver	0.02%	-0.42%	0.02%	-0.12%	-0.12%	-0.18%	-0.01%	-0.44%	0.01%	0.13%	-0.62%
Platinum	0.01%	-0.38%	0.02%	0.07%	0.07%	-0.67%	-0.38%	-0.33%	-0.04%	0.01%	-0.86%
Palladium	0.03%	-0.88%	0.005%	-0.06%	-0.06%	-0.57%	-0.71%	-0.22%	-0.10%	0.31%	-0.66%
Standard Deviation											
S&P 500	1.16%	8.67%	1.06%	2.23%	2.23%	4.67%	1.93%	1.74%	1.27%	1.58%	5.23%
Gold	0.96%	1.65%	0.59%	0.87%	0.87%	2.76%	1.12%	1.80%	1.06%	0.59%	2.05%
Silver	1.73%	3.66%	0.82%	1.10%	1.10%	4.58%	2.09%	2.98%	1.62%	0.93%	3.91%
Platinum	1.40%	2.80%	0.86%	1.17%	1.17%	3.63%	1.99%	1.58%	1.61%	0.89%	4.25%
Palladium	1.97%	3.00%	1.08%	1.84%	1.84%	4.70%	3.97%	2.73%	2.33%	1.46%	6.34%
Correlation with S&P 500											
Gold	-4.71%	-10.67%	-7.43%	-15.06%	-7.40%	6.37%	-35.73%	2.89%	1.67%	-1.88%	41.23%
Silver	2.35%	50.10%	-5.54%	14.84%	-1.78%	-34.10%	68.89%	6.09%	12.16%	20.32%	-45.20%
Platinum	4.19%	20.50%	-16.54%	-0.94%	4.04%	11.11%	8.18%	-7.82%	-5.50%	-6.16%	48.97%
Palladium	5.91%	-21.97%	14.54%	7.06%	19.18%	18.24%	-15.48%	23.01%	15.19%	-11.83%	5.14%

Note: The ICSS algorithm used to detect the breaking points (shift in variance) in the volatility of S&P 500 returns during our sample period. The sample period is from January 1987 to December 2024.

2.5 Conclusion

This study aims to analyze gold market behaviour over the past 37 years, assessing its role as a safe haven asset for both the stock and bond markets and investigating how changes in gold market behaviour impact its safe haven ability. The findings reveal two distinct market eras: stable (1987 - 2005) and high volatile (2006 - 2024). During the stable period, the gold price remains broadly flat. In contrast, the volatile period sees dramatic fluctuations and substantial price surges, characterised by high volatility.

The analysis estimates regressions designed to consider whether gold (as well as silver, platinum and palladium) act in a diversifying, hedging or safe haven role for stocks and bonds, considering this over the full sample and the identified sub-sample periods. The results indicate that while gold serves as a strong hedge for stocks on average during the stable period, it loses this role during the volatile period. Gold and platinum are the only precious metals to exhibit a statistically significant safe haven role for stocks during extreme market shocks in the stable period but not in the volatile period. Unlike gold, platinum is the only precious metal to exhibit a statistically significant safe haven role in both stable and volatile periods.

One of the more notable findings to emerge from this study is that gold is losing its appeal as a hedge and safe haven. Despite its strong hedge and safe haven performance in the stable period, gold's effectiveness declines in the volatile period. Furthermore, the DCC-GARCH model is used to consider the time-varying correlation between gold and stocks. A negative correlation is observed during the stable period, but a positive correlation emerges in the latter period. Moreover, gold shows a positive correlation with stocks during extreme market shocks in the volatile period, suggesting its safe haven role is fading in times of higher stock market volatility. Another important finding the study underscores during the volatile period is that gold exhibits a similar volatility pattern to the S&P 500, behaving like a risky asset.

Considering more formal breaks within volatility identified by the ICSS algorithm reveals further evidence of gold losing its safe haven role, especially during the volatile period. To act as a safe haven, gold would be negatively correlated with stocks, and while there is evidence for this in the stable period, this pattern does not persist in the volatile era. Instead, during the highest volatility periods, such as the global financial

crisis and the COVID-19 pandemic, gold displayed a positive correlation with stocks. Thus, it fails to act as a safe haven when it is most needed by market participants.

These findings contribute to the ongoing discourse surrounding gold's role under modern portfolio theory, particularly during times of extreme market conditions. In a world where market dynamics are constantly changing, understanding the behaviour of the most reliable safe havens like gold is more crucial than ever as it provides insights into future investment strategies.

This study provides new ground in understanding how gold market behaviour's changes impact gold's traditional roles' effectiveness against stock and bond market conditions. Distinguishing between stable and volatile periods adds to the existing literature on how the traditionally perceived safe haven role of gold is challenged by periods of high gold market volatility.

A novel aspect of this research lies in identifying that gold's behaviour has significantly shifted across these two periods, with its traditional roles often not held in the volatile period. Instead, gold increasingly behaves like riskier assets, showing positive correlations with stocks during severe market shocks. This finding challenges conventional wisdom, which has long treated gold as a reliable store of value during crises. Yet, gold can still serve as a diversifier.

The study has significant implications for investors, who should be aware that the traditional gold roles seem to have waned. It provides investors with insights for decision-making, such as asset allocation, portfolio diversification, and hedging strategies. Adding gold to a portfolio may raise volatility without providing expected protection. Besides, the gold market exhibits high volatility and, more often, a positive correlation with the stock market during periods of market stress. Increasing gold volatility requires investor's attention when taking risk management decisions. As such, gold's role in a diversified portfolio must be carefully considered to develop profitable strategies. Investors should act with cautious hedging strategies to avoid taking on gold volatility risk and deterioration in hedging and safe haven roles and, consequently, destruction of their portfolio.

Chapter 3: Gold Volatility and Financialization Effect

Abstract

The heightened volatility in the gold market has become increasingly evident in recent years, compared with a prolonged market stability period. The remarkable elemental properties of gold, coupled with its historical market stability, provide a new opportunity for capitalizing on the potential benefits of the gold market. It is plausible that the commencement of gold financialization through the introduction of gold Exchange-Traded Funds (ETFs) at the beginning of the 2000s may be linked to the observed volatility in the gold market. This study aims to examine the gold ETF introduction impact on the volatility of the underlying gold market and whether the introduction of gold ETFs provides an additional route by which the information can be rapidly assimilated to the spot market, increasing responses and, thus, increasing volatility. The study demonstrates that the gold market exhibits a structural change around the onset of gold ETFs, in which gold spot volatility in the post-gold ETFs period is characterized by an unstable (highly volatile) era. Notably, the findings suggest that the changes in gold market volatility can be attributed to an increase in the rate of information flow to the gold spot market. The outcomes imply that the gold spot market is more efficient in the post-gold ETFs period. Yet, it is highly volatile. These findings have important implications for investors and financial regulators regarding the interaction of gold ETFs with the gold spot market.

Keywords: Gold, Volatility, Financialization, ETFs, GARCH, Change point

3.1 Introduction

A significant increase in the level and volatility of gold prices over the past two decades, compared to a long period of market stability, has led to a debate about what has driven these developments. Gold price variations tend to be dominated by different market conditions and macroeconomic variables such as interest rate, inflation, exchange rate, economic uncertainty, and financial market turmoil ([Baur and Lucey \(2010\)](#); [Ghosh et al. \(2004\)](#); [Capie et al. \(2005\)](#); [Levin et al. \(2006\)](#); [Beckmann and Czudaj \(2013\)](#); [Baur and Smales \(2018\)](#); [Dinh et al. \(2022\)](#)). Besides, volatility and information are inextricably linked, and the information influencing gold market volatility is primarily driven by adverse events such as uncertain economic conditions, financial market movements, geopolitical tensions, macroeconomic variables, and macroeconomic policy changes ([Christie–David et al. \(2000\)](#), [Cai et al. \(2001\)](#)). Information leads to changes in expectations, which in turn leads to price changes. However, these elements have always remained present. Furthermore, these factors occur occasionally and would not cause daily fluctuations. Suppose these factors were the only drivers of gold price fluctuations. One would not notice significant deviations in gold volatility at any time. Is there a new factor?

This study examines whether gold financialisation, through gold ETF introduction, contributes to the increased volatility in gold prices. The prevailing assumption is that gold financialisation facilitates access and trade for investors to the gold market that was not previously accessible. Gold prices have experienced significant run-ups, and the nature of its fluctuations has changed considerably beyond the introduction of gold ETFs. It has been suggested that the increase in price volatility of an asset is likely witnessed with the introduction of new financial instruments ([Lee and Ohk \(1992\)](#); [Bae et al. \(2004\)](#); [Arisoy \(2008\)](#)). Besides, it has been found that commodity financialization increases commodity market fluctuations ([Ding et al. \(2021\)](#)). Evidence also has shown a considerable increase in volatility following the introduction of ETFs ([Liebi \(2020\)](#)).

Apart from [Baur \(2013a\)](#), who notes surging in gold prices and investment demand around the onset of gold ETFs and an increase in gold volatility after introducing gold ETFs in the long run, the literature on the impact of gold ETFs inception on gold volatility remains scarce. The goal of this study is to model the effect

of gold financialization on gold spot market volatility. Particularly, it focuses on identifying whether the onset of gold ETFs has changed gold spot volatility structure and examines how gold ETFs' presence affects gold spot volatility and flows of information to the gold market.

The study first addresses the fact that gold market volatility exhibits a statistical structural break. Although the world's biggest gold ETFs, the US gold ETF (GLD), were introduced in November 2004, the change in gold market volatility did not materialize before December 2005. It is expected that any new successful innovation or product will take some time to establish sustainable growth before it can exert a noticeable influence on the market. Next, the rolling variance reveals stability in gold variance in a certain period and high volatility in another. These findings support splitting data into two distinct periods: pre-ETF, where gold volatility was low, and post-ETF, with higher and fluctuating volatility.

The findings also address that introducing gold ETFs changes gold market volatility and efficiency using the Generalized Autoregressive Conditional Heteroskedastic (GARCH) model. There are noticeable differences in the conditional volatility process for periods before and after the introduction of gold ETFs, with volatility being higher in the post-ETF period across all subsamples. This is attributed to the increased speed of information flowing to the gold spot market. More importantly, although volatility increased, the findings suggest that the gold market is relatively more efficient after introducing gold ETFs in the sense of capturing the effects of recent information and incorporating them into the gold spot prices. These findings have implications for investors in terms of risk management and financial regulators regarding the interaction between gold ETFs and the gold spot market.

This study contributes to the empirical literature on gold volatility by examining gold ETF's effect on its underlying spot market volatility. Gold ETFs buy and store the underlying physical gold, providing an evident mechanism for investment to affect gold prices. Previous studies attribute gold volatility to traditional financial and macroeconomic factors. This study includes a new emerging factor, gold ETF, in the landscape of gold volatility. The presence of gold ETFs and the rebalancing mechanism of these ETFs can lead to more gold market volatility.

3.1.1 Gold & Financialisation

The conventional mechanisms of gold trading and associated market regulations were not conducive to facilitating convenient gold transactions. The gold market was dominated by central banks and major financial institutions, resulting in restricted access to trading for only those capable of bearing costs associated with physical gold investments. Moreover, potential investors would be reluctant to buy physical gold due to the time required to get to the market and concerns about storage and carrying costs, affecting their investment feasibility. Although gold can play different roles in different conditions, its inconvenience and associated costs make it a less attractive investment. Equally, the physical gold investment is illiquid, posing constraints for investors who need to adjust their positions quickly in response to changes in market conditions. Furthermore, investors holding gold in their portfolio to manage risks would lose the opportunity to invest their tied-up capital elsewhere as gold is a non-interest-yielding asset. Therefore, at least for the reasons mentioned above, it is plausible that the gold market may have experienced low volatility and reacted less to market conditions and other variables before financialisation found its way to the gold market.

Financialisation is a phenomenon characterized by the growing influence of financial markets and mechanisms that shape the markets. The term "financialisation" not only describes the growth of size and power of the financial sector but also signifies the shifts in business models across different industries towards the financial sector ([Krippner, 2005](#)). This phenomenon is expanding in scope to various markets with the primary aim of reshaping and restructuring them to capitalise on existing benefits.

The process of financialization primarily emerged in the late 20th century. During the 70s and 80s, the global economy underwent significant changes after the collapse of the Bretton Woods system, a period marked by restrictive financial regulations and limited international capital movement. Afterwards, the liberalization policies, deregulation, and technological advancements led to the substantial growth and influence of financial markets and institutions. The financialization phenomenon has expanded substantially and persisted throughout the 1990s and 2000s despite periodic crises.

More importantly, the financialization concept involves the proliferation of new financial instruments and an explosion of financial trading ([Krippner, 2005](#)). This view is supported by [Foroohar \(2016: P. 7\)](#) in her book *Makers and Takers*, who writes that “finance has shifted its attention to securitizing existing assets (like homes, stocks, bonds and such) turning them into tradable products, that can be spliced and diced and sold as many times as possible until things blow up”. Hence, introducing and widespread trading in complex financial products like, and limited to, derivatives and securitized debts and assets is the key feature of financialization, often leading to market instability. The financialization phenomenon is limitless and will continue exploring and expanding to capitalize on market opportunities.

The remarkable elemental properties of gold and its market stability provide a new opportunity for financial markets to capitalize on the potential benefits that exist in the gold market. The chairman of the World Gold Council (WGC), which was founded in 1987 by the world’s leading gold mining companies to stimulate gold demand by consumers and investors, stated that “With the fundamentals of the gold market outlook improving and some fresh new investment product ideas for gold in the pipeline, the future for gold is as bright as I have seen it for some time.” Chris Thompson, 2002. Besides, the newly appointed Chief Executive Officer stated, “I am thrilled with the opportunity to help bring gold to the greater attention of the world’s markets” James Burton, 2002.

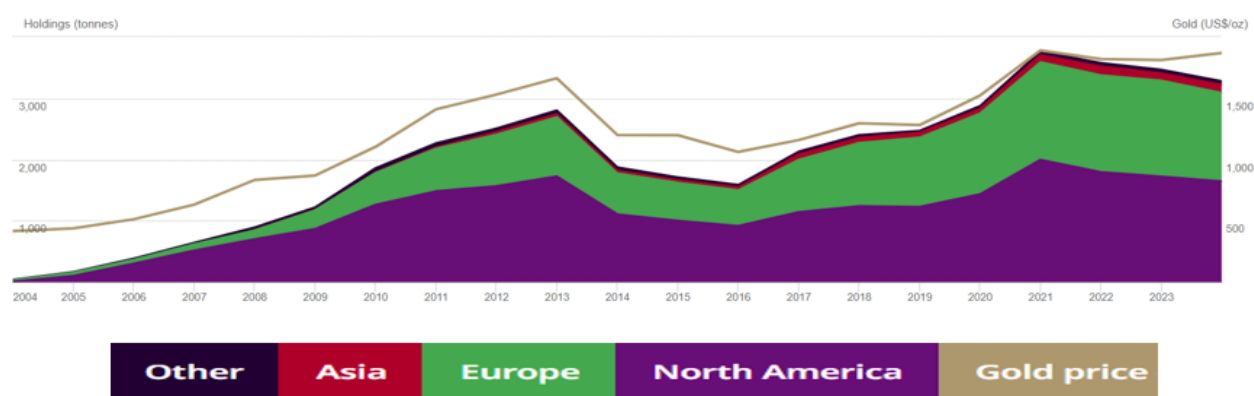


Figure 3.1 Shows the gold ETFs increments holdings (Tonnes) by region from 2004 to 2023, World Gold Council.

Perhaps the gold financialization that began in the early 2000s can be attributed to increased gold market volatility. Gold financialization refers to the process of transforming real gold into financial instruments or investment vehicles, “paper gold”. Unlike traditional gold trading, gold financialization has brought about innovations like

gold-backed Exchange Traded Funds (ETFs) that allow investors to gain exposure to gold prices without physically owning, storing, and insuring the metal.

The gold ETFs' onset reformed the gold market and provided a new and broader venue for investors to participate in the gold market. The exposure offered by gold ETFs provides diversification benefits to all types of investors at a lower cost, as well as tax efficiency, transparency, and low management fees. Hence, the significant rise in the popularity of gold ETFs has attracted considerable attention from investors and market participants, leading to a substantial change in the gold market, making the post-ETF gold market distinctly different from its pre-ETF state.

In addition to gold ETFs, Gold financialisation also includes derivatives and other forms of financial instruments. The introduction and trading of complex financial products, such as derivatives and securitized assets, often contribute to increased market instability. Although futures and options markets existed long before the gold ETF onset, it is worth noting that gold market volatility rose substantially after the gold ETF introduction.

It is important to note that futures and options are dominated by big institutions and carry significant risks. Individuals cannot bear the costs (commissions, margin interest, rolling) and risks associated with derivatives such as leverage risk (amplified losses), market risk (Large losses in unfavourable market movements), liquidity risk, counterparty risk, marginal call and forced liquidation, volatility risk (highly sensitive to volatility), and time sensitivity (contract's expiration).

On the other hand, gold ETFs opened up the market to those who wouldn't be able to trade and invest in gold, bringing new participants into the market, encouraging more investors to enter the market and changing sentiment toward gold trading to be part of their portfolio. The emergence of gold ETFs has fundamentally transformed gold trading, making it broadly accessible to institutions and individuals alike. Gold ETF has several advantages over futures and options in terms of accessibility and simplicity of trading, high liquidity, long-term holding (no expiration risk), no counterparty default (backed by physical gold), typically unleveraged, and low management fees.

Given these advantages of gold ETFs and their mechanism and market capital, it is plausible that the commencement of gold ETFs at the beginning of the 2000s may

be linked to the observed volatility in the gold market. Again, the futures and options in gold existed long before the gold ETFs' inception, but the nature of gold market fluctuations has changed considerably beyond the introduction of gold ETFs. Supporting this, [Liebi \(2020\)](#) finds a considerable increase in volatility following the introduction of ETFs.

3.1.2 Gold Exchange Traded Funds (ETFs) & Gold Market

The First gold ETF was launched and traded on the Australian Stock Exchange in March 2003, followed by, with the help of the World Gold Council, the First London gold ETF (GBS) in the same year and the First US gold ETF (GLD) in November 2004, and where traded in London Stock Exchange (LSE) and New York Stock Exchange (NYSE), respectively. Ever since, the number of gold ETFs has grown substantially along with their holdings, as shown in Figure 3.1. The Figure shows a positive correlation between gold prices and the amounts of gold owned by the gold ETFs. The increase (decrease) in gold investments by gold ETFs aligns with the increase (decrease) in gold prices over time. For instance, the substantial increase in gold holdings between 2004 and 2013 aligns with the gold price surging. Similarly, the sharp fall in gold ETFs' holdings between 2013 and 2014 aligns with the gold price plummet. This financial instrument, gold ETFs, has made it easier for a broader range of investors to participate in the gold market, leading to potentially increasing liquidity and, perhaps, daily gold market volatility.

Although the gold market was characterised by a prevailing perception of inconvenience, illiquid, and restricted access, the emergence of gold Exchange Traded Funds (gold ETFs) in 2003 significantly transformed the gold market, reshaping the investors' perspectives on trading gold. It provides a flexible means for investors to gain exposure to gold price changes. To explain, exchange-traded funds work as investment funds traded on exchange markets, pooling and holding the assets, dividing ownership of those investments into shares for trading that track the underlying assets' price. Generally, Exchange-traded funds have the flexibility to be structured to track different assets, ranging from the price of an individual commodity to a large and diverse collection of securities. In addition, exchange-traded funds provide crucial advantages such as, but not limited to, easy and intra-day real-time access to investments at low costs.

By drawing on the idea of exchange-traded funds, gold ETFs are regulated financial products with shares traded on securities markets and tracking the underlying gold prices, allowing investors to trade continuously and providing cost-effective access to the gold market that was not previously accessible. Gold ETF shares represent a designated quantity of gold held by the ETF. It is important to note that while a specific amount of gold indeed supports these shares, investors do not actually own the physical gold, and gold ETFs do not allow investors to exchange them directly for the corresponding amount of gold in grams. However, if investors decide to sell their shares, they are entitled to an equal amount of gold, corresponding to the number of shares owned, in cash based on the gold price on the day of sale. This demonstrates that gold ETFs simplify and broaden access to gold investments. Consequently, as the demand for gold ETF shares expands, additional physical gold must be secured by gold ETFs to back those shares to be issued, thus increasing gold demand, price, liquidity, and perhaps volatility.

Gold ETFs' success is partly due to the fact that gold has been viewed as a diversifier, hedge, and safe haven. Nevertheless, introducing gold ETFs may increase gold market volatility and affect the roles it can play. More often than not, the conventional perspective on introducing new financial instruments is that they encourage trading, leading to price instability and exacerbating spot market volatility. Under this destabilization hypothesis, introducing gold ETFs raises concerns about whether the onset of gold ETFs affects the volatility of the underlying gold market. Moreover, one can wonder if introducing gold ETFs provides an additional route by which the information can be rapidly transferred to the spot market, increasing responses and, thus, increasing volatility. It is found that daily volatilities are positively related to the rate of daily information arrival ([Lamoureux and Lastrapes, 1990](#)).

Theoretically, the prevailing assumption is that gold ETFs facilitate access and trade for investors to the gold market that was not previously accessible. The gold ETFs, in essence, broaden access to gold investments, leading to increased demand for physical gold by ETFs to back those shares to be issued and, thus, increase spot prices and liquidity. [Baur \(2013a\)](#) notes that gold ETFs increased gold prices due to increased investment demand and the rising number of gold ETFs around the onset of gold ETFs. Besides, gold ETFs offer cost-effective access to the gold market due to lower storage costs obtained through economies of scale or pooling of assets. The

author also finds an increase in gold volatility after introducing gold ETFs, but only in the long run.

Although the author indicated that gold market volatility increased after introducing gold ETFs, the study lacks evidence of daily fluctuations in the gold market. Using the GARCH(1,1) approach, the author considered the entire sample period to investigate the change in gold market volatility after introducing gold ETFs. However, the common empirical practice investigating the introduction of a new instrument on the underlying market, using GARCH, is to compare the volatility of the spot market before and after introducing the financial instrument.

In this context, several authors studied the effect of introducing new financial instruments on the underlying asset. For instance, the traditional view on derivatives markets is that they encourage speculation, leading to price instability and exacerbating spot market volatility. Considering the destabilization hypothesis and using the most common approach mentioned previously, some have reported an increase in equity market volatility after the inception of futures trading (e.g., [Lee and Ohk \(1992\)](#); [Bae et al. \(2004\)](#); [Arisoy \(2008\)](#)), while others reported a decrease or no effect (e.g., [Bessembinder and Seguin \(1992\)](#); [McKenzie et al. \(2001\)](#); [Alexakis \(2007\)](#); [Bohl et al. \(2015\)](#); [Fortune \(1989\)](#), [Darrat and Rahman \(1995\)](#), [Board et al. \(2001\)](#), [Debasish \(2009\)](#)).

3.1.3 Study Focus

It remains ambiguous whether the commencement of gold financialization marked by the introduction of new financial instruments like gold Exchange Traded Funds (ETFs) might contribute to the shifts in the gold market and cause volatility and instability.

Considering gold price volatility and the short presence of gold ETFs, there is a notable gap in the literature concerning gold financialisation's effect on gold market volatility. Except for [Baur \(2013a\)](#), none of the literature examines whether the introduction of gold ETFs affects gold spot market volatility. This study investigates whether the volatility of the gold market has increased following the introduction of gold Exchange Traded Funds (ETFs). The analysis first assesses potential shifts in the gold spot market behaviour over the period under investigation, identifying any

significant change that might align with gold ETF onset. Next, the rolling standard deviations illustrate and highlight changes in gold market volatility. Last, the study employs the GARCH model that incorporates a dummy variable in the variance equation, facilitating the comparative analysis of gold market volatility before and after the inception of gold ETFs. This approach also assesses whether the speed of information flow to the spot market has increased after the onset of gold ETFs, implying enhanced gold market efficiency.

This study makes several important contributions to the literature on gold financialization, particularly in relation to the effects of gold Exchange-Traded Funds (ETFs) on the volatility of the underlying gold spot market. First, identifying a structural break in gold volatility that coincides with the rise of gold ETFs, using changepoint detection. Second, providing robust econometric evidence, through split-sample GARCH modelling, that gold market volatility increased post-ETF. Using changes in GARCH parameters, α and β show that the speed of information flow increased post-ETF, leading to more responsive price movements to new information and reduced persistence of old information. This suggests the gold market's sensitivity reaction to gold-related news increased following the introduction of gold ETFs. This fills a critical empirical gap, as only [Baur \(2013a\)](#) has previously attempted to study this relationship, and without the methodological rigour applied here. This work advances our understanding of gold financialization by moving beyond narrative or correlational claims, offering a precise testing framework that links financial innovation to market behaviour in a way that is both theoretically grounded and empirically validated.

The remainder of this chapter is structured as follows. Section 2 summarizes the literature's main findings on introducing new instruments and gold financialization. Section 3 describes data and the methodology applied to investigate the effect of introducing gold ETFs on the gold spot market. Section 4 provides descriptive statistics of the gold market pre- and post-gold ETFs, empirical analysis and findings, and discusses the empirical results. Section 5 gives concluding remarks.

3.2 Literature Review

This section covers the literature on the effect of introducing new financial instruments on the underlying market and gold financialization (Gold ETFs).

The literature has widely investigated the role of gold in response to economic factors, conditions, financial market movements, and other related factors. However, the gold market recently exhibited surging and high volatility, and the occasional occurrence of these factors would not cause persistent daily fluctuations.

The high volatility in the gold market over the past two decades has challenged the gold market's stability, and increased volatility may perhaps coincide with the introduction of gold ETFs in the early 2000s. Furthermore, volatility is closely related to information, leading to expectation changes and causing market instability. Volatility in the gold market is driven, more likely, by information about economic instability, financial market swings, geopolitical tensions, and macroeconomic changes. Gold ETFs, as new financial investment instruments, might accelerate the market's response to such information, escalating the flow of information to the gold spot market, which leads to increased volatility and market efficiency. This shift suggests that the structural change in gold market volatility could be largely attributable to the new financial investment instrument, gold ETFs' inception.

[Baur \(2013b\)](#) investigates the fundamental drivers of gold prices from 1968 to 2013 and indicates that gold ETFs are a potential driver of gold prices. Still, the limited and inadequate data about gold ETFs made statistical analysis not possible and a systematic understanding of whether gold ETFs contribute to gold volatility is still rare.

3.2.1 Effect of introducing new financial instruments on the underlying market

The world of finance and investment is constantly evolving, with new instruments and strategies being introduced to capitalize on market trends. One such entity that has gained immense popularity over the past few decades is futures contracts. Likewise, the gold Exchange-Traded Funds (ETFs) in the past two decades. Empirical literature examined the impact of introducing a new financial instrument, futures, on spot market volatility. Employing different GARCH models, studies looked into how the introduction of futures contracts affects the volatility of spot prices by comparing the two periods of volatility, before and after the introduction, to capture changes in spot market volatility. Three distinct views on the topic have emerged from studies in both established and developing economies.

First, the onset of futures trading is believed to enhance the volatility of the underlying spot market due to different reasons, including increased speculation

activity, attracting additional (uninformed) traders for short-term gains, providing a new way for quick adjusting and transfer of new information to spot market, and volatility spillover to the underlying market ([Lee and Ohk \(1992\)](#); [Antoniou and Holmes \(1995\)](#); [Yu \(2001\)](#); [Bae et al. \(2004\)](#); [Pok and Poshakwale \(2004\)](#); [Robbani and Bhuyan \(2005\)](#); [Kumar and Mukhopadhyay \(2007\)](#); [Mallikarjunappa and Afsal \(2007\)](#); [Arisoy \(2008\)](#)). In addition, the introduction of futures contracts improved underlying market efficiency by increasing the rate of information flow to the spot market.

Counterargument views are discussed by [Bessembinder and Seguin \(1992\)](#), [Reyes \(1996\)](#), [Galloway and Miller \(1997\)](#), [McKenzie et al. \(2001\)](#), [Bandivadekar and Ghosh \(2003\)](#), [Alexakis \(2007\)](#), [Kasman and Kasman \(2008\)](#), [Çağlayan \(2011\)](#), [Wagner and Matanovic \(2012\)](#), and [Bohl et al. \(2015\)](#), concluded that spot market volatility decreased after the introduction of futures trading due to arbitrage activities and increasing liquidity in futures market, and migrate of speculation activities to futures markets due to low cost of transactions.

The third view that finds futures contracts had no effect on the volatility of spot prices is documented by [Moriarty and Tosini \(1985\)](#), [Fortune \(1989\)](#), [Beckett and Roberts \(1990\)](#), [Antoniou and Foster \(1992\)](#), [Kamara et al. \(1992\)](#), [Darrat and Rahman \(1995\)](#), [Dennis and Sim \(1999\)](#), [Board et al. \(2001\)](#), [Spyrou \(2005\)](#), [Debasish \(2009\)](#), [Gökbulut et al. \(2009\)](#), and [Xie and Huang \(2014\)](#).

Futures trading plays a critical role in shaping market volatility. Due to its lower transaction cost, the introduction of futures contracts attracts more market participants to speculate on the future price of the underlying market, which may lead to spot market destabilization. The onset of futures trading affects not only spot market volatility but also market efficiency by changing the rate of information disseminated to the spot market.

In the same vein, introducing a new financial instrument, gold ETFs, in the gold market might increase gold market volatility. Although financial products can help investors manage risks and achieve their investment objectives, they could destabilize the markets. Thus, it becomes essential to understand if gold financialization contributes to gold market volatility and increasing instability.

3.2.2 Gold Financialization (Gold ETFs)

The interest in gold increased in the early 2000s when the financialization of gold began. When gold Exchange-Traded Funds (ETFs) were first launched in markets, they facilitated the increased investment demand for gold. Gold ETFs buy a large amount of physical gold, maintain its storage level, and then issue and sell securities of specific units based on the amount of gold pooled.

Gold financialization is the process of transforming real gold into financial claims that simplify gold trading. [Demidova-Menzel and Heidorn \(2007\)](#) compare different classic investment forms in gold with the new innovation instruments of gold-backed securities, such as gold ETFs. The authors highlight that gold-backed securities are regulated financial products traded on securities markets. They track underlying gold prices and allow investors to exchange them for a specific gram of gold at any time, leading to considerable advantages over classic alternatives. According to the authors, “Handling gold as a security can considerably improve the investment efficiency.” [Demidova-Menzel and Heidorn \(2007: P.42\)](#). Therefore, it is expected that gold demand and price to increase as more and more investors consider gold ETFs in their investment strategy.

In his seminal paper entitled Glitter of Gold ETFs, [Sarkar \(2012\)](#) reviews the history of gold ETF innovation, explains its characteristics, and the benefits and risks associated with investing in gold ETFs. Investing in gold ETFs has several advantages over physical gold holding. It provides the investor with all the benefits of investing in gold while eliminating disadvantages related to physical gold possession. According to [Sarkar \(2012\)](#), the rapid growth in gold ETFs increases gold market volatility in the short and long term. The author found evidence of growing interest in gold ETFs as an alternative investment in India (77.86% increase in issued security by gold ETFs, 83% increase in asset under management for gold ETFs in two years between 2009 and 2011, the daily average turnover and daily average number of trades).

[Pule \(2013\)](#) investigates the potential benefits of investing in different gold investment forms, such as gold ETF, that a South African investor could seek to participate in the gold market. By comparing the performance of different gold investment vehicles to the equities markets in South Africa, [Pule \(2013\)](#) found that investing in gold ETF yields a comparable return to gold bullion investment and an

abnormal return compared to the other investment forms such as gold mining index, FTSE/JSE all share index, and unit trust index (gold & precious metals). The gold ETF in South Africa, NewGold ETF, followed gold prices almost perfectly and experienced similar volatility, as each security issued by the gold ETF is 100% backed by gold.

Perhaps a more detailed study that accounts for gold financialization's effect on the gold market is to be found in the work of [Baur \(2013a\)](#). The study investigated if the introduction of gold ETFs affects the gold price, causes gold market volatility, and whether gold ETFs offer similar functions to physical gold roles on occasions of market stress. The author finds supporting evidence that introducing gold ETFs has shifted demand and influenced the trading volume and, therefore, the underlying gold price, creating volatility in the gold market in the long run, not daily.

The author provides an overview of the general function of ETFs, with a particular focus on gold ETFs. Gold ETF shares are financial claims to the underlying holdings of gold. These shares can be sold cheaper than bars or coins due to lower storage costs achieved through economies of scale or pooling of gold. The more gold obtained by gold ETFs, the cheaper they can sell their shares and achieve cost-effectiveness. Besides, economies of scale or pooling of gold sought by gold ETFs cause an increase in gold demand. The rise in gold investment demand can be attributed to either the rising number of ETF providers or the expanding size of existing gold ETFs, which pool more gold to lower storage costs, thereby enhancing their competitiveness among ETF providers.

Through pooling gold into ETF shares, gold financialization has increased the demand for gold and, eventually, gold prices. Besides, the continuous increase of ETF size and competition among gold ETF providers further drives gold demand and prices up as the ETF providers pool more gold to achieve cost-effectiveness. Empirical results show strong positive co-movement between gold ETFs investment demand and physical demand since the introduction of gold ETFs during the entire sample period from 2002 to 2011. The rise in gold ETFs investment demand and the number of gold ETF providers, alongside gold prices, provide evidence of the role of gold ETFs in driving positive changes in gold prices. Also, Granger causality tests support the positive relationship between gold prices and the number of gold ETFs ([Baur, 2013a](#)).

Furthermore, the empirical evidence supports that gold ETFs' providers achieve high trading volume through their cost-effectiveness, evidenced by a small bid-ask spread and high daily trading volumes of large ETFs, such as SPDR Gold Shares ETF (GLD). Consequently, increasing trading volume leads to higher gold volatility. Besides, the simplicity of trading gold ETF shares stimulates the overreaction to gold-related news, causing and increasing gold volatility. The standard deviation of daily prices for gold pre-ETF and post-ETF introduction was 76.7 and 465.6, respectively, and it is similar to the monthly results. The daily volatility increased by 83% after the introduction of the gold ETF. However, the daily and monthly standard deviation based on gold returns was almost similar between the two periods (no real change before and after the gold ETFs introduction), but the results were insignificant ([Baur \(2013a\)](#)). The author concludes that introducing gold ETFs increased gold investment demand, price, and volatility. However, the results are less than conclusive.

Although the author indicated that gold market volatility increased after introducing gold ETFs, the study lacks evidence of daily fluctuations in the gold market, and the inferences drawn from this study fail to account for the time varying dependency of volatility and, therefore, are unreliable. The study shows changes in variance. However, the measure does not capture the structural change of time varying volatility. A common approach to capture the time varying nature of volatility is to model the conditional variance as a GARCH process. Besides, when using the GARCH model, the author considered the entire sample period to investigate the change in gold market volatility after introducing gold ETFs. However, the most common practice is to compare the volatility of the spot market before and after introducing the financial instrument. Moreover, the study does not make a statistical inference connection between information and volatility. Unless information remains constant, any changes in the rate of information flow will change the volatility of gold spot prices.

In summary, while prior research, such as [Sarkar \(2012\)](#) and [Pule \(2013\)](#), examine the growth and performance of gold ETFs highlighting benefits such as cost efficiency and returns, only [Baur \(2013a\)](#) has addressed their impact on gold price volatility, suggesting that the gold ETF introduction increased gold market volatility in the long run. However, Baur's study lacks accuracy in volatility modelling, employing

a full-sample GARCH approach without addressing structural changes. This study builds upon Baur's insight while addressing critical methodological limitations. By applying changepoint detection, rolling standard deviation analysis, and split-sample GARCH models with dummy variables, this study demonstrates that gold volatility not only increased after the introduction of gold ETFs but did so following a structural shift around December 2005. This identifies a clear causal link that was not previously addressed.

This study also draws on the broader literature concerning the introduction of financial instruments, particularly futures, and their impact on underlying market volatility. Much of this literature finds increased volatility following futures introduction (see Table 5.3, Appendix 2). This study focuses on the commodity sector and specifically tests the “destabilization hypothesis” in the context of gold ETFs. By adapting methodologies from futures market studies and applying them to gold markets, the study bridges a gap between general financial innovation literature and commodity-specific research.

3.3 Methodology

This section introduces the research questions and discusses methods employed to highlight changes in gold market volatility, examine the effect of introducing gold ETFs on gold spot market volatility, and evaluate the potential increase in the speed of information flow to the spot market.

3.3.1 Data

The data consists of daily closing spot prices for gold measured in US dollars per troy ounce. The closing time of the gold price is the afternoon (PM) Eastern time, and the data was obtained from Refinitiv Workspace. Initially, the study includes earlier data (1987 – 2024) to better identify the significant change in data series with the intention of obtaining more robust results. Then, the analysis conducted over the data period from 1st January 2004 to 31st December 2007, leading to a sample size of 1043 daily observations. In order to compare the structure of volatility of the gold spot market, the data was split into two sub-samples.

The study investigation begins with a one-year sample period before and after 2005, i.e. from 3rd January 2005 to 30th December 2005 (pre-gold ETFs), and from 2nd

January 2006 to 29th December 2006 (post-gold ETFs). Then, it expanded the range of the sample period to cover two years before and after 2005, i.e. from 1st January 2004 to 30th December 2005 (pre-gold ETFs) and 2nd January 2006 to 31st December 2007 (post-gold ETFs).

The daily returns on the gold market were computed based on the daily closing price (P_t), where the gold return (Gr_t) is defined as $(P_t - P_{t-1})/P_{t-1}$. The gold time series was tested for unit root through the Augmented Dickey-Fuller test¹⁴, with the null hypothesis of the existence of a unit root being rejected at a 5% level (p-value < 0.05). Hence, the gold returns series is stationary, which means that the statistical properties do not change over time, and it is necessary to generate unbiased and reliable results that lead to a better understanding of driving factors.

3.3.2 Research Aims and Hypotheses

This study seeks to:

- 1- Analyze changes in gold market volatility.
- 2- Examine the effects of gold ETF onset on gold spot market volatility.
- 3- Assess whether gold ETFs enhance the flow of information to the spot market.

The introduction of paper gold, which securitises gold by converting physical gold into financial claims, has simplified the gold trade, attracted additional traders, and perhaps destabilised gold market volatility. The recent volatility in the gold market coincides with the introduction of gold ETFs in 2004. Gold-backed securities, ETF shares, allow investors to trade and participate in gold price movements, either for diversification or speculation, without worrying about the associated costs of holding physical gold. Gold ETFs may also allow gold-related information to be transmitted more quickly to the gold spot market. Hence, based on this background, the following hypothesis is developed:

Hypothesis 1: The gold market exhibited a shift in the early 2000s, and the market volatility changed.

¹⁴ See appendix 2 for test result.

3.3.3 Is There a Break in the Gold Market Volatility?

Before diving into the study, it is essential first to check whether there is any change in the series around the time when gold ETFs were introduced. Assuming the knowledge as to when the introduction of gold ETFs took place, It is worth noting that this is not done to re-discover the event date but to statistically validate the occurrence of change after the event.

To establish whether the gold market volatility exhibits any shift with the introduction of gold ETF and to justify dividing the sample period, the study first explores whether a statistical breaking point exists in the gold market without using prior knowledge. Again, the goal here is not to find the exact date of the event but rather to primarily confirm whether there has been a change in volatility subsequent to the onset of gold ETFs so that it justifies dividing the sample period for further examination. Then, the study measures whether the variance of gold returns remains stable over the entire sample period and highlights the difference between the subsamples.

3.3.3.1 Changing point analysis

The changing point approach detects and analyses changes in time series data. It can be a valuable tool for identifying structural breaks in a dataset and understanding how the data may have changed over time. Change points are defined as points in the data series where there is a sudden significant change in the underlying statistical properties of the data. It splits a data series into two or more segments, each with its own (different) statistical properties (e.g., mean, variance, etc.).

In particular, detecting changes in the characteristics of time series data can be accomplished by comparing statistical properties across the data. Shifts in the mean value are one notable example of such changes and can be identified when the data can be segmented into different constant segments with different mean values. Another example is a change in variance, where the mean value of the data remains constant while having multiple segments with distinct variance values. These changes can be interpreted as sudden fluctuations in the time series data, providing valuable insight into its behaviour.

Furthermore, numerous changepoint search algorithms exist to identify the location of one or more change points within a time series. [Killick and Eckley \(2014\)](#) point out that the most well-known algorithms are the binary segmentation algorithm ([Scott and Knott \(1974\)](#); [Sen and Srivastava \(1975\)](#)); the segment neighborhood algorithm ([Auger and Lawrence \(1989\)](#); [Bai and Perron \(1998\)](#)) and, most recently, the PELT algorithm ([Killick et al. \(2012\)](#)). Evaluating the performance of 14 existing change point detection algorithms finds that the binary segmentation (BINSEG), At Most One Changepoint (AMOC), and Pruned Exact Linear Time (PELT) achieved the highest average performance on the univariate time series ([Van den Burg and Williams \(2020\)](#)).

The changepoint approach that was initially designed by [Killick and Eckley \(2014\)](#), and updated by [Killick et al. \(2016\)](#) utilizes these previously mentioned algorithms along with other algorithms, enabling the identification of single or multiple breakpoints related to changes in the mean or variance or both within a given time series or sequence. Additionally, the ability to specify parameters for detecting only one significant change per time series makes this approach a versatile tool for analyzing and interpreting time series data. It assesses the mean or variance of time series data to identify any significant changes in these properties. It offers different functions (e.g., detecting changes in the mean for data with constant variance, detecting changes in the variance for data with constant mean, and detecting changes in both the mean and variance) for different types of data to detect changepoints in time series data or sequence, and it uses a variety of algorithms (e.g., PELT and AMOC) to search for the optimal segmentation. The main difference between PELT and AMOC algorithms is in the number of changepoints they can detect. While PELT (Pruned Exact Linear Time) allows for the detection of multiple changepoints, AMOC (At Most One Changepoint) detects at most one changepoint. The choice between PELT, AMOC, and other algorithms largely depends on the nature of the data and the specific requirements of the analysis. For this study, the AMOC is considered.

The changing point approach is built on the concept of the cost-based approach defined below. It involves segmenting the data and measuring the "cost" of each segment, then looking for the points in the data sequence that minimize the total cost. Suppose the cost of a particular configuration of segments is significantly less than the cost of considering the whole data set as a single segment. In that case, the configuration is likely to indicate one or more changing points.

To explain, the function looks for points in the dataset where both the mean and variance change. The function tries to split the dataset into distinct segments, where the statistical properties (mean and variance) within each segment are stable or homogenous but may differ between segments. It accomplishes this by calculating the cost of each potential segment under the assumption that the data in the segment is independently and identically distributed (i.i.d.) with a normal distribution. In other words, the cost function measures how well the data in the segment fits a normal distribution with a specific mean and variance.

To consider whether there is a changing (break) point in the data, let's denote the observations as $X = \{x_1, x_2, \dots, x_n\}$ and the segment of this dataset from point i to j as $X_{ij} = \{x_i, \dots, x_j\}$

For each segment X_{ij} , the mean and variance are defined as follows:

$$M_{ij} = \frac{1}{j-i+1} \sum_{k=i}^j x_k$$

$$V_{ij} = \frac{1}{j-i+1} \sum_{k=i}^j (x_k - M_{ij})^2$$

Then, the cost function for each segment X_{ij} , based on the likelihood of the normal distribution, can be expressed as follows:

$$C(i, j) = -\log \left[\frac{1}{(2\pi V_{ij})^{(j-i+1)/2}} \exp \left(-\frac{1}{2V_{ij}} \sum_{k=i}^j (x_k - M_{ij})^2 \right) \right]$$

After computing the cost for each segment X_{ij} , the total cost for the dataset X segmented at each position i is the sum of the cost of all segments. Then, if the total cost is less than the cost of considering the whole data set as one segment, it implies one or more change points. The approach helps find a single change point, which infers to the first observation in the new data segment by considering the mean and variance of data.

Employing the changing point approach in the context of the gold market assumes that the gold time series may contain either zero or one change point. The primary objective is to identify the time of this potential changepoint. If there happens

to be a shift in the gold market due to the introduction of gold ETFs, it should approximately coincide with the actual period of gold ETFs' inception. While the world's first and largest gold ETF was introduced in the United States in 2004 by the World Gold Council, it is expected that changes in gold market behaviour would be observed around and beyond this period. This expectation is rooted in the fact that any new successful innovation or product takes a certain amount of time to establish sustainable growth before it can exert a noticeable influence on the market.

To clarify, the approach works in several subsequential steps. First, it assumes that the gold time series has no changing point, implying that the entire time series is treated as one segment¹⁵. The mean and variance of this segment are then calculated, and the cost function based on these properties is computed. Second, it systematically examines each data point in the gold time series, from the second data point to the last, as a potential changepoint. The data is split into two segments for each potential change point – one before and one after the potential change point. Then, again, the mean and variance for each of these segments are calculated, and the cost for each segment is computed. In the evaluation process, the total cost, which is the sum of the costs of the two segments, is compared to the initial cost (where no change point is assumed). If the total cost for a potential changepoint is significantly lower than the initial cost, then that point is selected as a changepoint. If no such point was found to reduce the cost significantly, it concludes that there is no changepoint.

3.3.3.2 Chow Test

To further statistically validate and confirm the occurrence of the structural break in the gold market, the Chow test is used. The Chow test commonly tests for structural breaks in the relationship between two or more time series variables. However, it can also be adapted to test for structural breaks within a single time series by treating the time series as its own predictor.

The test identifies whether a structural break has occurred, meaning that the relationship between the dependent and independent variables has changed at a certain point in time. Given prior knowledge or information about the time series data, the entire period is divided into pre-break and post-break. Then, the test compares the sum of squared errors of the regression models before and after the structural break.

¹⁵ The study includes earlier data (1987 – 2024) to better identify the significant change in data series.

If the difference between the two sums of squared errors is statistically significant, it indicates that a break has occurred in the time series data. Accordingly, the gold series is split into two distinct periods: one before the advent of gold ETFs and another following their inception. This division is determined based on the previous changepoint analysis.

Under the Chow test, the null hypothesis of no structural break is tested. Suppose the calculated Chow test statistic is less than the critical value (5%). In that case, the null hypothesis is rejected, indicating that a significant structural break has occurred and the identified changing point is significant.

3.3.3.3 Rolling Standard Deviation

To further illustrate the changing nature of the gold market volatility, the rolling standard deviation is calculated. The rolling standard deviation measures the stability of the variance of the gold market (G_t) distribution over a fixed window (60 periods)¹⁶. Then, as the window rolls ahead through the sample by a given increment (one period or one observation at a time) each time, the standard deviation is re-estimated, yielding individual statistics (standard deviation) for each window.

Thus, the model generates a series of standard deviations for each rolling window subset of the entire sample to highlight any fluctuations and trends. If the computed standard deviations remained relatively stable, not widely different over the whole sample, it would bear out market stability (no volatility changes). Hence, the division of the entire period into pre-ETFs and post-ETFs periods cannot be constructed. However, Suppose the computed standard deviations exhibit substantial variations at a specific time. In that case, it indicates that gold market volatility has changed, justifying dividing the entire period into two distinct volatility periods. More importantly, It would support the hypothesis that a new factor, gold ETFs, influence exists.

To consider whether the variance of the gold time series (G_t) remains constant over a sample from $t = 1, \dots, T$, the rolling window calculation is given for windows $t = n, \dots, T$, where n denotes the window size (a subset of the sample):

¹⁶ As with changing point approach, the study includes earlier data (1987-2024) to better identify the significant change in data series. To provide a clearer illustration, the calculations were undertaken with re-sampled monthly data and so the window size covers 60 months.

$$\hat{\sigma}_t^2(n) = \frac{1}{n-1} \sum_{i=0}^{n-1} (G_{t-i} - \widehat{\mu G}_t(n))^2 \quad \text{Variance}$$

$$\hat{\sigma}(n) = \sqrt{\hat{\sigma}_t^2(n)} \quad \text{Standard Deviation}$$

To provide a clearer illustration, the calculations were undertaken with re-sampled monthly data and so the window size covers 60 months, where the daily return would be noisy and not clearly reflect the changes. This is mainly illustrative but serves to highlight the change in the level of volatility within gold returns.

3.3.3.4 The Yang and Zhang variance estimator

As a further exercise in assessing changes in gold market volatility, the Yang and Zhang variance estimator is estimated across the two sample periods. Several range-based volatility estimators derive from open, high, low, and close (OHLC) prices to measure volatility. It ranges from Close to close estimator, Parkinson (1980) estimator, Garman Klass (1980) estimator, Rogers and Satchell (1991) estimator, and the most recent estimator by Yang and Zhang (2000), who took the best of all other estimators components into their model. The Yang and Zhang variance estimator takes into consideration the drawbacks (drift, opening price jump, intraday volatility) of the other variance estimators by incorporating possible sources of the market volatility that manifest themselves in the Open, High, Low, and Close (OHLC) data ([Korkusuz et al., 2023](#)).

The Yang and Zhang variance estimator is given by:

$$V_{YZ,t} = \left(\ln \frac{O_t}{C_{t-1}}\right)^2 + k \left(\ln \frac{C_t}{O_t}\right)^2 + (1-k)V_{RS,t} \quad k = \left(\frac{0.34}{1.34 + \frac{n+1}{n-1}}\right)$$

For simplicity, the formula can be presented in the following style:

$$\sigma_{Yang\ Zhang}^2 = \sigma_{open}^2 + k\sigma_{close}^2 + (1-k)\sigma_{RS}^2 \quad k = \left(\frac{0.34}{1.34 + \frac{n+1}{n-1}}\right)$$

The measure provides additional insights into gold market volatility, and comparing the volatility before and after the introduction of gold ETFs reveals the potential effect of the gold ETFs inception on gold market volatility.

Suppose the formal tests and the illustrative of gold market volatility highlight the view that the market experienced a shift around the introduction of gold ETFs. In that case, the change in the gold market volatility may be attributed to the gold ETF inception. Accordingly, the second hypothesis is developed to test whether this intervention destabilizes volatility in the gold spot market and facilitates information flow to the spot market.

Hypothesis 2: The introduction of gold ETFs raises gold market volatility and enhances the flow of information to the gold spot market.

3.3.4 Does Gold ETF Affect Gold Market Volatility?

A further exercise in understanding the effect of introducing a new financial instrument on market volatility is comparing volatility before and after the advent of financial instruments, using different statistical methods ranging from a simple comparison of variances and linear regression to more complex GARCH models. The GARCH model not only allows the capture of the structural change of time-varying volatility but also enables the link between information and volatility to be examined.

3.3.4.1 GARCH model

Perhaps the most commonly used approach to investigate the volatility of a time series of financial data that takes into account the time variation in volatility and the direct relationship between information and volatility is GARCH. The Autoregressive Conditional Heteroscedastic (ARCH) model developed by Engle (1982) and later generalized by Bollerslev (1986) and Engle and Bollerslev (1986) is a reliable method to model time-varying volatility. The generalized ARCH (GARCH) account for systematic changes in the variance of a time series by modelling the conditional variance by taking into consideration the past (lagged) squared error term (ε_{t-i}^2) in addition to the past volatility (lagged conditional variance (σ_{t-j})) of the series. GARCH(p,q) model given as below:

$$\sigma_t^2 = \omega + \sum_{i=1}^p \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^q \beta_i \sigma_{t-i}^2$$

If the formal tests and the illustrative of gold market volatility confirm a change in gold spot volatility around the gold ETFs introduction period, as explained previously, the gold market volatility is modelled using GARCH (1,1), with a dummy variable accounting for the structure of the change in volatility. This practice allows not

only examining whether the volatility has changed but also identifying if the exogenous factor is responsible for such changes in volatility. The model enables capturing the impact of introducing gold ETF on gold market volatility by marking and comparing the changes in the coefficient of volatility parameters in the gold market for the pre-ETFs and post-ETFs periods. By including the dummy variable in the GARCH (1, 1) model, one can identify and study the nature of the potential effects, increase or decrease, of introducing gold ETFs on gold market volatility. The conditional volatility model with a dummy variable takes the following form:

$$\sigma_t^2 = \omega + \sum_{i=1}^p \alpha_i \epsilon_{t-i}^2 + \sum_{i=1}^q \beta_i \sigma_{t-i}^2 + \gamma D_{ETF} \quad (1)$$

Where σ_t^2 is the conditional variance (volatility) at the time t, ω is the constant (average or unconditional) variance, α_i and β_i are coefficients that relate the past value of the squared residuals and the last period volatility, respectively, to the current volatility. The D_{ETF} is the dummy with a value of 0 for the pre-ETFs period and 1 for the post-ETFs period. The changes in coefficients of the conditional volatility are observed before and after the onset of gold ETFs to note any changes in the nature of the volatility.

Suppose the coefficient of the dummy variable γ is statistically significant. In that case, there is evidence that introducing gold ETFs has changed the spot market volatility. A positive coefficient of the dummy variable indicates that the introduction of gold ETFs has increased the volatility of the spot market. Conversely, a negative coefficient indicates a decrease in volatility. If the coefficient equals zero, the gold ETFs do not have a significant impact on spot market volatility.

Besides, suppose there is an increase in the total value of adding the dummy variable coefficient to the constant, ω (average variance). In that case, the increase in the average variance implies that introducing gold ETFs increases gold volatility.

Furthermore, a significant positive change in the volatility coefficients between pre- and post-ETF periods implies that more information is transmitted to the spot market following the introduction of gold ETFs, as suggested by [Pok and Poshakwale \(2004\)](#) and [Yilgor and Mebounou \(2016\)](#), who investigated the effect of the onset of futures on stock market volatility. Besides, [Ross \(1989\)](#) suggested that any change in the information flow rate will affect the underlying market's volatility. Additionally, it was

found that daily volatilities positively related to the rate of daily information arrival ([Lamoureux and Lastrapes, 1990](#)). So, the volatility parameters between the two periods are examined to determine whether more information is being transmitted and assimilated to the gold market due to the introduction of gold ETFs. Any changes in the parameters α_1 , β_1 indicates a change in the speed of information being conveyed to the gold market in the post-ETFs period. The value of α_i , which represents the recent news and the value of β_i , which represents old news, indicates how fast the information is incorporated into the price during the post-gold ETFs period. While a higher value of α_i indicates an increase in the speed of recent news incorporated into the price, a lower value of β_i indicates a decrease in the speed of old news incorporated into the price during the post-ETF period. In other words, the increase in the flow of information by the recent news is expected to reduce the effect of the old news. Besides, β_i , the volatility's persistence parameter is expected to persist less as the recent news effect is higher.

3.4 Empirical Analysis

This section presents data descriptive statistics, structural volatility change analysis, GARCH analysis, and results discussion. It focuses first on analysing whether there has been a structural change in the variance of the gold market around the introduction of gold ETFs, where the changing point and rolling variance are addressed. Then, the effect of introducing gold ETFs on gold market volatility is analyzed in detail using the GARCH model.

3.4.1 Data Descriptive Statistics

Table 3.1 summarizes the statistics of gold daily returns. It provides an initial view of a general comparison of the gold market in the pre- and post-gold ETF periods, as well as essential information about gold volatility. The gold series splits at the identified optimal changepoint, December 2005, to reflect the onset and rising popularity of gold ETFs and their potential impact on gold market dynamics. Initially, the study investigation begins with a one-year sample period covering pre-gold ETFs (from 3rd January 2005 to 30th December 2005) and post-gold ETFs (2nd January 2006 to 29th December 2006) sample period. Then, it expanded the range of the sample period covering two years, from 1st January 2004 to 30th December 2005 (Pre-gold

ETFs) and 2nd January 2006 to 31st December 2007 (Post-gold ETFs), for further robust examination of the impact of introducing gold ETFs.

As observed in Table 3.1, the different sample periods reveal similar higher summary statistics after introducing gold ETFs. What stands out in this table is the high standard deviation, excess kurtosis, and Yang and Zhang volatility estimator, which provides an initial view of volatility in the post-gold ETF period. While the volatility in pre-gold ETFs is lower, it is higher in post-gold ETFs. For one- and two-year sample period comparisons, the standard deviation in post-ETFs is 0.0146 and 0.0124, respectively, whereas in pre-ETFs, it is 0.0081 and 0.0086. Similarly, the excess kurtosis in post-ETF is higher at 2.000 compared to pre-ETF 1.5200 for the two-year comparison. However, the excess kurtosis is almost similar for the one-year comparison, with 1.1362 and 1.3526 for pre- and post-ETF, respectively.

Table 3.1 Shows the statistical summary for one-year and two-year sample periods of the gold market from 2004 to 2007

Summary Statistics Comparison				
	One-year sample period		Two-year sample period	
	January – December 2005	January – December 2006	January 2004 – December 2005	January 2006 – December 2007
	Pre-ETFs	Post-ETFs	Pre-ETFs	Post-ETFs
Mean	0.0006	0.0009	0.0004	0.0010
Standard deviation	0.0081	0.0146	0.0086	0.0124
Skewness	-0.1240	-0.5578	-0.3388	-0.6194
Ex. kurtosis	1.1362	1.3526	1.5200	2.0000
YZ Volatility Estimator	0.0073	0.0137	0.0085	0.0121

As a financial risk indicator, excess kurtosis indicates how much risk is involved in a particular investment, gold in this study. A high kurtosis for an investment indicates that there have been many price fluctuations. A high kurtosis means high risk because it is associated with a high probability of substantial return gains or losses. Besides, the Yang and Zhang estimator, which accounts for conceivable sources of market volatility, presents additional evidence for changes in gold market volatility, with higher estimates in the post-gold ETFs period. Although descriptive statistics lack an inferential basis for an abrupt change in gold volatility, these figures are reasonable for establishing an inference point to investigate further the effect of the onset of the gold ETF on the gold market and draw a final conclusion.

3.4.2 Structural Changing Point Analysis

This section examines whether the gold market exhibits a statistical structural break. Figure 3.2 illustrates that the new segment in the gold market occurred on 30th December 2005 by considering higher or lower significant changes in gold's mean and variance compared to the whole dataset¹⁷.

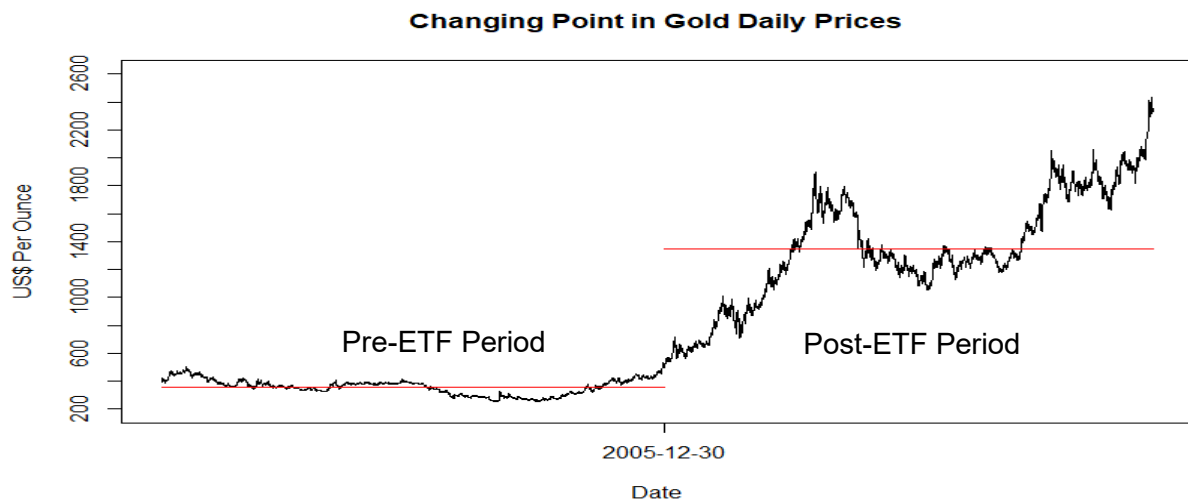


Figure 3.2 Shows the gold prices from 1987 to 2024 and the date of the detected changepoint in data.

As observed, the gold fluctuations are positive and higher in the new segment. The identified change point suggests splitting data into two distinct periods: pre-ETF, where gold fluctuations were low, and post-ETF, with higher fluctuations.

Remember that the world's biggest gold ETFs, the US gold ETF (GLD), were introduced in November 2004. The result aligns with the expectation that any new successful innovation or product takes a certain amount of time to establish sustainable growth before it can exert a noticeable influence on the market. Note that the changepoint analysis not only reinforces the fact that the change in gold market volatility happened around the introduction of gold ETFs but also allows an objective selection of the span of the event window for later analysis. Accordingly, the pre-gold ETFs period is taken from 1st January 2004 to 30th December 2005, and the post-gold ETFs period from 1st January 2006 to 31st December 2007.

¹⁷ To better capture more accurate potential change point, the study has extended the time frame of the gold series to cover a rich period from 1987 to 2024 with the intention of obtaining more robust results.

3.4.3 Chow Test

To further obtain robust results, the significance of the identified optimal single changepoint from the previous section is examined. As shown in Table 3.2, the Chow test¹⁸ supports and validates the shift in gold volatility occurring on 30th December 2005 by rejecting the null hypothesis of no structural breakpoint with a p-value less than 0.05.

Table 3.2 Chow test run to validate the identified breaking point on 30th December 2005

Augmented Regression for Chow Test				
Variable	F-Statistics/(P-value)	Critical values		Decision
				Reject the null hypothesis
Gold prices	3895.8/(0.0000)	At 5%	2.9957	"No Structural Break on 30 th December 2005"

Further to highlight the importance of the gold ETF's inception on the gold market, the study examined whether other precious metals markets also exhibited a structural break after ETF inception in their markets. Figure 3.3 Shows precious metals prices from 1987 to 2024 and the date of the detected changepoint. Figure 3.3 shows the results of the change point test for all precious metals. The results support splitting data into two distinct periods: a low volatility period and a higher and fluctuating volatility period. It is important to note that though the test identifies changing points in the Silver, Platinum, and Palladium markets, this is, unlike the gold market, not due to the ETF inception. In the gold market, the change in the market happened after the ETF's inception. However, in the other precious metals markets, it happened earlier than the ETF's inception.

In addition, the largest ETF in the gold market was introduced at the beginning of the gold ETF market, in November 2004. However, the largest ETF in other precious metals markets was introduced in the market at a later stage of the precious metal ETF market. Table 3.3 presents the change point date, the date of the first ETF introduced in each precious metal market, and the date of the largest ETF in each corresponding market.

¹⁸ See appendix 2 for detailed results output.

Table 3.3 presents changepoint date, date of precious metals' ETF inception and its largest ETF

Metal	change point date	First ETF	Largest ETF	Global ETFs' AUM (in 2025)		
Gold	Dec 30, 2005	SPDR Gold Shares (GLD)	Nov 18, 2004	SPDR Gold Shares (GLD)	Nov 18, 2004	~\$379B
Silver	Nov 15, 2005	iShares Silver Trust (SLV)	April 21, 2006	iShares Silver Trust (SLV)	April 21, 2006	>\$25.8B
Platinum	Jan 21, 2003	WisdomTree Physical Platinum ETF (PHPT)	April 24, 2007	abrdn Physical Platinum Shares ETF (PPLT)	Jan 8, 2010	~\$3.6B
Palladium	June 02, 1997	WisdomTree Physical Palladium ETF (PHPD)	Jan 8, 2010	abrdn Physical Palladium Shares ETF (PALL)	Jan 8, 2010	~\$386.9M

Besides, other precious metals markets are not as large and important as the gold market. The global ETFs' assets under management (AUM) in all precious metals are less than 10% of the global gold ETFs' AUM. Hence, the significant change that happened in the gold market with the introduction of gold ETF would not necessarily cause the same effect in other precious metals markets when their ETF was introduced. While the total assets under management for the world's 228 Metal & Mining ETFs reached approximately \$330.7 billion in 2024, gold metal ETFs constituted over 70% of this total.

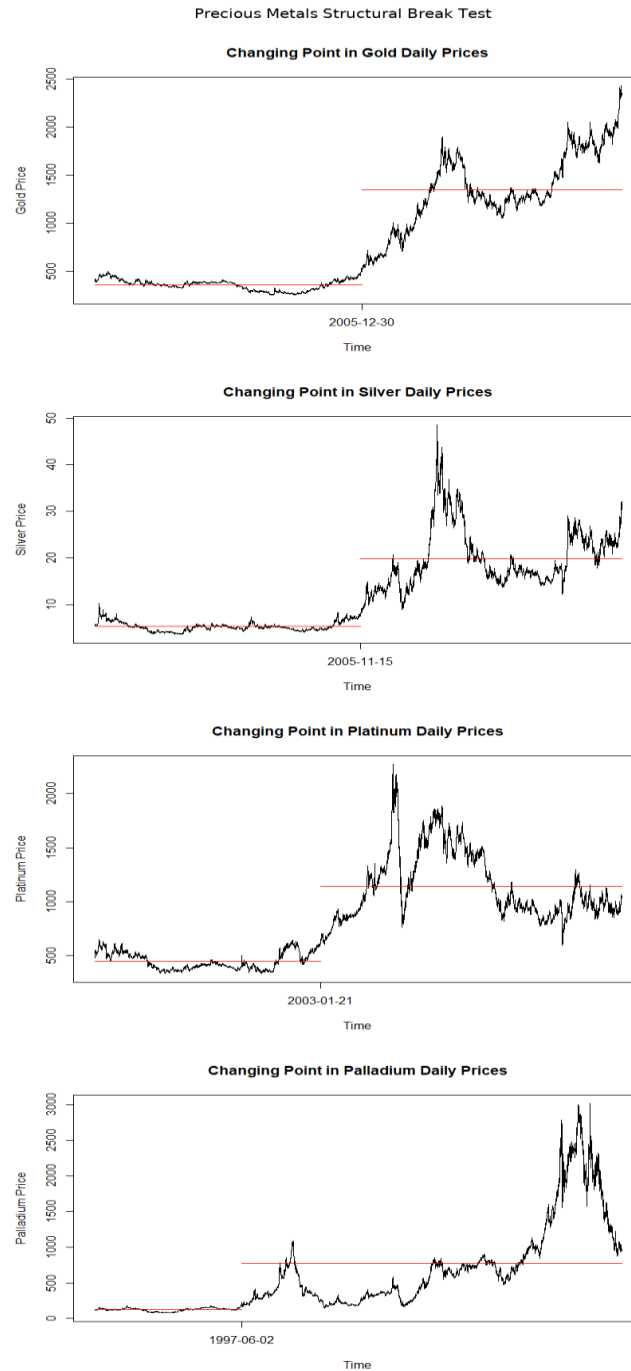


Figure 3.3 Shows precious metals prices from 1987 to 2024 and the date of the detected changepoint

3.4.4 Rolling Analysis

To further illustrate the changes in gold market volatility, the calculated rolling variance, which considers whether the variance of the gold return remains stable or exhibits shifts, has statistically revealed stability in gold variance in a certain period, pre-ETFs, and high volatility in another period, post-ETFs. The rolling variance approach justifies dividing the sample period into two distinct periods.

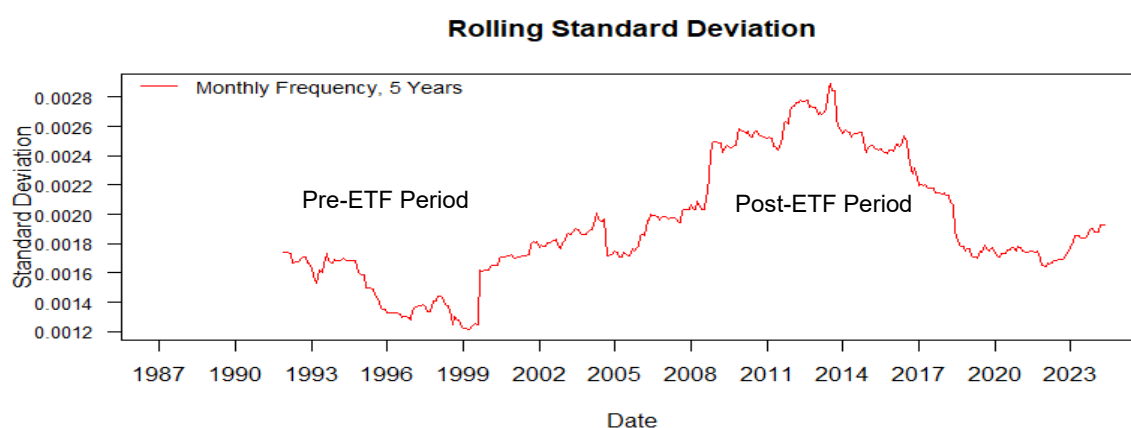


Figure 3.4 Shows the rolling standard deviation from 1987 to 2024 in the gold series.

Figure 3.4 presents the rolling variance (standard deviation) over the full sample period. As illustrated, the standard deviation remains relatively low, with minor fluctuations before the 2000s. However, a period of market transition in volatility begins in the early 2000s with a gradual increase in standard deviation. A noticeable increase in gold market volatility occurred around 2005, with a significant standard deviation surge. The graph shows a slight swing in the pre-ETF period compared to escalated post-ETF movements. The introduction of gold ETFs around (2003-2004) may have contributed to increased market activity and volatility, and the sustained higher volatility in the post-ETFs period suggests that gold market dynamics changed, and the risk associated with gold investments rose after the introduction of gold ETFs. The building structure of gold ETF and its features, which attract more participants in the gold market, may contribute to the instability of the gold market.

Overall, with respect to the first hypothesis, both the formal tests and the illustrative figures highlight the view that the gold market exhibited a shift in the early 2000s, and the market volatility changed.

3.4.5 Controlling Other Factors

In analyzing the effects of introducing gold ETFs on gold market volatility, it is necessary to highlight other factors that might contribute to gold market volatility, not due to gold ETFs inception, to directly and precisely evaluate the impact of gold ETFs when they were first introduced in the market in 2003. At the beginning of 2000 and before 2003, the gold market addressed a few major changes: central bank selling stopped, gold producer hedging was contained, the VAT was removed on physical

gold purchases, and gold trading was deregulated. Besides, other events in the financial markets were the Dot.com bubble (2000 – 2002) and the September 11th attack (2001). It is evident that these events happened before the introduction of gold ETFs. To the extent of our knowledge, the only remarkable event was the announcement of the World Gold Council (WGC) about their plans to bring gold to the greater attention of the world's markets by its newly appointed Chief Executive Officer, James Burton, in 2002. It is worth noting that the gold market volatility increased substantially after introducing gold ETFs and before the global financial crisis (2007-2009).

The next consideration involves determining the duration of the investigation period, or more precisely, the length of the event window, as previously specified, from 1st January 2004 to 31st December 2007. The decision about the length of the test period is a critical question where a balance must be attained between the length of the period for reliable estimation of model parameters against the possibility of existing other events that might affect the series and, thus, the parameter estimates. This is because the gold market is frequently affected by several different events over time, distinct from the event in question. Hence, there is a potential for confounding variables resulting from these intervening events. The effects of these events on gold volatility are uncertain, and disentangling these events and extracting a "normal" volatility model is not a simple task.

As the study concentrates only on the impact of gold ETF inception and to avoid the effect of potential other confounding events, a test period of one year and two years pre and post-gold ETF introduction is considered around the identified optimal changepoint (28th November 2005), which is free from potential confounding effects.

3.4.6 GARCH Estimations

This section examines whether gold ETFs advent raises gold market volatility and enhances the flow of information to the gold spot market. The GARCH model accounts for the time variation in volatility and the direct relationship between information and volatility. The study focuses on the change in gold market volatility as addressed previously, and Table 3.4 presents the estimation results of the GARCH

model with a dummy variable for extended¹⁹ sample period to better obtain significant evidence of the effect of gold ETF introduction given by equation below:

$$\sigma_t^2 = \omega + \sum_{i=1}^p \alpha_i \epsilon_{t-i}^2 + \sum_{i=1}^q \beta_i \sigma_{t-i}^2 + \gamma D_{ETF}$$

Table 3.4 shows that the coefficient (γ) of the dummy variable (D_{ETF}), which measures the impact of introducing gold ETFs on spot gold volatility, is positive (0.00329) and significant at a 10% level. The positive coefficient on the ETF dummy suggests that the onset of the gold ETF trading resulted in increased gold spot price volatility. In addition, the sum of the coefficients of the constant (average or unconditional variance) term ($\omega = 0.002978$) and the dummy variable ($\gamma = 0.003298$) yielded an increase in average variance equal to (0.006276), which in lines with increasing volatility in gold market after the onset of gold ETFs.

Table 3.4 Shows the GARCH parameters' coefficients for the gold time series from 1987 to 2024

GARCH (1,1) with Dummy variable (D_{ETF})				
	<i>Coefficient</i>	<i>Std. Error</i>	<i>Z statistic</i>	<i>p-value</i>
ω	0.003207	0.000382	8.395868	0.00000
α_1	0.045759	0.001305	35.06408	0.00000
β_1	0.950937	0.001369	694.8529	0.00000
$(\gamma) D_{ETF}$	0.003159	0.000608	5.196864	0.00000

The increase in volatility suggested by results in Table 3.4 is further investigated by evaluating the behaviour of parameters in the GARCH equation for pre- and post-gold ETFs periods around the identified breaking point, December 2005, which reflects the gold ETF introduction in the market. Two sample ranges are used: one year before and after gold ETFs onset (from 3rd January 2005 to 30th December 2005, and from 2nd January 2006 to 29th December 2006, respectively) and two years before and after (from 1st January 2004 to 30th December 2005, and from 2nd January 2006 to 31st December 2007, respectively).

Table 3.5 presents the results for the one-year sample period and all parameters (α_1 and β_1) were statistically significant at a 5% level. There are

¹⁹ To better capture more accurate effect of gold ETF introduction, the study has extended the time frame of the gold series to cover a longer period from 1987 to 2024 with the intention of obtaining more robust results.

noticeable differences in the conditional volatility process for periods before and after the introduction of gold ETFs.

Table 3.5 Shows the GARCH results for a one-year comparison before and after the onset of gold ETFs

GARCH (1,1)						
One-Year Sample Period						
Pre-ETFs			Post-ETFs			
03-01-2005 : 30-12-2005			02-01-2006 : 29-12-2006			
	Coefficient	Std. Error	p-value	Coefficient	Std. Error	p-value
ω	0.000000	1.02276e-06	0.8302	0.000002	2.89348e-06	0.5032
α_1	0.025071	0.0115437	0.0299	0.050185	0.0177283	0.0046
β_1	0.974929	0.0189310	0.0001	0.939354	0.0145037	0.0001

By comparing the coefficients in Table 3.5, the first point to note is $\alpha_{1\text{post}} > \alpha_{1\text{pre}}$ and $\beta_{1\text{post}} < \beta_{1\text{pre}}$. The coefficient α_1 represent the lagged square error term that relates to the impact of yesterday's market-specific price changes on today's price changes. A change in the value of α_1 relates to the impact of recent news on the current gold price changes. In other words, the change in the value of α_1 shows that today's gold volatility is caused by yesterday's information changes. A higher α_1 implies that recent news has a greater impact on price changes and an increase in α_1 from (0.0237) to (0.0521) suggests that recent information is included in prices more quickly after the introduction of gold ETFs.

Conversely, coefficient β_1 represent the lagged conditional variance that reflects the information before yesterday's price changes and thus captures the effect of news that arrived before yesterday (old news). An increase in α_1 is expected to decrease β_1 because the increase in the rate of flow of recent news would lead to a decrease in the uncertainty regarding old news, which in turn leads to a fall in the persistence of the information, thus having less impact on today's price changes. This view is confirmed by the fall in the coefficient of β_1 from (0.9751) to (0.9363) in the post-gold ETFs period. In addition, the sum of α_1 and β_1 pre-gold ETFs are close to unity (0.9988), whereas it slightly decreases to (0.9885) post-gold ETFs, indicating a decrease in persistence during post-gold ETFs.

Besides, Table 3.6 presents similar results by examining a two-year sample period. The results show a higher estimate of the coefficient α_1 from (0.0139) to (0.03319) in the post-gold ETFs period, suggesting that information is being impounded in spot prices more quickly due to the introduction of gold ETFs.

Table 3.6 Shows the GARCH results for a two-year comparison before and after the onset of gold ETFs

GARCH (1,1)						
Two-Year Sample Period						
Pre-ETFs				Post-ETFs		
01-01-2004 : 30-12-2005				02-01-2006 : 31-12-2007		
	Coefficient	Std. Error	p-value	Coefficient	Std. Error	p-value
ω	0.000000	5.95961e-07	0.1893	0.0000002	1.07521e-06	0.1608
α_1	0.015433	0.00846121	0.0682	0.033054	0.0107491	0.0021
β_1	0.974367	0.00826431	0.0001	0.956308	0.0128759	0.0001

Again, a higher α_1 implies that recent news has a greater impact on price changes today, thereby indicating an increase in gold market efficiency. This is followed by a decrease in the persistent coefficient, β_1 , from (0.9763) to (0.9557) in the post-gold ETFs period. A lower β_1 implies that old news has less impact on today's price changes and volatility.

Therefore, considering the results of α_1 ²⁰ and β_1 from the two sample periods along with the coefficient (γ) of the dummy variable (D_{ETF}), there has been a significant change in the process of volatility formation of the underlying gold market due to gold ETFs inception, and the gold market is more volatile post-gold ETFs. The results indicate that substantial changes in market efficiency occur after the onset of gold ETFs. It makes the gold market relatively more efficient because the information causing volatility is more quickly digested and reflected in the gold market after the gold ETF inception. The results are consistent with [Ross \(1989\)](#) argument that any change in the rate of information flow will affect the underlying market's volatility, and with [Lamoureux and Lastrapes \(1990\)](#), who found that daily volatilities are positively related to the speed of daily information arrival.

²⁰ While the GARCH (1,1) estimates for both sub-samples show that the (α) and (β) parameters are individually significant ($p < 0.05$), the Wald test indicates that the differences in these parameters between the pre- and post-ETF periods are not statistically significant. Though α nearly doubles, and β drops slightly, these changes are not statistically significant given the standard errors. This suggests that although volatility dynamics have changed but did not change significantly in a statistical sense. The volatility dynamics may have changed mathematically and visually or economically, but not statistically conclusive with the current standard errors and sample. This may have more to do with sample size and statistical power. The Wald test relies on the difference being large relative to the standard errors, and that's unlikely with limited data. See Appendix 2 for Wald test results.

3.5 Conclusion

Gold prices in the past two decades have experienced significant run-ups, and the nature of its fluctuations has changed considerably. The recent gold market volatility could be attributed to the emergence of gold ETFs. This study documents the effect of gold financialization, particularly the introduction of gold ETFs, on the underlying gold market's spot price volatility and efficiency. By focusing on introducing gold ETF (late 2003 and 2004) and its impact, this study empirically addresses a significant gap and brings more insights into understanding how financial innovation like gold ETF influences the traditionally stable market.

While gold has traditionally been perceived as a stable asset, the empirical findings address evidence of a significant structural shift in gold market volatility post-gold ETF inception, challenging the long-standing assumption of gold's stability. By using a changepoint approach, the study objectively identifies a turning point, December 2005, in the gold market for volatility changes around gold ETF introduction, illustrating that the effects of gold ETF inception are distinct and measurable. Besides, the rolling standard deviation approach further emphasises volatility behaviour changes in periods beyond 2005.

This focused analysis allows to select the event window objectively (January 2004 to December 2007), which was carefully chosen to concentrate only on the impact of gold ETF inception and avoid the effect of potentially other confounding events, leading to robust findings.

The study further, by employing the GARCH(1,1) model, addresses the effect of gold ETFs inception on gold market volatility and uncovers important dynamics changes in how information flows to the gold market. The results support other statistical findings and indicate increasing volatility during the post-gold ETFs period. The analyses suggest that the increase in volatility is due to more information being impounded into gold prices after the gold ETF inception. The findings indicate that introducing gold ETFs improves the speed of information flow to the gold spot market. This is documented by the increased sensitivity to recent news (α_1) and the reduced persistence of old news (β_1) signify a shift toward a more efficient but less stable gold market in the post-ETF period. These findings support the destabilization hypothesis, in which the high volatility in the gold market appears to result from introducing gold

ETFs and expanding the routes over which information can be faster assimilated to the gold market after gold ETFs onset.

The study contributes to the literature with new insights into the effect of the financialization of gold, through the introduction of gold ETFs, on the gold market dynamics, volatility, and efficiency while offering practical insights for market participants and regulators.

The novelty of this study lies in several key aspects that distinguish it from other works. First, it identifies a structural break in the gold market due to the introduction of gold ETF. Second, it investigates the impact of introducing gold ETF on gold market volatility and dynamics, i.e. how gold ETFs alter gold market volatility by weighting the influence of the recent market information versus old information, showing a shift in the market's responsiveness and persistence. Third, it links the increased volatility post-gold ETF inception in the gold market to enhanced market efficiency, i.e. how gold ETF facilitate the acceleration of the assimilation of new information into gold prices, making the market more responsive and efficient but also more volatile. This adds depth to understanding gold ETFs' effects on market volatility.

The impact of gold ETF inception on the volatility of the underlying gold spot market is of particular interest to investors and financial regulators alike. Investors are concerned with ongoing changes in volatility because of its implications for risk management. Increasing gold market responsiveness after introducing gold ETFs requires additional attention and reassessment of gold's role in portfolio diversification. [Bekiros et al. \(2017\)](#) note that the financialization of commodities results in accessibility for gold trading and creates a close connection between stock and gold markets. [Baur and Glover \(2012\)](#) argue that significant investment in gold (the financialization of gold) for speculation and hedging purposes can reduce gold effectiveness in financial markets. Hence, increased volatility leads to greater risk, threatening investors' investments.

Financial regulators are equally interested in learning about the potentially destabilizing effects of financial innovations like ETFs on the spot market volatility, i.e., recognizing the link between information and volatility, since this would indicate whether further regulation of financial markets is needed to minimize any detrimental effect. While gold ETFs may enhance market efficiency, they may also introduce risks that require monitoring.

Chapter 4: The Rise of Gold ETFs Roles & The Co-integrating Relation with Gold Prices

Abstract

Gold Exchange Traded Funds (ETFs) have emerged as the most successful gold investment vehicle among other existing investment forms. The introduction of gold ETF has considerably restructured the gold market and reshaped sentiments towards gold trading. There was a considerable degree of price steadiness in the gold market, but the gold financialisation, through introduction of gold ETF, in the early 21st century has led to a substantial surge in gold prices, making the post-ETF gold market distinctly different from its pre-ETF state. Gold prices and investment demand by gold ETFs rise concurrently and exhibit a positive correlation. This study explores two key aspects of the gold market. It starts with investigating the relationship between gold prices and gold ETF holdings, focusing on their co-integration. Then, it examines whether change in gold ETF holdings cause gold prices. The study applies the ADF root test, Engle-Granger and Johansen co-integration tests to find whether gold prices and gold ETFs' holdings were co-integrated, and the Vector Error Correction Model (VECM) was employed to find if there are long-run and short-run causal effects running from gold ETFs' holdings to gold prices. The results indicate that the gold prices and gold ETFs' holdings exhibit a long-run relationship, i.e. co-integrated. Notably, gold ETFs' holdings cause gold price movements in the long-run. The results suggest that gold ETFs play an important role in gold price determination, leading to a shift from traditional forces to more financialised drivers. The implications of this study provide valuable insights for different stakeholders in the gold market.

Keywords: Gold, Gold ETF, Financialization, Engle-Granger and Johansen test, VECM

4.1 Introduction

The recent development in the gold market that began in the early 21st century has led to a substantial surge in gold prices. There was a considerable degree of price steadiness in the gold market during the two decades before 2005, but it is no longer in place. The introduction of gold ETFs raises questions about the impact of gold ETFs in reshaping the gold market, whether gold ETFs investment demand (holdings) contributes to the gold market changes, whether gold ETF holdings co-integrate with gold price movements, and whether gold ETFs holdings cause gold price movements.

This study first investigates if the co-integration between gold ETFs' holdings and gold spot prices exists. Second, it determines whether a causal relationship exists between gold ETFs' holdings and gold markets, i.e. whether gold ETFs' holdings cause gold prices.

The study finds that gold ETF holdings are co-integrated with gold prices, i.e. a long-run relationship exists. This suggests that changes in gold ETFs' holdings (inflows and outflows), with limited gold production and high demand, may increasingly influence gold price dynamics and potentially substitute the traditional supply and demand forces in the gold market. Besides, the finding shows that gold ETFs' holdings significantly cause gold prices in the long run and hence play an important role in gold price determination. These findings have implications for regulators and policymakers to monitor gold ETF activities and ensure transparency to promote accuracy and timely disclosure of vital information to market participants, leading to better market stability, portfolio and risk management decisions, and gold price forecast.

4.1.1 Role of Financialisation in reshaping the gold market

The process of financialisation essentially emerged in the 1970s, driven by significant changes in the global economy, including liberalisation policies, deregulation, and technological advancements. These changes led to substantial growth and influence of financial markets and institutions. The term "financialisation" not only describes the growth of size and power of the financial sector in the economy but also signifies the shifts in business models across different industries. This phenomenon is expanding in scope to various markets with the primary aim of reshaping and restructuring them to capitalise on existing benefits. Others have used the term to refer to the large inflows of investment capital ([Tang and Xiong \(2012\)](#); [Cheng](#)

[and Xiong \(2014\)](#); [Adams and Glück \(2015\)](#). [Krippner \(2005\)](#) further refers to the financialisation concept involving the proliferation of new financial instruments and a surge in financial trading. For instance, the key characteristics of financialisation are the securitising of debts and assets, turning them into tradable products, and the widespread proliferation of complex financial products.

In this evolving landscape of financialisation, gold's unique elemental properties and market stability provide a solid foundation for financial markets to capitalise on the potential benefits of the gold market. Gold, the well-known safe haven asset, is a notable asset that investors purchase when uncertainty increases. [Erb and Harvey \(2013\)](#) note that a safe haven asset should possess at least two key characteristics. It should maintain a stable value during times of stress and be easily accessible. A safe haven asset should also be liquid, allowing investors to buy or sell at any time without affecting its price. These elements help frame the beginning of gold financialisation.

The chairman of the World Gold Council (WGC), an organisation founded in 1987 by leading gold mining companies to enhance gold demand among consumers and investors, remarks that "With the fundamentals of the gold market outlook improving and some fresh new investment product ideas for gold in the pipeline, the future for gold is as bright as I have seen it for some time." Chris Thompson (2002)²¹. This favourable environment of the gold market within the financialisation process carried out by the World Gold Council ultimately led to the proliferation of the most successful investment vehicles in the gold market, gold Exchange-Traded Funds (ETFs).

Looking at the gold market for the 20 years prior to 2003, participating in the gold market was not popular and less attractive among investors due to the available approaches to investing in gold and its associated risk. Investors had two essential options to participate in the gold market, mainly by directly buying physical gold or indirect investment in gold mining companies stocks. While investing in physical gold is associated with the risk of carrying, storing, and insuring, gold mining companies' stocks are subjected to stock market volatility, crashes, and bankruptcy.

Although alternative ways to invest in gold during this period were developed, such as mutual funds, pool accounts, and futures, none have significantly affected the

²¹ <https://www.gold.org/news-and-events/press-releases/new-ceo>

gold market. However, introducing gold ETFs in 2003 reformed the gold market and provided a new venue for investors to participate in the gold market. Unlike other investment forms, gold-backed ETFs can be viewed as the most directly linked with gold price and successful investment vehicle for gold. The exposure offered by gold ETFs to the gold market provides diversification benefits to all types of investors at a lower cost, tax efficiency, transparency, and low management fees. Hence, the significant rise in the popularity of gold Exchange-Traded Funds has attracted considerable attention from investors and market participants to the gold market which had previously been inaccessible or prohibitively expensive. The gold market underwent substantial changes, making the post-2003 gold market distinctly different from its pre-2003 state ([Mishra and Mohan \(2012\)](#)).

The First gold ETF, named gold bullion securities, was launched and traded on the Australian Stock Exchange (ASX) in March 2003, followed by the First US gold ETF (GLD) in November 2004, traded on the New York Stock Exchange (NYSE). Notably, the rise and growing size of gold ETFs worldwide in the last 20 years, with total holdings across the gold ETFs market reaching 3476 tonnes and worth \$220.7(bn), has changed the gold market dynamics, providing investors with a new way to gain exposure to gold without physically owning the metal. Along the same lines, [Tang and Xiong \(2012\)](#) note that the massive inflow of investment in the commodity markets played a dominant role in restructuring and functioning of the target markets.

4.1.2 Gold Securitisation – Paper Gold

To understand how the gold market has changed, it is necessary first to realise how gold ETF, paper gold, works. Let's assume that the gold ETF is like a listed company in an exchange market, where its shares are traded. The company initially takes money from investors, buys gold, and stores it in a safe place. Then, each share issued by the company to be traded in the market is backed by a specific amount of stored gold. This process is called gold securitisation or paper gold, in which the real gold is transformed into financial instruments or investment vehicles for trading. Gold ETFs maintain the balance between the number of issued shares and the amount of stored gold. Hypothetically, it cannot issue shares that are more than owned gold.

It's important to note that although a specific amount of gold backs these shares, investors do not own the physical gold itself. However, when investors choose to sell their shares, they are entitled to receive an equivalent amount of gold's value in cash, corresponding to the number of shares owned and the price of gold on the day of the sale. The gold ETF shares price fluctuates according to gold market prices. [Kumar and Ram \(2019\)](#) indicate a strong positive correlation between physical gold and gold ETFs. [Anand \(2017\)](#) shows that gold prices influence gold ETFs and generate similar returns.

The gold ETF shares gain if the gold market prices rise and lose if the gold prices fall. In this manner, gold-backed Exchange-Traded Funds (ETFs) offer investors alternative exposure to the gold market without physically owning gold and worrying about associated costs. More importantly, gold becomes highly liquid. Investors can easily and swiftly sell their gold ETF shares and deposit their proceeds into their bank accounts. It is worth noting that investors trading paper gold, ETF shares, are more interested in taking advantage of gold price fluctuations and are not concerned with owning the yellow metal.

Besides, Investors benefit substantially from investing in gold ETFs due to their price discovery. Price discovery is the "process of adjustment of asset prices due to the constant flow of fundamental information about the asset" ([Ivanov \(2013\)](#), P.454). Price discovery helps identify the dominant market where the fundamental information is incorporated into prices more efficiently. By analysing various markets trading the same asset, price discovery helps identify which market continuously and efficiently integrates ongoing information into its prices. [Ivanov \(2013\)](#) finds that the onset of gold ETFs shifts the price discovery for gold towards ETF markets rather than futures markets, predominantly occurring in the ETF markets.

In addition, the gold ETF performance is better than physical gold and other asset classes or ETFs. The cost-effectiveness of gold ETFs and their consistently close tracking of gold prices produce better returns with lower risk than physical gold. [Aggarwal et al. \(2013\)](#), [Sunkara and Srinivasa Reddy \(2017\)](#), and [Kumar and Ram \(2019\)](#) show that gold ETFs have lower volatility than the gold market and perform better than physical gold. Others find that gold prices influence gold ETFs, and their returns are directly and positively correlated, leading to similar returns ([Ivanov \(2013\)](#), [Anand \(2017\)](#), [Naylor et al. \(2011\)](#)). The gold ETFs perform better compared to other precious metal

ETFs, index funds, stock markets, diversified equity funds and market portfolios ([Bok \(2012\)](#), [Athma and Mamatha \(2012\)](#), [Mukul et al. \(2012\)](#), [Sinha and Dutta \(2013\)](#), [Singh and Nadda \(2013\)](#), [Goyal \(2014\)](#), [Athma and Mamatha \(2017\)](#), [Aarthi \(2020\)](#)).

4.1.3 Gold ETFs investment demand & gold prices

Notably, gold ETFs have greatly enhanced the appeal and interest in gold investment, culminating in surging gold investment demand. Building on the mechanism of gold-backed exchange-traded funds, the growing number of gold ETFs and their sizes (holdings) have greatly impacted the demand for gold. Bernstein (2009, cited in Cheng et al., 2018) points out that the demand for commodity ETFs leads to significant changes in the underlying assets and their futures markets. [Baur \(2013a\)](#) mentions that introducing gold ETFs leads to a structural demand shift by increasing investment demand and the rising number of gold ETFs. Similarly, [Durham \(2013\)](#) notes that holdings of the SPDR Gold Trust (GLD), the biggest US Gold ETF, steadily rose since its inception from 2004 to 2012. Figure 4.1 shows that the number of gold ETFs has grown substantially along with its holdings. As the popularity and number of gold ETFs increases and the demand for gold ETF shares expands, additional physical gold must be secured by the existing and new gold ETFs to back those shares to be issued, leading to increased gold investment demand and prices. This also suggests that the introduction of gold ETFs created significant interest and awareness among market participants.

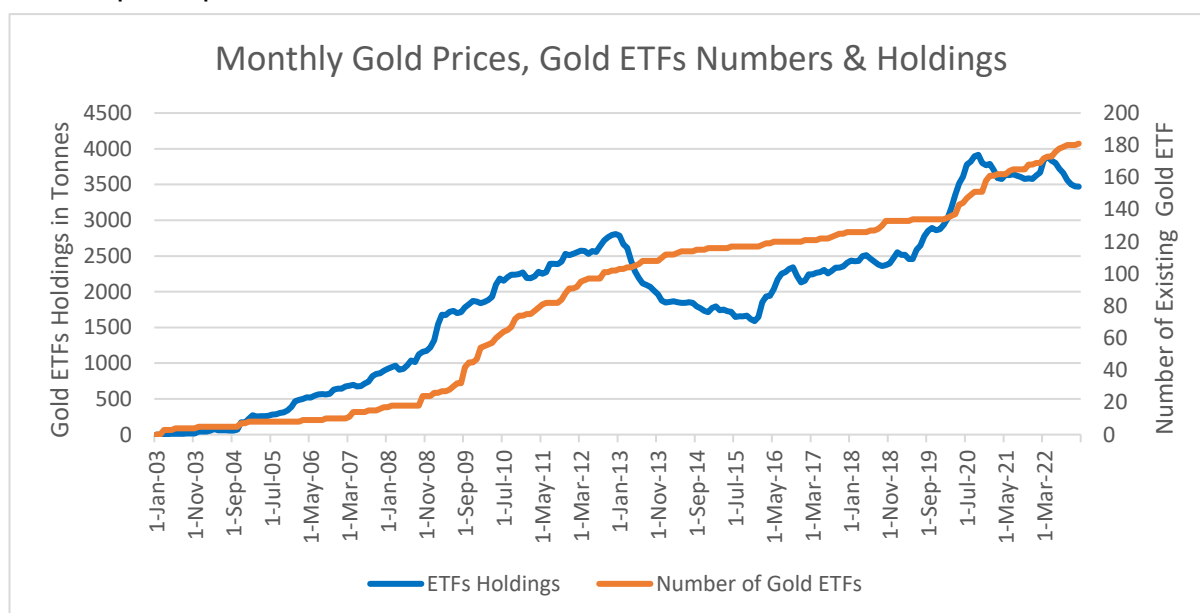


Figure 4.1 shows the monthly accumulated number of gold ETFs & holdings (Tonnes) from 2003 to 2022

Besides, changes in gold investment demand by gold ETFs corresponded to fluctuations in gold prices over time, as shown in Figure 4.2. An increase in gold investments by these ETFs is associated with rising gold prices, while a decrease in holdings aligns with falling prices. This view is supported by [Durham \(2013\)](#), who notes that the increase in investment demand could explain the gold price sensitivity given the limited gold production.

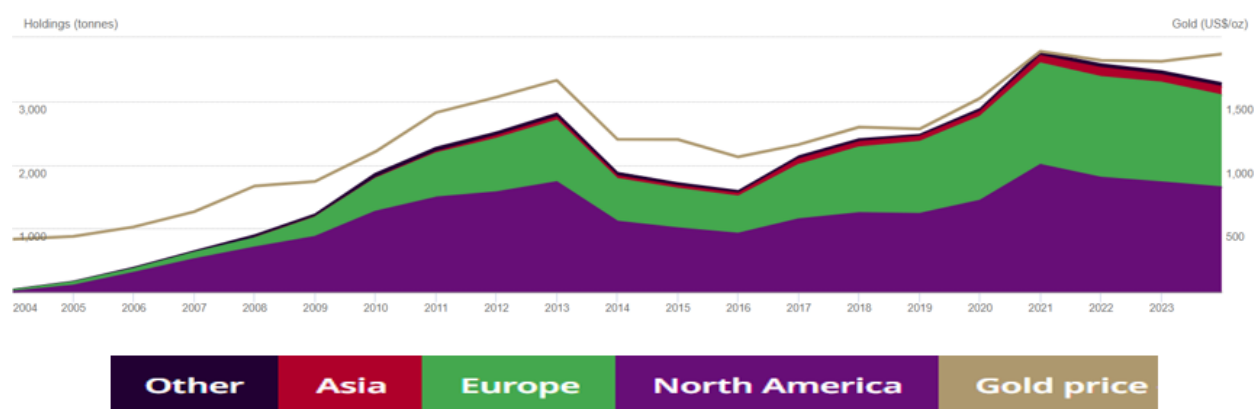


Figure 4.2 shows the gold ETFs increment holdings (Tonnes) by region from 2004 to 2023, World Gold Council.

Furthermore, gold-backed ETFs and similar products account for a significant part of the gold market. Gold ETFs provide crucial advantages such as, but not limited to, easy and intra-day real-time trading of gold at lower transaction costs and higher liquidity than those of physical investments in gold. It offers cost-effective access to the gold market that was not previously accessible, allowing institutional and smaller individual investors to trade continuously and implement many of their investment strategies, as discussed by [O'connell \(2007\)](#).

According to the World Gold Council, there are four main sources of gold demand: jewellery fabrication, central banks, technology, and investment, and the average yearly demand in the last 13 years is 50%, 13%, 8%, and 29%, respectively, as shown in Figure 4.3. The commonly believed assumption to drive prices in the gold market is the size of the demand for physical gold from the jewellery sector.

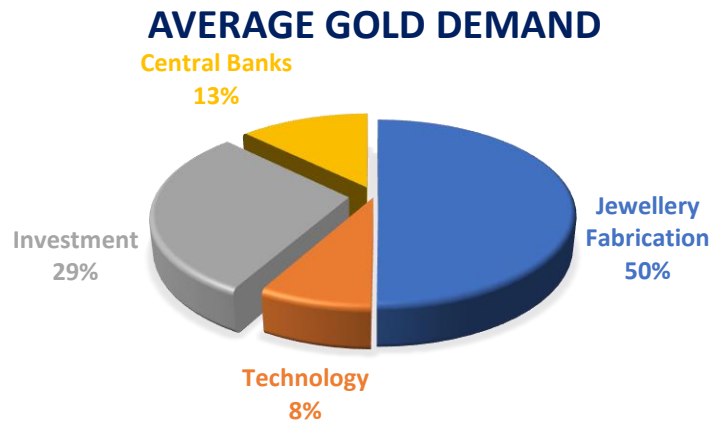


Figure 4.3 shows the yearly average investment demand from 2010 to 2023.

Although the jewellery industry accounts for 50% of the demand in the gold market, this perspective cannot hold. The Investment demand by gold ETFs and other forms is, more likely, the key driver of gold price fluctuations due to their high liquidity and fluctuating nature. Before the existence of gold investment, the demand for jewellery existed, and the gold market did not experience high price movements. Further, [Durham \(2013\)](#) notes that demand for jewellery dropped from 3,009 to 1,963 metric tons between 2001 and 2011, while gold prices increased. On the other hand, the investment demand by gold ETFs rose from 357 to 1,641 metric tons during the same period, even when gold prices were surging. Hence, the gold ETFs could drive gold prices up by demanding more and continuing to increase their holdings.

4.1.4 Gold ETFs Holdings & Price Co-integration

In reviewing the literature, gold prices have been influenced by a range of factors, including economic uncertainty, fluctuations in the financial market, geopolitical tensions, macroeconomic variables, and shifts in macroeconomic policy, all of which subsequently drive gold prices. The presence of these well-established drivers and their occasional occurrence suggests that, following the inception of gold ETFs, additional factors may have emerged as significant drivers of gold prices. [Baur \(2013b\)](#) examines the key factors driving gold prices from 1968 to 2013 and suggests that gold ETF demand is a potential driver of gold prices. However, it may not necessarily cause it. Yet, the author notes that the limited and inadequate data made the statistical analysis of this factor not possible.

In 2023, the total holdings across the gold ETF markets reached 3476 tonnes, and assets under management were worth \$220.7(bn). The trading volume in gold ETFs in one day during August 2023 was \$143(bn), and such a high daily trading volume in the gold ETFs market can heavily influence gold prices. Hence, what could drive daily gold prices is that investors trade paper gold, not physical gold, for either hedging or speculation purposes with no interest in owning gold. Again, remember that the number of gold ETF shares traded is associated with the amount of gold owned by these ETFs, and changes in their holdings affect the number of available shares and, eventually, gold prices. This view is illustrated by Figures 4.4, 4.5, and 4.6, which suggest a strong co-movement between gold prices and investment demand by gold ETFs on a monthly, quarterly, and yearly basis, respectively.

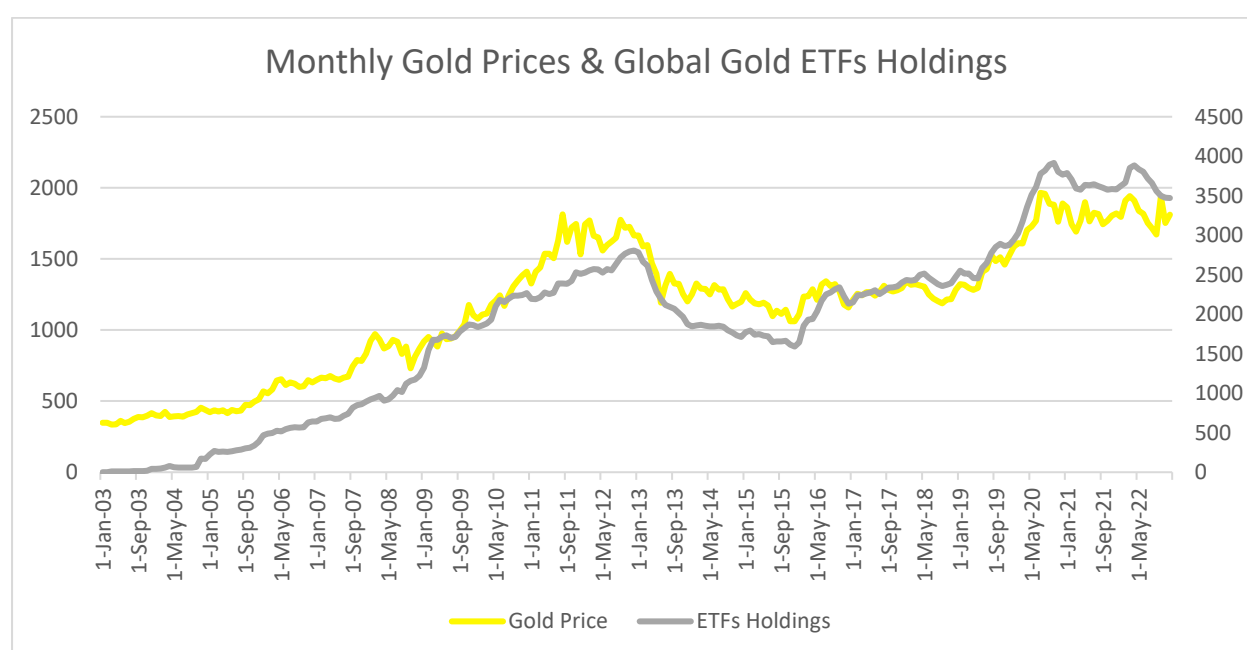


Figure 4.4 shows the monthly gold prices and Gold ETF holdings from 2003 to 2023.

Figure 4.4 clearly illustrates strong co-movements between the gold price and global gold ETFs holding since the inception of the gold ETFs. Both gold prices and ETFs holding rose gradually between 2003 and 2007 before they spiked during the global financial crisis. After reaching a peak in 2011, gold prices began to decline, and gold ETFs holding showed a similar pattern until 2016. Once again, gold prices and gold ETFs holding maintained their positive co-movements and peaked around 2020, followed by a slight decline to the end of 2022. Although a slight discrepancy occurred at a few different periods, the co-movements were maintained most of the time,

suggesting a strong co-integration. As gold investment demand for gold ETFs increases, so does gold prices. This relationship is consistently evidenced by similar patterns in both quarterly and yearly graphs, as shown in Figure 4.5 and Figure 4.6. These graphs underscore the impact that gold ETFs' holding might have on gold price movements.

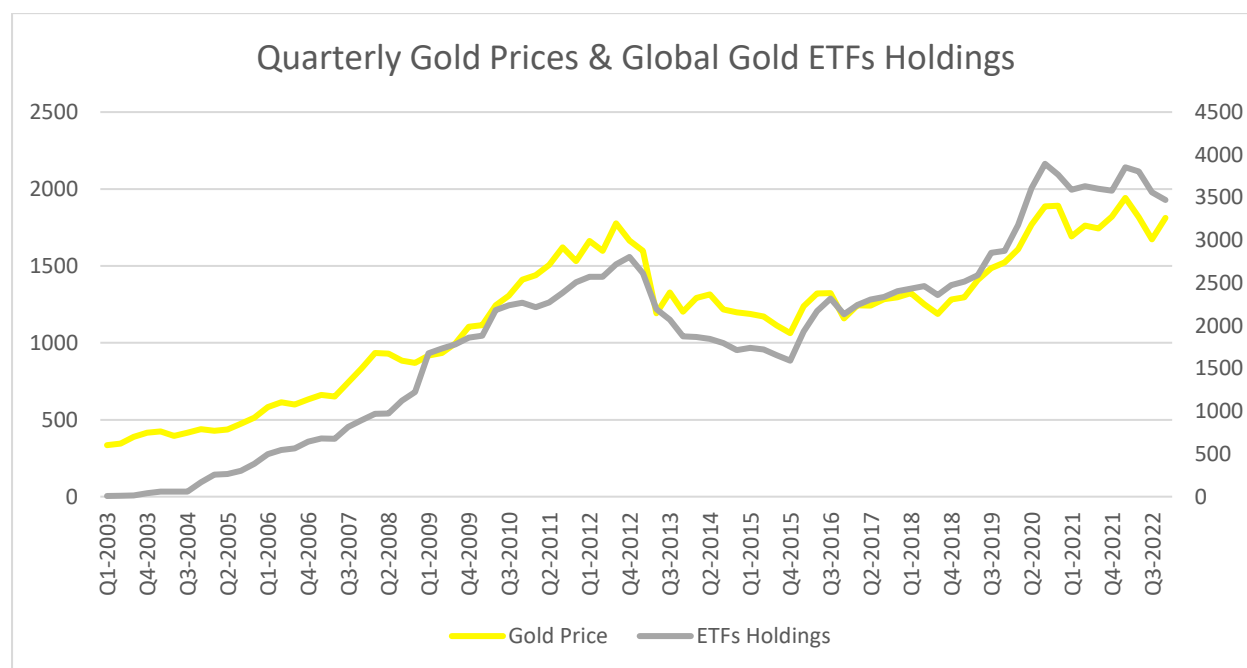


Figure 4.5 shows the quarterly gold prices and Gold ETF holdings from 2003 to 2023.

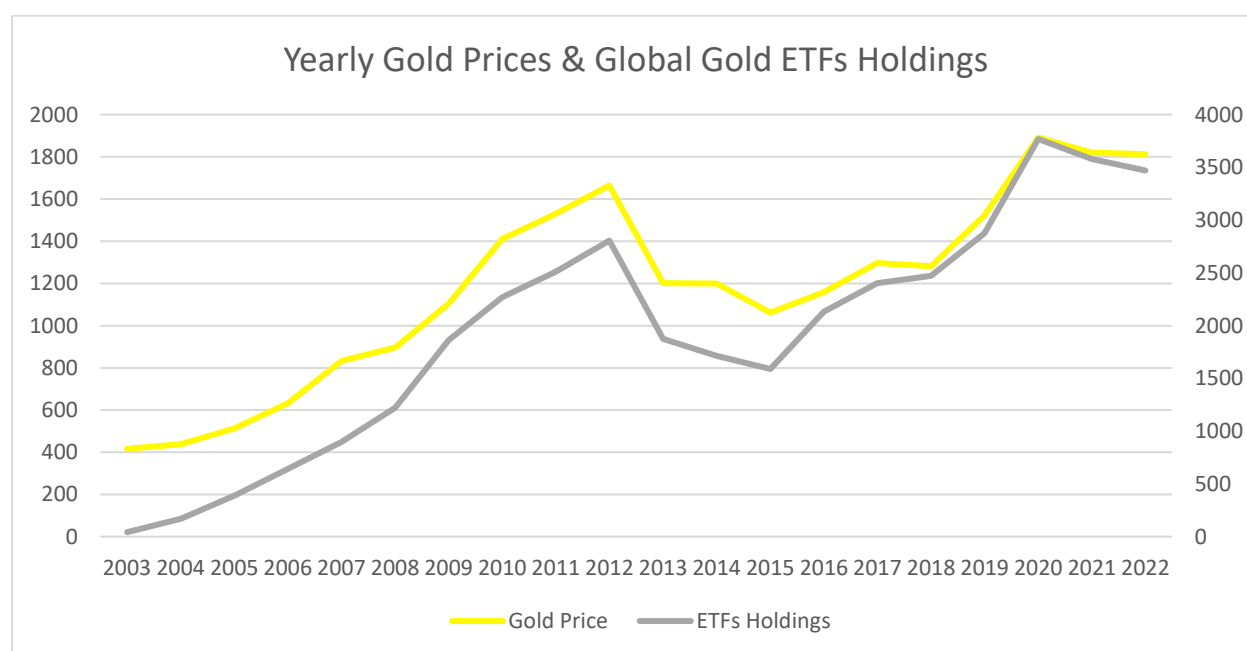


Figure 4.6 shows the yearly gold prices and Gold ETF holdings from 2003 to 2023.

4.1.5 Study focus

To conclude, changes in gold market behaviour after the introduction of gold ETFs shed light on how gold ETFs reshaped the gold market. Gold ETFs provide an alternative and effective way to continuously trade gold without physically owning gold and worrying about the associated costs of holding the metal. It offers investors exposure to the gold market by tracking the price changes in the gold market at a lower cost, which increases interest and the attractiveness of trading. Trading gold ETFs is more convenient and cost-effective, making them a successful successor for investors to mitigate risks and implement different investment strategies. Given the prevailing understanding of the gold ETF mechanism, the increase in gold investment demand and the apparent co-movement between gold ETFs' holdings and gold prices might cause gold prices. Except for [Fassas \(2012\)](#), none of the literature, to our best knowledge, examines whether gold ETFs' holdings co-integrate with gold prices and whether causality effects run from gold ETFs' holdings to gold prices.

This study contributes to the literature in several ways. First, it is the first to empirically establish a long-run co-integrating relationship between global gold ETF holdings and gold spot prices using both the Engle-Granger and Johansen co-integration approaches. In contrast to earlier studies which relies on correlation or descriptive analysis (e.g., [Baur \(2013a\)](#); [Baur \(2013b\)](#); [Durham \(2013\)](#)), and focuses on ETF performance or return correlations with physical gold (e.g., [Ivanov \(2013\)](#); [Kumar and Ram \(2019\)](#)), this study provides formal evidence that gold ETFs are not merely passive investment vehicles reflecting gold prices but active participants in shaping them, shifting attention to the role of gold ETFs' investment demand as a structural driver of gold price dynamics. Second, it extends the literature by using a Vector Error Correction Model (VECM) to capture both short-run and long-run causal dynamics between ETF holdings and gold prices. The model allows for more understanding of how deviations from long-run equilibrium are corrected over time, providing insight into both immediate market responses and persistent structural relationships. The finding that gold ETF holdings significantly cause gold prices in the long run, and at the quarterly level in the short run, highlights the price-setting influence of gold financialisation. Third, it addresses gaps in previous literature by using a more comprehensive dataset, monthly and quarterly data from 2006 to 2022. This extended timeframe allows for more robust results than studies using shorter or more volatile

windows, such as [Fassas \(2012\)](#), who found no long-run causality over a limited sample period. Finally, by incorporating the VIX index as a control variable, the study distinguishes gold ETF-specific effects from broader market sentiment and macroeconomic uncertainty, validating the causality effects, and providing evidence that gold ETFs play an active price-setting role in the gold market, highlighting a shift from traditional demand forces to financialised drivers.

The remainder of this chapter is structured as follows. Section 2 summarises the literature's main findings on introducing gold ETFs. Section 3 describes the methodology applied to investigate whether co-integration exists between gold ETF investment demand (holdings) and gold prices and whether a causal relationship runs from gold ETFs' holdings to gold prices. Section 4 provides empirical analysis and findings and discusses the empirical results. Section 5 gives concluding remarks.

4.2 Literature Review

This section covers the literature about the impact of gold ETF onset on the underlying market, and the Co-integration between gold ETFs' investment demand & gold prices.

The introduction of gold ETF in 2003 has apparently restructured the gold market and reshaped investors' sentiments towards gold trading. Gold ETF emerged as the most successful gold investment vehicle among other existing forms of gold investment due to its characteristics. It is well-established that exchange-traded funds (ETFs) offer diversification benefits for investors, easy and intra-day real-time access to the underlying market (e.g., stock market indices) without needing to purchase each market element. In the case of gold ETFs, a single underlying asset, investors can get full exposure to gold at a lower cost without buying physical gold. The high liquidity of the gold ETF markets, ease of trading and cost-effectiveness facilitate and encourage individuals and investors to participate in the gold market for different purposes, e.g. diversification, risk mitigation, and speculation.

Furthermore, the structure of gold ETFs broadens access to gold trading, leading to increased gold investment demand to back shares issued by ETFs. As the popularity and number of gold ETFs grew, it contributed to the surge in gold investment demand and changes in their holdings (Assets Under Management). Changes in gold

ETFs' holdings were noticed to be aligned with gold price movements, showing a potential co-integrating process, as illustrated in Figures 4, 5, and 6.

Evidence of the effect of financialisation on commodities that commenced in 2004 can be found in the work of [Tang and Xiong \(2012\)](#) and [Baur \(2013c\)](#). The authors find that the increase in price co-movement and change in dependency structure within commodities markets and with financial assets is due to the financialisation process of commodities since 2004.

Considering the short presence of gold ETFs, there is a lack of empirical studies on whether gold ETFs' holdings co-integrate with and cause gold prices.

4.2.1 The impact of gold ETF onset on the underlying market

In the framework of growing interest in gold that commenced with the introduction of gold Exchange Traded Funds (ETF) into the market, [Demidova-Menzel and Heidorn \(2007\)](#) outline that gold ETFs offered a new dimension for investing in gold, providing cost-effective, improved investment efficiency and avoiding all disadvantages of investing in physical gold, futures, and gold pool accounts. [Sarkar \(2012\)](#) reinforces this perspective by reviewing the history of gold ETF innovation, detailing their characteristics, and analysing the benefits and risks associated with investing in gold ETFs both in the international market and in India. [Sarkar \(2012\)](#) notes that gold ETFs provide all the benefits of investing in physical gold while eliminating the drawbacks associated with possessing physical gold. Additionally, The author presents evidence of increasing interest in gold ETFs as an alternative investment in India, noting a 77.86% increase in issued security by gold ETFs and an 83% increase in assets under management for gold ETFs between 2009 and 2011, alongside significant growth in daily average turnover and the daily average number of trades.

Other studies attempt to address gold ETFs and highlight their performance and benefits. [Pule \(2013\)](#) examines the potential advantages for investors participating in the gold market through various investment forms, including gold ETFs. By comparing the performance of different gold investment vehicles to the equities markets in South Africa, Pule found that gold ETF yield returns comparable to those of gold bullion investment and generate abnormal returns when compared to other investment forms, such as gold mining index, FTSE/JSE all share index, and unit trust index (gold & precious metals). [Singh and Nadda \(2013\)](#) assert that both gold and gold

ETF returns are directly correlated. Similarly, [Naylor et al. \(2011\)](#) note a consistency between the return properties of gold ETFs and physical gold. The authors analysed three gold-backed ETFs, evaluating their performance against their physical gold behaviour, revealing a remarkable consistency between these ETFs and the respective physical assets.

In related studies, [Aggarwal et al. \(2013\)](#) address that gold ETFs exhibit lower variability than physical gold, and gold ETFs' performance outperforms physical gold. Likewise, [Kumar and Ram \(2019\)](#) find that gold ETFs generate better returns than physical gold in India. Their study analysed various gold ETFs, showing that almost all gold ETFs strongly positively correlated with physical gold and outperformed it in nearly half of the period under investigation. In addition, gold ETFs exhibit lower volatility (Beta less than 1) compared to physical gold. [Aarthi \(2020\)](#) also finds that gold ETFs in India outperformed its benchmark, physical gold, while maintaining the same level of risk. The performance of gold ETFs is closely identical to physical gold, occasionally generating slightly higher returns.

In the same vein, [Ivanov \(2013\)](#) studies how gold ETFs track their underlying asset using tracking error and pricing deviation. The tracking error is the difference between the return on gold in the spot market and the return of the gold ETF, whereas pricing deviation is the difference between the spot log prices of the gold and the gold ETF log prices. The findings indicate that gold ETFs effectively track the underlying asset's return and price level. Moreover, Ivanov identifies that new information is most effectively incorporated into gold ETFs prices, suggesting that the introduction of gold ETFs has shifted the price discovery process for gold to its ETF market. Consequently, the gold ETF market emerged as a great investment option.

There are relatively few studies attempted to evaluate the impact of introducing gold ETFs on its underlying market. [Baur \(2013b\)](#) suggests that gold ETF demand is a potential driver of gold prices. [Baur \(2013a\)](#) examines the mechanics of gold ETFs and their influence on gold prices and demand. His findings suggest that the introduction of gold ETFs has led to a structural demand shift and affected gold prices, primarily through increased investment activity and the rising number of gold ETFs. An increase in gold investments by these ETFs is associated with higher gold prices, while a decrease in holdings aligns with price declines. [Durham \(2013\)](#) supports this perspective,

noting that the increased investment demand could explain the gold price sensitivity given the limited gold production.

4.2.2 Co-integration between gold ETFs investment demand & gold prices

Further examination of the ramifications of gold ETF inception on the underlying gold market, [Baur \(2013a\)](#) provides a detailed explanation of how gold ETFs affect gold prices and demand. The author notes that introducing gold ETFs has shifted gold demand and affected gold prices. The author explains that gold ETF shares represent financial claims on underlying gold holdings, and the cost-effectiveness achieved through economies of scale offers a competitive advantage over each gold ETF. As gold ETFs acquire more gold, they can further reduce costs and increase demand. The surge in gold demand is attributable to the increasing number of gold ETFs and the expansion of existing ones. The empirical findings revealed a strong positive correlation between investment demand by gold ETFs and physical demand since the introduction of gold ETFs from 2002 to 2011. The rise in gold ETFs investment demand, coupled with an increase in the number of gold ETF providers and gold prices, suggests their significant role in driving positive changes in gold prices. The Granger causality tests also support the positive relationship between the gold price and the number of gold ETFs.

Perhaps the most thorough account of the effect of gold ETF inception on underlying spot prices is to be found in the work of [Fassas \(2012\)](#). The study attempts to examine whether introducing commodity Exchange-Traded Products influences the spot prices of precious metals. Specifically, it investigates the relationship between inflows and outflows in these ETFs' precious metals and returns of the underlying metals. The analysis mainly focuses on Exchange-Traded Funds (ETFs) while acknowledging the broader category of Exchange-Traded Products (ETPs), which includes Exchange-Traded Commodities (ETCs), Exchange-Traded Notes (ETNs) and US Grantor and other statutory trusts. The weekly spot returns of the four precious metals and the percentage changes in the ETFs' holdings from May 2007 to February 2011 were used to assess this relationship.

The econometric analysis initially examines whether the flows into precious metal ETFs, measured by changes in respective metal holdings, lead to fluctuations in spot prices and vice versa, using lagged flows. Subsequently, the study examines

the contemporaneous relationship between spot returns and ETFs' holdings. The author notes that the correlation analysis demonstrates a significant positive association between gold and precious metals returns and the respective ETFs' holdings, except for palladium. However, the causality test does not provide evidence to support a causal link between lagged precious metals ETF flows and spot price movements.

On the other hand, the contemporaneous analysis highlights that gold ETFs' inflows and outflows exert a significant influence on gold spot returns, confirming that they play an influential role in driving gold spot prices. The author argues that given the substantial market capitalisation of gold ETFs, nearing \$100 billion under management, their active trading directly affects the gold supply and demand forces, thus influencing the dynamics of gold spot prices.

In summary, it has been shown from this review that little is known about the ramifications of gold ETF onset on gold price, as well as the co-integrating²² relation between gold ETFs' holdings and gold prices, and whether gold ETFs' holdings cause gold price movements and whether gold ETFs holdings ongoing rebalancing supplant the gold supply and demand forces (see Table 5.5, Appendix 3). Baur ([2013a](#); [2013b](#)) and [Durham \(2013\)](#) argue that gold ETFs may exert an influence on spot prices due to growing investor participation, but their analyses are limited to correlation-based or descriptive assessments without testing for causality or long-run equilibrium. Studies such as [Ivanov \(2013\)](#), [Anand \(2017\)](#), [Aggarwal et al. \(2013\)](#), and [Aarthi \(2020\)](#) compare gold ETFs with physical gold and other asset classes, frequently concluding that ETFs exhibit superior returns, higher liquidity, and lower volatility. However, these performance-oriented analyses do not address whether ETFs' investment demand shapes the dynamics of the underlying gold market. As far as the literature shows, [Fassas \(2012\)](#) stands alone in formally examining the relationship between ETF flows and spot price returns in precious metals, including gold. However, the study finds no long-run causality over a relatively limited short period (2007–2011), leaving the long-run impact of gold ETF holdings unexplored.

²² Other research works studied the cointegration of gold and gold ETF prices with equities markets, commodities markets, ETF markets, other assets, and macroeconomic variables.

This study critically engages with these limitations by moving beyond correlation and performance metrics to assess the co-integration between gold ETF holdings and gold prices, and the role of gold ETF holdings in price determination.

4.3 Methodology

This section introduces the research questions and discusses methods employed explores the potential existence of co-integration and investigates causality between gold ETFs' holdings and gold prices.

Before the introduction of gold ETFs, the gold market experienced a considerable degree of price stability. However, following the introduction of gold ETFs, increasing accessibility to the gold market through gold ETFs, which offer a convenient and cost-effective way to invest in gold, might alter gold market dynamics and influence gold prices.

There has been a notable increase in gold prices, the number of gold ETFs, and investment demand through ETFs since their inception. Gold ETFs' holdings exhibit a pronounced co-movement with gold prices, indicating a potential relationship and possibility of co-integrating relation and causality effects between gold ETF holdings and gold prices that warrants further investigation.

4.3.1 Data

The data set includes gold prices, global gold ETFs holdings, and the volatility index (VIX). Data for gold prices is obtained from Refinitiv Workspace, while gold holdings for the global physical-backed gold ETFs is retrieved from the World Gold Council website. The volatility index (VIX) was obtained from the Federal Reserve Economic Data (Fred ST. LOUIS) website. It is worth noting that VIX represents a benchmark for volatility and fear in the market, incorporates the sensitivity of other factors in the market, and thus gives an idea of how far the gold price may be affected by other variables. It is included to account for other possible effects on gold price changes.

The sample data comprises monthly average gold prices, global gold ETFs holdings, and volatility index. Although the first U.S. gold ETF was introduced in November 2004, the sample spans from January 2006 to December 2022 to ensure greater market stability, as an early stage of any new product or market mark with

development and instability. Where necessary, the monthly gold, gold ETF holdings, and volatility index (VIX) returns were calculated using natural logarithmic. i.e., $R_t = \text{LN} (P_t / P_{t-1})$ where P_t and P_{t-1} are the average value of monthly prices at time t and $t-1$.

4.3.2 Research aims and Hypotheses

This study seeks to:

- 1- Investigate whether the gold ETFs' holdings co-integrate with gold price movements.
- 2- Analyse the long-run and short-run causality between gold ETFs' holdings and gold prices.

The significant rise in the popularity of gold exchange-traded funds has attracted considerable attention from individuals and investors. A compelling argument for changes in gold price is the rapid increase in gold investment demand. Building on the mechanism of gold-backed exchange-traded funds, they have greatly influenced the demand for gold. In other words, as the demand for gold ETF shares expands, additional physical gold must be secured by gold ETFs to back these shares to be issued, leading to increased gold investment demand and prices. [Baur \(2013a\)](#) notes that introducing gold ETFs leads to a structural demand shift with increasing investment demand and the rising number of gold ETFs. Hence, gold prices might rise, driven by increasing gold investment demand, as gold ETFs' popularity, numbers, and sizes (holdings) increase. Accordingly, the following hypothesis investigates if the gold ETFs' investment demand is co-integrated with gold price movements, and whether there is causality relation running from gold ETFs' holdings to gold prices.

Hypothesis 1: There is no co-integration between gold ETFs' holdings and gold prices, or they do not have a long-run relationship.

Hypothesis 2: There is no long-run causality between Gold ETFs investments demand (holdings) and gold prices.

Hypothesis 3: There is no short-run causality between Gold ETFs investments demand (holdings) and gold prices.

To establish whether gold ETFs' holdings and gold prices are co-integrated, the study first explores the relationship between the aforesaid timed series using Pearson correlation, with the significance of the coefficients tested by the t-test.

The correlation formula is given by:

$$r = \frac{[n(\sum xy) - \sum x \sum y]}{\sqrt{[n(\sum x^2) - (\sum x)^2] [n(\sum y^2) - (\sum y)^2]}}$$

The significance of the correlation coefficient is given by:

$$t = \frac{r}{\sqrt{(1 - r^2)/(N - 2)}}$$

follows a t-distribution with N-2 degrees of freedom.

However, it is important to avoid the mistaken assumption that correlation implies co-integration. It is not sufficient on its own to prove the relationship.

Subsequently, the co-integration test between the variables is performed within the Vector Error Correction Model (VECM) framework, which accounts for co-integration among non-stationary variables. The Vector Error Correction Model (VECM) is a restricted form of vector autoregression (VAR) designed for non-stationary time series that exhibit co-integration. The co-integration test forms the basis for determining the suitable selection model between VAR and VECM. A VAR of the first differences only captures short-run variation and fails to account for the long-run relationship. However, the VECM captures the short-term dynamics and long-term relationships when two or more variables are non-stationary and integrated of order one. This framework also explores the Granger causality analysis between the gold ETF holdings and gold prices.

4.3.3 Engle-Granger co-integration two steps method

The Engle-Granger co-integration test examines the hypothesis of existing long-term relationships between non-stationary variables. Time series variables may be non-stationary, but the linear combination between the integrated variables makes the residuals stationary. Hence, the variables are said to be co-integrated. There is evidence for a co-integrating relationship if the unit-root hypothesis is not rejected for the individual time series and the unit-root hypothesis is rejected for the residuals obtained from co-integrating regression.

The essential steps of the co-integration test are to find whether the variables are non-stationary at level, not I(0) and have the same order of integration, E.g. co-integrated of order one, I(1). Then, the co-integration test is performed.

4.3.3.1 Step 1 – Co-integrating regression test

In the first step, the GLS Augmented Dickey-Fuller (ADF) unit root test examines the statistical hypothesis of non-stationarity for each individual time series, specifically gold prices and ETF holdings. This test also finds whether both series are stationary in the same order of integration.

The unit root test hypothesis:

H₀: The log gold prices and log gold ETFs holdings have unit root (non-stationary)

H₁: The log gold prices and log gold ETFs holdings do not have unit root (stationary)

If the calculated t-statistic value is less than GLS-ADF critical value (at 5%) or if the p-value is less than the significant level (5% significant level), the null hypothesis is rejected; otherwise, it is accepted. Then, If the variable is found to be non-stationary at level, the first difference of the variable can be tested for stationarity. In this case, the variable is said to be integrated of order one, $I(1)$, meaning that it becomes stationary (its mean and variance do not vary over time) after differencing once, and thus may exhibit co-integrating relationships. Similarly, the Augmented Dickey-Fuller (ADF) unit root test examines the statistical hypothesis of stationarity of the first difference $I(1)$ for each individual time series. If the calculated t-statistic value is less than ADF critical value, the null hypothesis is rejected; otherwise, it is accepted.

The unit root test hypothesis:

H₀: The first difference of log gold prices and log gold ETFs holdings have a unit root

H₁: The first difference of log gold prices and log gold ETFs holdings do not have a unit root

Following the Augmented Dickey-Fuller stationary tests, the optimum lag selection for the model is determined using the criteria of Akaike information criterion (AIC), Hannan-Quinn information criterion (HQIC) and Bayesian Information Criterion (BIC), where the lower the value, the better the model. All variables take the same number of lags.

To this end, suppose the analysis confirms the non-stationarity of the variables at level and the variables are stationary in the same order of integration, $I(1)$. In that case, there can be a linear combination of integrated variables that are stationary, which can be co-integrated, and the long-run relationship is estimated as follows:

Long-run equilibrium relationship (co-integrating regression) model

$$GP_t = \beta_0 + \beta_1 GETFh_t + \varepsilon_t \quad (4)$$

$$\varepsilon_t = GP_t - \beta_0 - \beta_1 GETFh_t \quad \text{Where } \varepsilon_t = I(0) \quad (5)$$

4.3.3.2 Step 2 – Testing stationarity of residuals

Then, to find out whether the time series are co-integrated (having a long-run relationship), the Augmented Dickey-Fuller (ADF) unit root test examines the statistical hypothesis of stationarity of the residuals ($\varepsilon_t = I(0)$) generated from the long-run model.

H₀: The residuals (ε_t) has a unit root (non-stationary)

H₁: The residuals ε_t does not have a unit root (stationary)

It is important to note that the critical values of the ADF test are not appropriate for determining the unit roots in this context, as the residuals from the regression are not directly observable. Instead, the critical values for regression-residual based co-integration tests should be used. If the calculated t-statistic value falls in the rejection area, the null hypothesis is rejected, indicating that gold prices and ETF holdings in the long run are co-integrated. On the other hand, failing to reject the null hypothesis indicates that variables are not co-integrated.

4.3.4 Johansen Co-integration Test

Further to obtain robust results for co-integration between gold prices and gold ETFs' holdings, a Johansen test is applied. The Johansen co-integration test is an ADF test for multivariate time series. It is used to examine the hypothesis of the existence of a significant long-run relation between unit root variables. The Johansen (1988) approach determines the number of co-integrated vectors for any given number of non-stationary variables of same order. It uses two test statistics, viz., the Trace test statistics, and the maximum Eigenvalue test statistics for testing the cointegration.

The co- integration test hypothesis:

H₀: The log gold prices and log gold ETFs holdings do not have long-run relationship ($r=0$)

H₁: The log gold prices and log gold ETFs holdings have long-run relationship ($r>0$)

If the test statistics, trace or max eigenvalue, computed is greater than the critical value, reject the null hypothesis that there are (r) co-integrating vectors. The alternative hypothesis of ($r + 1$) co-integrating vectors is accepted.

4.3.5 Vector Error Correction Model (VECM)

The presence of a co-integration relation between variables leads to estimating the vector error correction model (VECM), which accounts for the short-term dynamics of co-integrated time series while maintaining the long-term equilibrium relationship. This means that while the model allows for short-term adjustments, it ensures that the long-term trends are aligned. The VECM can be run to examine the short-run and long-run dynamics of the series. It identifies any short-term relationship between variables and highlights how deviations from the long-run equilibrium are corrected in subsequent periods.

Suppose the analysis confirms the variables are non-stationary and integrated of order one, $I(1)$, and the co-integration (a long-run relationship among variables) exist. In that case, the VECM can be estimated as follows:

Short-run (Error Correction) model

$$\Delta GP_t = \beta_0 + \sum_{i=1}^{k-1} \beta_i \Delta GP_{t-i} + \sum_{i=1}^{k-1} \theta_i \Delta GETFh_{t-i} + \gamma ECT_{t-1} + \delta VIXS\&P500_t + v_t \quad (6)$$

Where:

- $K - 1$: the lag length reduced by one due to differencing
- ΔGP_t : gold prices in differences
- ΔGP_{t-1} : lagged gold prices in differences
- $\Delta GETFh_{t-1}$: lagged gold ETFs' holdings in differences
- δ : coefficient for the exogenous explanatory variable, which accounts for external influences on the model. It is worth noting that VIX represents a benchmark for volatility and fear in the market, incorporates the sensitivity of other factors in the market, and thus gives an idea of how far the gold price may be affected by other variables. It is included here to account for other possible effects on gold price changes.
- β_0 : the constant
- v_t : error term
- β_i & θ_i : the short-term dynamic coefficient, measuring the effect of changes in lagged gold prices and gold ETFs' holdings on gold prices.
- γ : error correction term coefficient with a negative sign, measuring the speed of adjustment to the long-run equilibrium after a change in the explanatory

variables. The coefficient (γ) must be negative and statistically significant, where the value must be between $-1 < \gamma < 0$.

- ECT_{t-1} : error correction term, representing long-run equilibrium relationship (contain long-run information). It is the lagged residuals obtained from the long-run (co-integrating) model in Eq.4 and is defined as follows:

$$ECT_{t-1} = GP_{t-1} - \beta_0 - \beta_1 GETFh_{t-1}$$

The results obtained from the VECM model reflect the short-run and long-run causal effects. The short-run causal effect exists if the t-statistics of the regressor is significant, i.e. p-value < 0.05 or 0.1 . Likewise, the long-run causal effect occurs if the t-statistics of the ECT_{t-1} is significant. If both regressor and error correction term (ECT_{t-1}) were significant, it implies a strong causal relationship.

4.4 Empirical Analysis and Discussion

This section consists of two sub-sections. The First section examines co-integrating relations, and Second section investigates short-run and long-run causality effects.

4.4.1 Co-integration analysis

This section examines the co-movements between gold prices and global gold ETFs holdings. Apparently, Figures 4.4, 4.5 and 4.6 show that both series, gold prices and global gold ETFs holdings, are moving in parallel from 2006 to 2022. Although these Figures represent monthly, quarterly, and yearly frequency, the study focuses on monthly frequency. The value of Pearson's correlation coefficient (r) between the aforesaid time series from 2006 to 2022 is $r = 0.9488$. This shows a positive and significant (p-value < 0.000) high degree of correlation between gold prices and gold ETFs holdings. Although correlation analysis helps determine the degree of co-movement between two or more variables, It does not tell anything about co-integration existence and short and long-run causality effects. Correlation, even a high degree of correlation, does not necessarily imply a co-integration and causation relationship, though the existence of co-integration always implies correlation.

In order to test for the co-integration relationship between gold prices and gold ETFs' holdings, first the GLS – Augmented Dicky Fuller (ADF) unit root test was applied to check the stationarity of the variables. Table 4.1 shows the results of the

analysis of the stationarity of gold prices and gold ETFs' holdings time series. The test presumes that the given time series are non-stationary, with the null hypothesis (H_0) stating that the log gold prices and log gold ETFs's holdings have unit root (non-stationary) and the alternative hypothesis (H_1) asserting that they do not have a unit root (stationary).

Table 4.1: Stationarity Test for variables at level

GLS – Augmented Dicky Fuller (GLS - ADF) Test				
Variables in their level	t-Statistics/(P-value)	Critical values		Decision
Gold prices	-2.2249 (0.4751)	At 10%	-2.577815	Do not reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	
Gold ETFs Holdings	-2.2493 (0.4614)	At 10%	-2.577815	Do not reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	

If the test fails to reject the null hypothesis, then the series is said to have a unit root and is non-stationary. However, if the null hypothesis is rejected, it can be concluded that the time series does not have a unit root and is integrated of order zero [$I(0)$], i.e. it has stationary properties. The results confirm that both series are not stationary. The test failed to reject the null hypothesis. The p-value and calculated test statistic value for gold prices and gold ETFs' holdings are greater than the critical value (-2.882) at the given significant level, 0.05.

Second, by confirming the non-stationarity of variables at level, the unit root test was further conducted to test whether both series are integrated of order one [$I(1)$], meaning that it becomes stationary after differencing once and, thus, may exhibit co-integrating relationships. The results are presented in Table 4.2.

Table 4.2 shows that t-statistics for the first difference gold price (-16.309) and gold ETFs' holdings (-9.118), and the p-values for both series are less than the critical value (-2.882) at 0.05 significant level. Hence, the null hypothesis that stated the log gold prices and log gold ETFs holdings are not $I(1)$ is rejected. The alternative hypothesis is accepted, which states that both variables are integrated of order 1 [$I(1)$] and they are stationary.

Table 4.2: Stationarity Test for the first difference of the variables

GLS – Augmented Dicky Fuller (GLS - ADF) Test				
Variables in their first difference	t-Statistics/(P-value)	Critical values		Decision
Δ Gold prices	-16.309 (0.0000)	At 10%	-2.577815	Reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	
Δ Gold ETFs Holdings	-9.118 (0.0000)	At 10%	-2.577815	Reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	

Table 4.3 presents the results of VAR lag selection. According to AIC, BIC, and HQIC results, the optimum lag for the model is 2.

Table 4.3: Optimal Lag Selection

Lag Selection					
Lags	Loglik	P(LR)	AIC	BIC	HQC
1	763.76501		-7.429069	-7.331477	-7.389591
2	797.37822	0	-7.719394*	-7.556741*	-7.653598*
3	797.86404	0.91406	-7.684942	-7.457227	-7.592827
4	799.01048	0.68207	-7.656965	-7.36419	-7.538533
5	800.29049	0.63392	-7.630299	-7.272462	-7.485548
6	801.87829	0.52888	-7.60665	-7.183752	-7.43558
7	810.96119	0.00115	-7.656482	-7.168523	-7.459094
8	811.84151	0.77967	-7.625897	-7.072877	-7.402191
9	813.45214	0.52151	-7.602472	-6.984391	-7.352447
10	818.16726	0.0512	-7.609483	-6.926341	-7.333139
11	820.27555	0.37749	-7.590937	-6.842733	-7.288275
12	826.94659	0.00972	-7.617123	-6.803859	-7.288143

Last, Table 4.4 provides evidence on whether gold prices and gold ETFs' holdings have a long-run relationship. i.e. co-integrated. Testing the statistical hypothesis of stationarity of the residuals ($\varepsilon_t = I(0)$) from the long-run regression model given by equation (4), the calculated t-statistics (-3.101) is less than the critical values for regression-residual based co-integration tests at 10% significant level. Hence, the null hypothesis that the residuals (ε_t) has a unit root (non-stationary) is rejected. By accepting the alternative hypothesis, the result suggests that gold prices

and gold ETF's holdings are co-integrated, having a long-run relationship. Thus, the null hypothesis "There is no co-integration between gold ETFs' holdings and gold prices, or they do not have a long-run relationship" is rejected.

Table 4.4: Stationarity test of residuals

Augmented Dicky Fuller (ADF) Test			
Variable	t-Statistics	Critical values*	Decision
e_t (residuals)	-3.101	At 10% -3.063	Reject the null hypothesis
		At 5% -3.363	
		At 1% -3.945	

*Engle-Granger critical value for regression-residual based co-integration test

Equally, Table 4.5 presents the automated Engle-Granger co-integration test result. The t-statistics (-3.101) is less than the critical value (-3.063), at a 0.1 significance level, suggesting to reject the null hypothesis of no long-run relationship.

Table 4.5 Engle-Granger co-integrating test

Engle-Granger Co-integration Test			
Variable	t-Statistics	Critical values*	Decision
e_t (residuals)	-3.101	At 10% -3.02	Reject the null hypothesis
		At 5% -3.37	
		At 1% -4.00	

*Engle-Granger critical value for regression-residual based co-integration test

Similarly, Table 4.6 presents the results for two different ratio tests viz., the trace test and the max eigenvalue test of the Johansen co-integrating test. The result offers robust support for the long-run co-integration relationship between gold prices and gold ETFs' holdings. It is inferred that the trace value statistics (21.0385) as well as the maximum eigenvalue (14.6057) are greater than critical value (zero integration), which establish a long-run relationship in the model. As per the statistics, the null hypothesis H_0 "The log gold prices and log gold ETFs holdings do not have long-run relationship ($r=0$)" is rejected, implying that there is at least one co-integrating vector between the variables. Therefore, with the respect to the first hypothesis "There is no co-integration between gold ETFs' holdings and gold prices, or they do not have a long-run relationship" is rejected.

Table 4.6 Johansen co-integrating test

Johansen Tests for Co-integration							
Trend: Constant				Number of obs.= 202			
Sample: 2006m3 thru 2022m12				Number of lags = 2			
Trace Test						Max Eigenvalue Test	
						5%	5%
Maximum				Trace	Critical	Max	Critical
Rank	Params	LL	eigenvalue	Statistics	Value	value	Value
0	6	787.6623	.	21.0385	15.41	14.6057	14.07
1	9	794.9651	0.06975	6.4328	3.76	6.4328	3.76
2	10	798.1815	0.03134				

4.4.2 Long-run and short-run causality analysis

The analysis confirms the variables are non-stationary, integrated of order one, $I(1)$, and the co-integration exists. The presence of co-integration between variables suggests a long-run relationship between gold prices and gold ETFs' holdings, leading to the estimate of the Vector Error Correction Model (VECM). The VECM identifies any short-term relationship between variables and highlights how deviations from the long-run equilibrium are corrected in subsequent periods. Table 4.7 summarises the outcomes of the estimated Vector Error Correction Model (VECM), given by equation (6), for the dependent variable gold prices using monthly (panel A) and quarterly (panel B) data.

The results obtained from the VECM model reflect the short-run and long-run causal effects. The coefficient of error correction term (ECT_{t-1}) is negative (-0.041) and (-0.301) for monthly and quarterly estimation, respectively, and are highly significant at 1%, indicating a convergence to long-run equilibrium. This implies that gold price responds to disequilibrium between gold prices and gold ETFs' holdings, and gold ETFs' holdings have long-run causality on gold prices²³.

²³ The co-integration analysis focuses on whether gold ETFs' holdings cause gold price movements. This comes from the fact that the introduction of gold ETFs increases gold demand and perhaps gold prices. Baur (2013a) finds that introducing gold ETFs has shifted gold demand and affected gold prices. The author argues that the surge in gold demand is attributable to the increasing number of gold ETFs and the expansion of existing ones. Gold ETFs securitise gold in which real gold is transformed into shares (financial claims) for trading, and as the number of gold ETFs and their sizes (holdings) increases and the demand for gold ETF shares expands, additional physical gold must be secured to back those shares to be issued, leading to increase gold demand and price. Hence, the rise in gold ETFs' investment demand, coupled with an increase in the number of gold ETF providers and gold prices, suggests their significant role in driving changes in gold prices.

Table 4.7: Vector Error Correction Model (VECM) estimation results (ETFs' holdings → gold prices)

Panel A. Monthly Data				
Variables	Coefficient	Std. Error	t-ratio	p-value
constant	0.218651**	0.0910965	2.400	0.0173
ΔGP_{t-1}	-0.140537*	0.0784772	-1.791	0.0748
$\Delta GETFh_{t-1}$	-0.0162356	0.125856	-0.1290	0.8975
$LVIXS\&P500_t$	0.0154747	0.0101059	1.531	0.1273
ECT_{t-1}	-0.0410361***	0.0147731	-2.778	0.0060
Panel B. Quarterly Data				
Variables	Coefficient	Std. Error	t-ratio	p-value
constant	1.16855***	0.313494	3.728	0.0004
ΔGP_{t-1}	0.0469393	0.156964	0.2990	0.7659
ΔGP_{t-2}	0.399030**	0.153930	2.592	0.0119
$\Delta GETFh_{t-1}$	-0.0299401	0.157832	-0.1897	0.8502
$\Delta GETFh_{t-2}$	-0.366257**	0.150937	-2.427	0.0182
$LVIXS\&P500_t$	0.0507479**	0.0247476	2.051	0.0446
ECT_{t-1}	-0.301107***	0.0750598	-4.012	0.0002

Note: The optimal lag selection for monthly data is 2, and for quarterly data is 3 lags. *, **, and *** mean statistically significant at 10%, 5%, and 1%, respectively.

Since the error correction term (ECT_{t-1}) from the VECM model is significant with a negative sign, suggesting to reject the hypothesis “there is no long-run causality between gold prices and gold ETFs’ holdings”. The result reveals that there is a long-run equilibrium causality running from gold ETFs’ holdings to gold prices. The

Figures 4.1 and 4.2 show a notable increase in gold prices, the number of gold ETFs, and investment demand through ETFs since their inception. Figures 4.2 and 4.4 show that gold ETFs’ holdings exhibit a pronounced co-movement with gold prices. An increase in gold ETFs’ holdings aligns with an increase in gold prices and vice versa. Hence, the presence of co-movement between holdings and gold prices indicates a potential relationship and the possibility of co-integrating relations and causality effects between gold ETFs’ holdings and gold prices. This relationship is consistently evidenced by similar patterns in both quarterly and yearly graphs, as shown in Figure 4.5 and Figure 4.6. These Figures Highlight the impact that gold ETFs’ holdings might have on gold price movements.

Given these illustrations and mechanisms of gold ETFs, the question arises about whether gold ETF holdings cointegrate with gold prices. If yes, is there a causal relationship running from gold ETF holdings to gold prices? In other words, do gold ETF holdings derive gold prices? Hence, the empirical analysis focuses on this direction of the relationship, i.e. ETFs’ holdings → gold prices.

Although the Vector Error Correction Model (VECM) allows us to model all variables as endogenous, meaning each variable can be treated as dependent in its own equation, the significant negative ECT in both equations cannot hold under the theoretical assumption and economic perspectives. The Error Correction Term (ECT) represents the long-run equilibrium, and its coefficient shows how quickly deviations from the equilibrium are corrected. A negative and statistically significant ECT coefficient confirms stability and convergence to long-run equilibrium (the dependent variable adjusts in a way that helps correct the disequilibrium). To consider the other way around the relationship, i.e. gold prices → ETFs’ holdings, this relation can hold mathematically but may not converge to equilibrium. If both variables are actively adjusting (significant negative ECT), they might destabilize each other. Moreover, from an economics perspective, it's usually found that only one variable adjusts, especially when there's a clear theory about which one is “driven” and which one “responds”. In our case, according to figures and ETF mechanisms, the theory assumes gold ETFs’ holdings derive changes, and the gold price is expected to respond and adjust.

The results from the VECM show that both Error Correction Terms (ECTs) are negative and significant (See Table 4.7 & Table 5.4 in Appendix 3), which contradicts the theoretical assumptions and expectations. Therefore, we report the first model only (i.e. ETFs’ holdings → gold prices) in our study.

coefficient of the error correction term (-0.041) suggests that about 4.1% of the discrepancy between the long-run and short-run is corrected within a month. Similarly, about 30.1% of the discrepancy between the long-run and short-run is corrected within a quarter. In addition, the results indicate a strong causal relationship, where the error correction term (ECT_{t-1}) and coefficient of gold ETFs' holdings ($GETFh_{t-2}$) are significant in the quarterly estimates.

On the other hand, the short-run causality from gold ETFs' holdings to gold prices is examined using the coefficient of gold ETFs' holdings ($GETFh_{t-1}$) for monthly data, and ($GETFh_{t-1}$) and ($GETFh_{t-2}$) for the quarterly data. The coefficient of gold ETFs' holdings from monthly estimation is insignificant, suggesting no short-run causality on gold prices, implying that the gold ETFs' holdings do not cause gold prices in short-run. However, the coefficient of gold ETFs' holdings from quarterly estimation is negative (-0.3662) and significant for the second lag ($GETFh_{t-2}$), suggesting short-run causality on gold prices. This means that gold ETFs' holdings granger cause gold prices in short-run. Since the coefficient of gold ETFs' holdings is insignificant from monthly estimation, the hypothesis "there is no short-run causality between gold prices and gold ETFs' holdings" is accepted using monthly data. However, the quarterly estimation shows significant results and the hypothesis is rejected. There is short-run causality between gold ETFs' holdings and gold prices. Furthermore, to account for other factors influencing gold prices beyond the model environment, the analysis reveals that the monthly estimation of VIX, an exogenous variable that captures a broader market effect, shows no short-run causality on gold prices. The $LVIXS\&P500_t$ coefficient is statistically insignificant. However, when quarterly data is considered, the VIX coefficient estimation suggests statistically significant short-run causality on gold prices. This highlights that, in a longer time frame, gold ETF forces and other market variables contribute to gold price dynamics.

4.5 Conclusion

The financialisation of the gold market ultimately led to the proliferation of the most successful investment vehicles in the gold market, gold Exchange-Traded Funds (ETFs) that track the underlying gold market and trade continuously. Gold ETFs provide cost-effective and easy access to the gold market that was not previously accessible, allowing institutional and smaller individual investors to trade continuously

and implement many of their investment strategies. There is a lack of evidence on the co-integrating relation between gold ETFs investment demand and gold prices.

This study set out to explore whether gold ETFs onset impact gold prices. The study Investigates whether the gold ETFs' holdings co-integrate with gold price movements and whether a long-run and short-run causality exists between gold ETFs' holdings and gold prices.

The findings indicate that gold financialisation through introduction of gold ETF has affect gold market. The findings show that gold ETF holdings are co-integrated with gold prices, meaning that a long-run relationship exists between the two. The co-integrating relation could facilitate understanding the dynamics between gold ETFs' holdings and gold prices. This suggests that fluctuations in gold ETFs' holdings (inflows and outflows), with limited gold production and high demand, may increasingly influence gold price dynamics, potentially substituting the traditional supply and demand forces in the gold market. In practice, though, the gold ETFs are becoming so large that they cannot be ignored; with almost \$220 billion under management, their direct buying and selling of physical gold could affect the supply and demand forces and, eventually, gold prices.

Furthermore, the Vector Error Correction Model (VECM) reveals short-run and long-run causal effects running from gold ETFs' holdings to gold prices. The finding shows that gold ETFs' holdings significantly cause gold prices in the long-run. However, in the short-run, the causality effects from gold ETFs' holdings to gold prices were limited to quarterly estimations. The long and short-run effects of gold ETFs' holdings on gold prices suggest that gold ETFs, rather than just supply and demand, play an important role in gold price determination. This indicates a shift from traditional forces to more financialised drivers.

This study provides new insights into understanding the gold market transformation under financialisation, revealing how gold ETF contribute to gold price dynamics and determinations.

The novelty of this study lies in several key aspects that distinguish it from other works. The study highlights the impact of gold ETFs on gold market after its inception. The study uniquely establishes a long-run co-integrating relation between gold ETFs' holdings and gold prices and a short-run causal effect run from gold ETFs' holdings to gold prices. This shows how gold ETF mechanisms could increasingly supplant

traditional supply-and-demand drivers in the gold market and adds depth to understanding gold ETFs' effects on gold price dynamics. Hence, the study not only bridges existing gaps in the literature but also provides an understanding framework of the impact of financialisation on the gold market.

The study yields some interesting implications for investors, portfolio managers, regulators and policymakers. For investors and portfolio managers, the evidence of long-term relationship between gold ETF holdings and gold prices suggests that ETFs become key drivers of gold market dynamics, actively shape the gold market and influence long-term price trends. This makes gold ETFs a strategic asset worth considering in long-term portfolio planning. In the short run, the causal effect from ETF holdings to gold prices provides a useful signal for timing investment decisions. Changes in ETF holdings can serve as early indicators of price movements, offering tactical advantages for managing risk and adjusting their exposure. Moreover, the influence of ETF holdings on price changes becomes essential for assessing market conditions and highlights the need to include ETF holdings data into risk management and diversification strategies. For regulators and policymakers, the impact of gold financialisation through gold ETFs on gold price dynamics and determination, driven by increasing gold ETFs' activities rather than traditional supply and demand forces, underlines the need to monitor the growing influence of such financial instruments on the gold market. The increasing activity of gold ETFs raises concerns about the potential gold market instability driven by large ETF flows on gold prices, requiring further transparency, accuracy, and timely disclosure of vital information to market participants. Building on the mechanism of gold ETF through which ETF influence gold prices, regulators may need to monitor gold ETFs' size and trading patterns to ensure they do not exacerbate price instability or disrupt traditional market forces. Illustrating the role of financial innovation like gold ETFs in shaping the traditionally most stable commodity market leads to better anticipation and effective adaptation by regulators and policymakers to future changes not only for the gold market but also for other interactions between future innovations and markets.

Chapter 5: Summary & Conclusion

This section covers the summary and conclusion of the study, as well as its limitations and future work.

5.1 Summary

There is ongoing debate about gold's role as a safe haven, but no definitive conclusion has been reached. The question "Is gold still a safe haven?" continues to attract attention. While some studies suggest that gold's traditional role may have diminished or evolved, there has been no consistent or systematic investigation to confirm this. The first empirical chapter addresses this gap by applying a structured and methodical approach to test the safe haven hypothesis.

The study starts by questioning if gold is still a safe haven, and has its behaviour changed over time? Figure 1.1 reveals a clear shift in the gold market, a sharp surge in gold prices accompanied by increasing fluctuations, following a long period of market stability. So, what commenced as a stable and risk-mitigating asset now appears to behave more like risky assets. This observation leads to exploring the possibility that gold's role has changed.

To investigate, the study first runs some tests, including change point and rolling mean, to divide the sample into two periods, stable and volatile. Then, the GARCH model was applied to assess changes in volatility across these periods. The results confirm a shift in volatility. To examine whether this shift corresponds with a change in gold's role, further tests were conducted and confirmed that changes happened in gold's role. The study further investigated changes in gold behaviour using ICSS, which identifies structural breaks and volatility regimes in financial markets. Looking into these regimes, the results confirm that gold's relationship with the equity market has shifted, as shown in Table 2.6, where gold moves from being negatively correlated with stocks (a classic safe haven role) to being positively correlated. Figure 2.8, using DCC-GARCH, supports this finding, indicating that gold's safe haven role has weakened or even disappeared.

While previous studies provided bits of evidence suggesting gold's role has changed, we provide a systematic examination by splitting the gold market into stable and volatile periods, documenting a clear shift in volatility, testing the safe haven role

directly (and finding evidence of its loss), analyzing volatility regimes and showing correlation shifts between gold and equities.

Our contribution lies in conducting structured empirical tests to answer two key questions: Is gold still a safe haven? And if not, why not? Our findings suggest that gold has lost its safe haven role due to a change in behaviour in terms of volatility. This naturally leads to the next question: Why has volatility changed? What happened in the gold market? Why did we get that jump in the gold market as shown in Figure 1.1?

To explore that, the second empirical chapter reconfirms the presence of volatility through running a couple of tests, change point analysis and rolling standard deviations, for breaks. Then the study further examines what happened to create this break, the market shift. The volatility shift coincides with the introduction of gold ETFs. The study further applies the GARCH model to test this link and finds evidence suggesting that the jump in gold prices and volatility aligns with the emergence of gold ETFs.

This brings us to the third empirical chapter. Given the timing and potential impact of gold ETFs, the questions arise here: Do gold ETFs influence gold prices? Does the mechanism of gold ETFs, which securitise physical gold into tradable financial claims, affect demand and price dynamics? As the number and size of gold ETFs grow, demand for gold appears to increase, potentially driving prices higher. Figure 1.3 illustrates a strong positive co-movement between ETF holdings and the number of gold ETFs, while Figure 1.4 shows a similar relationship between ETF holdings and gold prices. These patterns motivate our final investigation.

In the third empirical chapter, the study explores whether there is a long-run relationship and causal link between gold ETF holdings and gold prices. Using cointegration analysis and a VEC model, the study finds that gold ETF holdings and gold prices are cointegrated and that gold prices respond to changes in ETF holdings in the long run. With limited gold production and rising demand, the results suggest that gold ETFs have become an influential driver of gold price dynamics.

The first empirical study in this thesis (Chapter 2) focuses on gold market volatility and its effect on the traditional roles of gold. The literature commonly assumes

gold market stability, ignoring possible changes in gold market behaviour. Using different statistical approaches like changing point, rolling mean and standard deviation, and GARCH, the study first establishes that the gold market exhibits two distinct, stable and volatile periods. Then, the econometric regression model reveals that gold's hedging and safe-haven properties deteriorate mainly in the high-volatility period of the gold market. Moreover, the DCC-GARCH and ICSS Algorithm shows that gold positively correlates with the S&P 500, especially during extreme market conditions, i.e. gold behaves more like a risky asset. The findings challenge the prevailing definition of the safe haven, which assumes a negative correlation with risky assets, specifically during crises and provoke the assumption of the stabilising role gold may offer to mitigate losses in the face of extreme market downturns.

Chapter 3 focuses on whether the increase in the level and volatility of gold prices, after a long time of market stability, is due to the beginning of gold financialisation through the introduction of gold ETFs. The changing point approach, rolling standard deviation, and Yang and Zhang variance estimator initially establish evidence of a turning point in gold market volatility, in which gold volatility increases around the introduction of gold ETF. Then, the GARCH model, including a dummy variable representing the introduction of gold ETF, demonstrates a significant structural change in gold market volatility dynamics with gold ETF onset. Further GARCH analysis reveals that volatility is higher in the post-ETF period. The findings suggest that introducing gold ETFs improves the speed of information flow to the gold spot market. This implies that the gold market is relatively more efficient after introducing gold ETFs, as they capture the effects of recent information and impound them into the gold spot prices. But it is still highly volatile.

Last, considering the gold ETF structure mechanism, the study investigates if the co-integration between gold ETFs' holdings and gold spot prices exists. Besides, it examines whether a causal relationship exists between gold ETFs' holdings and gold markets, i.e. whether gold ETFs' holdings cause gold prices. The cointegration tests, including Engle-Granger and Johansen tests, find that gold ETF holdings are co-integrated with gold prices, i.e. a long-run relationship exists. Besides, The finding shows that gold ETFs' holdings significantly cause gold prices in the long-run and hence play an important role in gold price determination. The findings suggest that changes in gold ETFs' holdings (inflows and outflows), with limited gold production

and high demand, may increasingly influence gold price dynamics and potentially substitute the traditional supply and demand forces in the gold market.

Overall, the study highlights a significant transformation in the gold market due to gold financialisation through the introduction of gold Exchange-Traded Funds (ETFs). The gold market became highly volatile in the post-ETF period. The study indicates that gold's traditional role as a hedge and safe haven has weakened over time, particularly during periods of gold market volatility. The weakening of gold's traditional roles has broader consequences for financial market portfolio diversification and risk management. Moreover, the traditional negative correlation between gold and equities has turned positive during periods of increasing volatility. This challenges the prevailing assumptions about gold's reliability to protect investors in times of financial stress and pushes investors to explore alternative assets for managing risks during market turmoil. Investors need to reassess their investment decisions, considering gold ETFs in their portfolio construction and investment strategies.

Furthermore, gold ETF has potentially emerged as a new factor influencing gold prices, increasing volatility, and reshaping gold price determinants. The observed co-integrating relation and causality between gold ETF holdings and gold prices, in the long run, suggest that gold ETF holdings, through investment demand (inflow and outflow), can play a potential driver role in gold price dynamics. This growing influence of gold ETF holdings requires market participants to closely monitor ETF activity as a potential influencer of gold price movements, possibly substituting traditional supply-demand forces. Besides, given the gold ETF's large market presence and substantial assets under management and its potential to influence gold price dynamics, regulators and policymakers need to ensure transparency and monitoring activities to maintain market stability and ensure fair practices to control risks associated with the growing dominance of ETFs in the gold market.

5.2 Conclusion

The study (Chapter 2) begins with the aim to analyze gold market behaviour over the past 37 years, assessing its role as a safe haven asset for both the stock and bond markets and investigating how changes in gold market behaviour impact its safe

haven ability. The findings reveal two distinct market eras: stable (1987 - 2005) and high volatile (2006 - 2024). During this stable period, the gold price remained broadly flat. In contrast, the volatile period sees dramatic fluctuations and substantial price surges, characterised by high volatility. The results indicate that while gold serves as a strong hedge and safe haven for stocks during the stable period, it loses this role during the volatile period.

Furthermore, a notable finding to emerge from this analysis is that gold is losing its appeal as a hedge and safe haven, i.e. gold's effectiveness declines in volatile periods. Considering the time-varying correlation between gold and stocks, a negative correlation was observed during the stable period, but a positive one emerged later. The positive correlation with stocks during extreme market shocks in the volatile period suggests that its safe haven role is fading in times of higher stock market volatility. Besides, considering more formal breaks within volatility identified by the ICSS algorithm reveals further evidence of gold losing its safe haven role, especially during the volatile period. To act as a safe haven, gold would be negatively correlated with stocks, and while there is evidence for this in the stable period, this pattern does not persist in the volatile era. Instead, during the highest volatility periods, such as the global financial crisis and the COVID-19 pandemic, gold positively correlated with stocks. Thus, it fails to serve as a safe haven when market participants most need it. Moreover, the study underlines that during the volatile period, gold exhibits a similar volatility pattern to the S&P 500, behaving like a risky asset.

Next (Chapter 3), given significant run-ups in gold prices and considerable change in its volatility, the study documents the effect of gold financialization through the introduction of gold ETFs on the underlying gold spot market volatility and efficiency. By focusing on introducing gold ETF (late 2003 and 2004) and its impact, the study brings more insights into understanding how financial innovation like gold ETF influences the traditionally stable market. While gold has traditionally been perceived as a stable asset, findings address evidence of a significant structural shift in gold market volatility around the gold ETF inception, challenging the long-standing assumption of gold's stability. The changepoint approach objectively identifies a turning point, December 2005, in the gold market volatility around gold ETF introduction, illustrating that the effect of gold ETF inception is distinct and measurable. Besides, the rolling standard deviation approach further emphasises volatility

behaviour changes in periods beyond 2005. The results indicate increasing volatility in the post-gold ETFs period. The analysis suggests that the increase in volatility is due to more information being impounded into gold prices after the gold ETF's inception. The findings indicate that introducing gold ETFs improves the speed of information flow to the gold spot market. This is documented by the increased sensitivity to recent news parameter (α_1) and the reduced persistence of old news parameter (β_1) of the GARCH model, signify a shift toward a more efficient but less stable gold market in the post-ETF period.

Last (chapter 4), the study provides new insights into understanding the gold market transformation under gold financialisation, revealing a better risk management role by gold ETF and how gold ETF contribute to gold price dynamics and determinations. Given recent developments in the gold market, the introduction of gold ETF that began in the early 2000s, and the substantial surge in gold prices, the study sets out to assess the impact of gold ETFs in reshaping gold market after introducing gold ETF, whether gold ETFs investment demand (holdings) contributes to the gold market changes, whether gold ETF holdings co-integrate with gold price, and whether a long-run and short-run causality exists between gold ETF holdings and gold prices.

The findings show that gold ETF holdings are co-integrated with gold prices, meaning that a long-run relationship exists between the two variables. The analysis suggests that the co-integrating relation could explain the dynamics between gold ETFs' holdings and gold prices. The fluctuations in gold ETFs' holdings (inflows and outflows), with limited gold production and high demand, may increasingly influence gold price dynamics, potentially substituting the traditional supply and demand forces in the gold market. In practice, the gold ETFs are becoming so large that they cannot be ignored; with almost \$220 billion under management, their direct buying and selling of physical gold could affect the supply and demand forces and, eventually, gold prices.

In addition, the Vector Error Correction Model (VECM) reflects short-run and long-run causal effects running from gold ETFs' holdings to gold prices. The finding shows that gold ETFs' holdings significantly cause gold prices in the long run, indicating a convergence to long-run equilibrium. In other words, this implies that gold prices respond to disequilibrium between gold prices and gold ETFs' holdings, meaning that the gold prices respond to changes in gold ETFs' holdings. However, in

the short run, the causality effects from gold ETFs' holdings to gold prices were limited to quarterly estimations. The long and short-run effects of gold ETFs' holdings on gold prices suggest that gold ETFs, rather than just supply and demand, may play an important role in gold price determination. This indicates a shift from traditional forces to more financialised drivers.

5.3 Limitations

The availability of data about gold and gold ETF at different frequencies is limited to a certain number of years. The higher the frequency, the lower the number of available years. For example, the gold ETF holdings (in/outflows) data for monthly, quarterly, and yearly frequency goes back to the time of the introduction of gold ETF in 2003. However, weekly and daily data is only available from 2018. Similarly, supply and demand data for the gold market is only available on quarterly and yearly frequencies and only goes back to 2010. The World Gold Council has justified this due to changing reporting format/style after 2010. The availability of such data in high frequency back to the time of the introduction of gold ETF may further support the argument of gold ETF holdings (in/outflows) potentially replacing the gold supply and demand forces by establishing a statistical comparison of gold demand changes in jewellery fabrication, central banks, technology, and investment. Besides, a higher frequency of data for gold ETF holdings, like weekly data, may establish better short-run causal effects between gold ETF holdings and gold prices.

5.4 Future Work

The study established that gold has lost its traditional roles and positively correlated with the equity market during market turbulence in the post-ETF period. These findings can be attributed to gold ETF onset and, thus, encourage future work to investigate whether a precautionary action by gold ETFs affects the gold market, leading to the noticed positive relation between gold and the stock market during market stress in the post-ETF period. More precisely, does the precautionary action by gold ETFs and traders (diversifying role) affect gold safe haven role effectiveness?

Remember that the gold ETF mechanism works by investing in gold to issue shares for trading. When anticipating changes in market conditions and increasing uncertainty and volatility, gold ETFs would take precautionary action by increasing

their holdings (inflows) to meet future demand for their shares. Accordingly, when market conditions change or a crisis arises, and the demand for gold ETF shares increases, the gold ETF's precautionary action allows it to sell more shares without necessarily acquiring additional physical gold and increasing gold demand and prices. This process meets the increased demand for gold ETF shares without driving gold demand and, ultimately, raising gold prices.

Similarly, Investors may adopt a precautionary strategy by including gold in their investment strategies for diversification purposes. This can reduce the demand for gold and its safe haven role during crises, shifting its role toward diversification rather than risk mitigation. Hence, the precautionary actions taken by both gold ETFs and investors in response to uncertainty and changing market conditions may weaken gold's safe haven role effectiveness and help explain the observed positive relationship between gold and the stock market during crises.

Appendix 1

For Chapter 2

Stationarity Test for variables Daily Returns

Augmented Dicky Fuller (ADF) Test				
Variables	t-Statistics/(P-value)	Critical values		Decision
Gold	-21.6548/(0.0000)	At 10%	-2.577815	Reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	
Silver	-97.5274/(0.0001)	At 10%	-2.577815	Reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	
Platinum	-37.0443/(0.0000)	At 10%	-2.577815	Reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	
Palladium	-27.9423/(0.0000)	At 10%	-2.577815	Reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	
S&P 500	-17.5976/(0.0000)	At 10%	-2.577815	Reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	
Bond	-19.4375/(0.0000)	At 10%	-2.577815	Reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	

Serial Correlation and ARCH Effect Tests

Box-Ljung Test				
Variable	t-Statistics/(P-value)	Chi-square Critical value		Decision
ARIMA's Residuals	0.0029811/(0.9565)	At 5%	3.841	Accept the null hypothesis "No serial correlation"
Squared ARIMA's Residuals	114.54/(2.2e-16)	At 5%	3.841	Reject the null hypothesis "No ARCH effect"

Table 5.1 Structural break dates using PELT algorithm

Structural Break Dates:	
Break 1	1978-07-26
Break 2	1979-08-29
Break 3	1979-08-29
Break 4	1979-12-26
Break 5	1981-01-28
Break 6	1984-06-13
Break 7	1986-08-27
Break 8	1989-01-11
Break 9	1997-07-02
Break 10	2003-08-13
Break 11	2006-01-04
Break 12	2007-10-24
Break 13	2009-10-07
Break 14	2010-09-15
Break 15	2011-04-06
Break 16	2011-07-20
Break 17	2013-04-10
Break 18	2014-09-10
Break 19	2016-02-10
Break 20	2019-06-19
Break 21	2020-04-08
Break 22	2023-03-15
Break 23	2024-03-06

Table 5.2 Chapter 2 Literature Review Summary

Authors	Method	Period	Countries/Markets	Data Frequency	Main findings
Tully and Lucey (2007)	Asymmetric Power GARCH (APGARCH) model	1984 to 2003	Gold prices (cash and futures) and macroeconomic variables	Monthly	The US dollar is confirmed as the main macroeconomic variable influencing gold prices, with other macroeconomic variables having less impact.
Bekiros et al. (2017)	Continuous wavelet transforms and copula models	2000 to 2014	Stocks in the BRICS and 3-month gold futures prices	Daily	Gold acts as a diversifier but not as a hedge or safe haven for BRICS stocks, and its diversifying potential reduces in the long run as it becomes more integrated into portfolios.
Reboredo and Rivera-Castro (2014)	Likelihood ratio tests of conditional dependence	2000 to 2012.	AUD, CAD, EUR, GBP, JPY, NOK, CHF, TWEXB, USD exchange rate index, and gold.	Weekly	- Gold serves as a hedge against US dollar depreciation. - Gold is a weak safe haven against extreme US dollar movements.
Bhunia and Das (2012)	Vector Error Correction Model.	2001 to 2011	Stock returns (NIFTY) and gold prices	Monthly	There is evidence of feedback causality between gold prices and stock market returns in India, indicating that each variable can predict the other, and a long-run equilibrium relationship is exist between gold prices and stock market returns.
Qureshi et al. (2018)	Wavelet analysis at multiple time horizons and Quantile Regression	1992 to 2015	Gold prices and exchange rates in Pakistan	Daily	- Gold acts as a consistent short-run hedge against exchange rate fluctuations. - Gold is an effective safe haven during times of intense decline in exchange rates.
Iqbal (2017)	EGARCH model and Quantile Regression	1990 to 2013	India, Pakistan, and the US (KSE-100, BSE-100, S&P-500 for stock markets; CPI for inflation.)	Daily and monthly	- Gold hedges inflation risk in the US, but only under certain conditions, and not in India and Pakistan. - Gold acts as a safe haven against exchange rate risks in Pakistan and India. - Gold does not uniformly hedge stock market risks across different gold market conditions in the three countries.
Bredin et al. (2015)	Wavelet analysis to examine hedging and safe haven properties of gold.	1980 to 2013	Equity and bond indices from four markets (USA, UK, Germany), and gold spot price	Daily	- Gold acts as a hedge for international equity and debt markets. - Gold acts as a safe haven during financial crises, such as the global financial crisis and the 'Black Monday' crash. - Gold did not act as a safe haven during economic contractions in the early 1980s.
Baur (2012)	Asymmetric GARCH model (GJR specification)	1979 to 2009	Gold spot prices in different currencies and types of gold	Daily, weekly, monthly, and quarterly	The volatility of gold returns exhibits an inverted asymmetric reaction, where positive shocks increase volatility more than negative shocks.

					• The increased volatility of gold can positively affect its effectiveness as a hedge or safe haven and lower portfolio risk under certain conditions.
Klein (2017)	Modified Dynamic Conditional Correlation (DCC) model by Engle (2002) Univariate APARCH, FIGARCH, and FIAPARCH models	2000 to 2016	Precious metals and major stock indexes	Daily	• Gold and Silver are identified as safe havens, but their status has been diminishing in recent years. Platinum shows signs of being a surrogate safe haven in extreme market conditions.
Pukthuanthong and Roll (2011)	Bivariate regressions	1971 to 2009	Gold prices and exchange rates (US Dollar, Euro, Yen, and Pound)	Daily	• The price of gold is associated with currency weakness, not strength, across the currencies studied, indicating a global market influence.
Beckmann et al. (2015)	Smooth Transition Regression (STR) model with an exponential transition function model	1970 to 2012	Gold price and Stock indices	Monthly	• Gold serves as both a hedge and a safe haven, but this ability is market specific. • Gold provides a strong hedging function in markets like EMU, Indonesia, Russia, and Turkey, but not in China, Germany, or the world index. • Gold exhibits a strong safe haven function in markets like India, the UK, and the world.
Joy (2011)	Dynamic Conditional Correlation (DCC-GARCH)	1986 to 2008	16 Major dollar-paired exchange rates and gold price	Weekly	• Gold has behaved as a hedge against the US dollar over the past 23 years, and has been a poor safe haven against US dollar movements
Filiz YILDIZ CONTUK (2013)	MGARCH modeling using Baba-Engle-Kraft-Krone (BEKK) modeling to analyze volatility effects.	2009 to 2012	Gold prices and ISE return	Daily	• Gold and stock exchange yields are affected by both their own shocks and by shocks from each other.
Boubaker et al. (2020)	Markov-switching model to capture regime changes and nonlinearity. Structural breaks test (Bai and Perron)	1257 to 2018	Gold prices in pound and CPI	Yearly	• Gold serves as a strong hedge against crises, especially during bullish market regimes and from the post-World War I period
Coudert and Raymond (2011)	Bivariate ARMA-GARCH-X model	1978 to 2009	Gold and stock market indexes (France, Germany, the UK, the US, and the G7).	Monthly	• Gold is a hedge against stocks in most cases and is valuable for diversifying portfolios during bear markets, and safe haven against various stock indexes. • The conditional covariance between gold and stock returns decreases during crises.
Ibrahim (2012)	Autoregressive distributed lag (ARDL) model	2001 to 2010	Domestic gold bullion prices and Kuala Lumpur composite index	Daily	• A significant positive but low correlation is found between gold and stock returns. • The gold market surges during consecutive market declines, indicating potential benefits of gold investment during stock market slumps

Capie et al. (2005)	Autoregressive distributed lag (ARDL) model	1971 to 2004	Gold prices and exchange rates (sterling-dollar and yen-dollar)	Weekly	Gold has been a hedge against exchange rates, and its effectiveness as a hedge has varied over time.
Tiwari et al. (2020b)	Time-varying Markov switching copula models linear regressions.	1985 to 2017	Gold and oil prices	Daily	Gold is a good hedge for oil returns for short- and medium-term investors but not for long-term investors, and acts as a safe haven during market crises. The inclusion of geopolitical risks in a gold and oil portfolio provides diversification benefits due to their negative effect on the gold-oil dependence structure
Ciner et al. (2013)	Dynamic Conditional Correlation (DCC) approach, Quantile and Rolling Regressions	1990 to 2010	Equity, bond, currency, gold and oil markets in US and UK	Daily	Gold acts as a safe haven against exchange rates in both the US and the UK.
Nguyen et al. (2020)	Copula	2000 to 2018	Gold prices and exchange rates	Daily	Gold serves as a strong hedge and weak safe-haven asset against exchange rate devaluation and during periods of high uncertainty and turmoil.
Seetharam and Bodington (2015)	Regression model	1998 to 2013	Spot gold price and MSCI Global Equity Index	Daily	Gold acts as a hedge for South African equities and bonds on average, but not for international stocks. It is safe haven but short lived, lasting only two trading days after an extreme negative shock in the stock market
P.K. Mishra (2010)	Vector Error Correction Model	1991 to 2009.	Domestic gold prices and BSE 100 index returns	Monthly	- There exists a long-run equilibrium relationship between gold prices and stock market returns in India. - Gold prices Granger-cause stock market returns and vice versa, indicating a significant relationship between the two
Robiyanto (2018)	Quantile regression (QREG), Ordinary Least Square (OLS) analysis	2008 to 2016	Composite Stock Price Index (CSPI), Kuala Lumpur Composite Index (KLCI), S&P Indonesian Corporate Bond Index (SPICBI), S&P Indonesian Government Bond Index (SPIGBI), S&P Malaysian Corporate Bond Index (MCB), S&P Malaysian Government Bond Index (MGB), gold prices in local currencies	Monthly	Gold does not serve as a safe haven for the Indonesian capital market but does for the Malaysian capital market.
Choudhury et al. (2022)	Regression analysis	2001 to 2022	Gold, sovereign bond indices, and U.S. and emerging stock market indices	Daily	Gold is a weak safe haven for stock market investors during epidemics.
Kopyl and Lee (2016)	Regression model	1964 to 2014	32 Assets	Monthly and weekly	Gold shows insignificant correlation, i.e. not a safe haven.
Śmiech and Papież (2017)	Rolling regression framework, ICSS and modified tests for structural breaks in volatility	1995 to 2015	Gold, oil, bond yields, S&P 500, and US dollar exchange rates	Weekly	Gold is a weak hedge for equity in normal market conditions, and strong safe haven in periods before 2007 and weak safe haven in subsequent periods. Gold is strong hedge and safe haven against currency movements.

					• Gold is neither a hedge nor a safe haven for the bond market. Gold is positively correlated with commodities.
Selmi et al. (2018)	Quantile-on-quantile regression (QQR) approach, Value-at-Risk (VaR) and conditional Value-at-Risk (CoVaR)	2011 to 2017.	Spot price oil, Bitcoin, and gold	Daily	• Gold can serve as hedges, safe havens, and diversifiers against oil price movements.
Reboredo (2013a)	copula models	2000 to 2011	Gold and Crude oil prices	Weekly	• Gold cannot hedge against oil price movements. • Gold acts as an effective safe haven against extreme oil price movements.
Dee et al. (2013)	Quantile regression VAR and VEC models	2002 to 2012	Gold prices, stock prices, and Consumer Price Index (CPI)	Daily and monthly	• Gold does not serve as a hedge for stock and inflation risks in the short term but does so in the long term. Gold is not a safe haven for investors facing stock and inflation risks in the Chinese capital market
Ghazali et al. (2013)	Autoregressive distributed lag (ARDL) model	2001 to 2013	Domestic gold price, Kuala Lumpur Composite Index (KLCI)	Daily	• Gold is a hedge, but its characteristic is short-lived. Gold is a safe haven in some thresholds, and at best, it is a weak safe haven during financial stress
Lucey and Tully (2003)	Mean-variance analysis	1988 to 2003	National indices as and FTSE World Indices, gold bullion	Weekly, monthly, quarterly	• Gold bullion plays an important role in creating optimal portfolios, improving the optimal portfolio composition compared to mean-variance analysis. This implies hedge and safe haven properties.
Baur and Lucey (2010)	Regression model	1995 to 2005	MSCI stock/bond indices and US spot gold prices (US, UK, Germany markets)	Daily	• Gold is a hedge against stocks on average and a safe haven in extreme stock market conditions, but not for bonds.
Echaust and Just (2022)	Extreme Value Theory (EVT) Two-step analysis: Estimation of GEV parameters for each market, then testing differences across markets Value-at-Risk (VaR) for hedging effectiveness	GFC (August 2007 to November 2009) COVID-19 (December 2019 to February 2021)	Stock indices and gold portfolios	Daily	• Gold acted as a safe-haven asset during the GFC, but not for the COVID-19 pandemic. Gold's effectiveness as a safe-haven asset has weakened over time, particularly during the COVID-19 pandemic
Shahzad et al. (2020)	Regression analysis	2010 to 2018	Gold, Bitcoin, stock market indices of the G7 countries (Canada, France, Germany, Italy, Japan, UK, US)	Daily	• Gold is a strong safe haven and hedge for most G7 stock indices.
Reboredo (2013b)	Copulas	2000 to 2012	Gold and USD	Weekly	• Gold acts as a hedge against USD movements and safe haven during extreme market movements.

Baur and McDermott (2010)	Regression models	1979 to 2009	Seven largest developed countries (G7), largest emerging markets (BRIC countries), Australia and Switzerland, gold	Daily, weekly, monthly	• Gold acts as both a hedge and a safe haven for major European stock markets and the US, but not for Australia, Canada, Japan, or large emerging markets like the BRIC countries.
Baur and McDermott (2012)	Regression models Vector Autoregression (VAR) model	1980-2010	World stock market indices, US government bonds, and gold	Daily	• Both US government bonds and gold act as safe haven assets during periods of market stress, with gold is more responsive to increasing uncertainty.
He et al. (2018)	Capital Asset Pricing Model (CAPM) and Markov-switching CAPM with ordinary least squares (OLS) regression.	1985 to 2017	FTSE All Share index, S&P 500 and Dow Jones indices, gold	Daily, weekly and monthly	• Gold is consistently a hedge for stock market risk. • Gold's usefulness in managing risk remains consistent even during crises, indicating it is always a hedge rather than a safe haven.
Bulut and Rizvanoglu (2020)	GARCH-copula approach	2000 to 2018	34 Emerging countries, and gold	Daily	• Gold serves as a hedging instrument for all 34 countries in the sample. • Gold has a weak safe haven property in 20 countries, indicating some protection against losses during market downturns. Only 9 countries show evidence of gold being a strong safe haven asset.
Choudhry et al. (2015)	Granger causality tests	2000 to 2014	FTSE100, S&P500, Nikkei 225 indices and Gold in UK pound, US dollar, Japanese yen	Daily	• Gold is a hedge against stock market returns and volatility in stable financial conditions. • Gold does not perform well as a safe haven during financial crises, with both bivariate and multivariate tests show that gold lost its safe haven characteristics during the global financial crisis
Hood and Malik (2013)	Regression model ICSS algorithm	1995 to 2010	Spot prices for gold, silver, platinum, S&P 500, and VIX	Daily	• Gold serves as a hedge and a weak safe haven for the US stock market.
Gürğün and Ünalımsı (2014)	Regression model	2008 to 2013	MSCI emerging markets index, gold prices	Daily	• Gold is both a hedge and a safe haven for domestic investors in most emerging and developing countries. • Gold is strong safe haven during extreme losses in equity markets for both domestic and foreign investors.
Ji et al. (2020)	Pairwise mean-variance analysis Value-at-Risk (VaR)	2019 to 2020	Bitcoin, gold, forex rates (EUR, USD, CNY-USD), WTI crude oil futures, soybean futures, three-month Treasury Bill.	Daily	• Gold futures remain robust as a safe-haven asset during the COVID-19 pandemic.
Chiarella et al. (2016)	Continuous time multi-factor stochastic volatility model	1982 to 2012	gold and crude oil futures and futures options	Daily	• Gold futures exhibit an inverted asymmetric volatility due to the safe haven property.
Tarchella et al. (2024)	Linear and nonlinear (GARCH), DCC-GARCH, ADCC-GARCH, GO-GARCH.	2017 to 2022	G7 stock market indices, oil, gold, Bitcoin, and Ethereum prices.	Daily	• Gold is an optimal hedge asset in normal conditions. • Gold is a strong diversifier for equity investments in the G7 markets under all conditions (pre- and post-COVID-19 periods).

Lucey and Li (2015)	Regression model and DCC-GARCH model	1989 to 2013	Futures contract for gold, silver, platinum, and palladium, S&P 500 index and US 10-year government bond index.	daily	• Silver, platinum, and palladium can act as safe havens during certain periods when gold does not.
Baur and McDermott (2016)	Quantile regression	1970 to 2013	Gold, global stock market indices (MSCI World and S&P 500)	Daily	• Gold is identified as a strong safe haven asset, particularly during significant financial crises like the aftermath of September 11, 2001, and the Lehman bankruptcy in 2008.
Chang et al. (2021)	Two-state, quantile-based Markov-switching GJR-GARCH model	2002 to 2018	Gold prices and stock indices (United States, United Kingdom, Germany, Australia, Japan)	Daily	• Gold serves as a safe haven in high-volatility regimes but not in low-volatility regimes, except for specific cases like Australia. • The asymmetric nature of gold's volatility and contagion/flight behaviors are influenced by volatility regimes
Cheema et al. (2020)	Regression models	1990 to 2021	Gold prices and ten largest indices (S&P500 US Index, SSE composite Index China, NIKKEI 225 Index Japan, MSCI Germany Index, FTSE100 Index UK, MSCI France Index, NIFTY 500 Index India, MSCI Italy Index, Brazil Stock Exchange Index (BOVESPA), and TSX composite Index Canada)	Daily	• Gold is not reliable protectors during 2008 GFC (weak safe haven) and COVID-19 pandemic (very risky, not safe-haven).
Triki and Maatoug (2021)	- MV-GARCH model - Dynamic copula VAR-MV-GARCH models	1985 to 2018	S&P500 and gold price	Monthly	• Gold is a hedge against stock market volatility.
Umar et al. (2023)	Causality-in-quantiles test and quantile-on-quantile regression method.	2010 to 2021	Eight safe-haven assets (gold, silver, oil, Bitcoin, Euro, Pound Sterling, Japanese Yen, Chinese Yuan) and risk aversion index	Daily	• Silver, oil, Euro, and Pound Sterling are consistent safe havens regardless of risk aversion levels, while gold and Bitcoin are not.
Gokmenoglu and Fazlollahi (2015b)	ARDL co-integration approach	2013 - 2014	Crude oil price, gold price, oil price volatility, and gold price volatility	Daily	• There is a long-run equilibrium relationship between the S&P500 stock market price index and gold price and its volatility. • An increase in gold price leads to a decrease by 74% decrease in the stock market index in the long run. • The volatility of gold increases the stock market index by 8.7% in the long run.
Apak et al. (2012)	GARCH model	2000 to 2011	Gold prices, exchange rates, bond returns, oil prices, silver prices, credit default swaps	Daily	• Gold is hedge and safe haven against return of silver, USD returns, and change in the volatility index.
Todorova (2017)	Heterogeneous Autoregressive (HAR) model	2003 to 2016	COMEX gold futures	Intraday	• The study suggests an inverse asymmetric volatility effect, where positive semi variance drives the overall variation in the gold market more than negative returns
Akhtaruzzaman et al. (2020)	DCC-GARCH model	Phase I (December 31, 2019-March 16, 2020)	Contract for differences (CFDs) on equity (S&P500, Euro Stoxx 50, Nikkei 225, China FTSE A50 indices), West Texas Intermediate (WTI) crude oil, and spot exchange rates (EURUSD, USDJPY, USDCNY), gold	Intraday	• The hedging effectiveness of gold was maintained. Gold served as a safe haven asset during Phase I (December 31, 2019-March 16, 2020) of the COVID-19 pandemic, but not during Phase II (March 17-April 24, 2020)

		Phase II (March 17- April 24, 2020)			
Feder-Sempach et al. (2024)	Multivariate factor stochastic volatility (MSV) model	2014 to 2022	Five safe-haven assets (gold, bitcoin, euro, Japanese yen, and Swiss franc) and five primary stock market indices (S&P 500, FTSE 100, DAX, STOXX Europe 600, NIKKEI 225)	Daily	• Gold acts as an efficient safe haven for all stock markets.
Drake (2022)	Regression models, Granger causality tests Simple and rolling correlations, Engle-Granger and Johansen co-integration tests	1990 - 2021	Gold, S&P 500 index, CBOE VIX index, and 30-year US Treasury Inflation-Indexed Bond	Daily	• The traditional belief of the negative correlation between gold and stock returns during economic stress is not supported in the 2007-09 financial crisis and COVID-19. • Gold acts as a safe haven during times of stock market volatility and negative interest rates, but not as a hedge against economic stress. • The gold-stock market relationship is positive when real interest rates are negative.
Le Thi Thuy et al. (2024)	Regression model	2006 to 2023	Gold, US dollars, and Bitcoin, stock indices in China, Netherlands, UK, US, Germany, Poland, Russia, Turkey	Daily	• The safe-haven role of gold, US dollar, and Bitcoin changes over periods of crisis. • Gold lost its safe-haven role during the COVID-19 pandemic but regained it during the Russia-Ukraine conflict.
Ryan et al. (2024)	Regression model	1979 to 2020	Gold and S&P500 index	Daily	• Gold's protective efficacy as a safe haven is conditional on the underlying causes of market downturns, triggered by macroeconomic news, terrorism, and trade policy.
Baur and Dimpfl (2020)	Quantile regression:	1985 to 2020	Safe Haven Index (SHI) and S&P 500 index	Daily and monthly	• The SHI is a hedge against market losses. The Safe Haven Index (SHI) consistently performs well during safe haven events by rising sharply, being safe haven against market downturns. • Safe haven index (SHI) fell at the beginning of the COVID-19 crisis, and did not perform as expected.

Appendix 2

For Chapter 3

Gold returns Unit root test

Augmented Dicky Fuller (ADF) Test				
Variables	t-Statistics/(P-value)	Critical values		Decision
Gold	-32.2606/(0.0000)	At 10%	-2.577815	Reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	

Chow test results

Augmented regression for Chow test

OLS, using observations 1990-01-01:2020-12-31 (T = 8089)

Dependent variable: Gold Price

	coefficient	std. error	t-ratio	p-value
const	355.436	5.49433	64.69	0.0000 ***
time	-0.00336919	0.00229271	-1.470	0.1417
splitdum	-355.766	16.3823	-21.72	1.11e-101 ***
sd_time	0.203026	0.00337695	60.12	0.0000 ***
Mean dependent var	773.6191	S.D. dependent var		496.8790
Sum squared resid	2.53E+08	S.E. of regression		176.9417
R-squared	0.873235	Adjusted R-squared		0.873188
F(1, 8087)	18564.88	P-value(F)		0.000000
Log-likelihood	-53343.0	Akaike criterion		106694.0
Schwarz criterion	106722.0	Hannan-Quinn		106703.6
rho	0.998164	Durbin-Watson		0.003979

Chow test for structural break at observation 2005-11-28

Null hypothesis: no structural break

Test statistic: $F(2, 8085) = 3895.8$ with p-value 0.0000

Wald Test using z-statistic

$$Z = \frac{\phi_{post} - \phi_{pre}}{\sqrt{SE_{post}^2 + SE_{pre}^2}}$$

Period	One-year	Two-year
Pre-ETF	January 2005 to December 2005	January 2004 to December 2005
Post-ETF	January 2006 to December 2006	January 2006 to December 2007

We test the following, considering one-year and two-year sample periods.

- Is the difference in α between the pre-ETF and post-ETF periods statistically significant?
- Is the difference in β between the pre-ETF and post-ETF periods statistically significant?

One-year

Parameter	Wald Z statistic	5% Critical Value	10% Critical Value	Significant?
Difference in Alpha	1.198	1.96	1.645	No
Difference in Beta	1.431	1.96	1.645	No

Two-year

Parameter	Wald Z statistic	5% Critical Value	10% Critical Value	Significant?
Difference in Alpha	1.278	1.96	1.645	No
Difference in Beta	1.146	1.96	1.645	No

Table 5.3 Chapter 3 Literature review summary

Authors	Objective	Method	Countries/Markets	Main findings
Robbani and Bhuyan (2005)	Examine the impact of introducing futures and options on the DJIA index on the volatility of the underlying stocks.	GARCH (1,1)	DJIA index	The introduction of futures and options trading on the DJIA index significantly increased market volatility.
Bandivadekar and Ghosh (2003)	Study the impact of introducing index futures on spot market volatility for S&P CNX Nifty and BSE Sensex.	GARCH (1,1)	S&P CNX Nifty and BSE Sensex	There is a decline in spot market volatility after the introduction of index futures
Kasman and Kasman (2008)	Provide evidence on the impact of futures trading on spot market volatility in the Turkish stock market.	Asymmetric GARCH model (specifically EGARCH)	ISE-30 index	The introduction of futures trading reduced the conditional volatility of the ISE-30 index.
Çağlayan (2011)	Investigate the impact of the introduction of index futures on the volatility of the Turkish spot market.	Symmetric and asymmetric conditional-volatility models (GARCH, EGARCH, GJR-GARCH, APARCH)	ISE-30 index	There is a decrease in market volatility post-futures trading.
Galloway and Miller (1997)	Investigate the effect of creating the MidCap index and introducing MidCap index futures on the return volatility of MidCap stocks.	Squared daily returns OLS regression	MidCap 400 stocks	There is a significant decrease in return volatility and systematic risk, for the MidCap 400 stocks after the introduction of the MidCap index and futures.
Bessembinder and Seguin (1992)	Examine the relationship between futures-trading activity and equity volatility.	OLS estimation.	S&P 500 index and NYSE	Active futures markets are associated with decreased equity volatility, supporting theories that futures trading enhances market liquidity and depth.
Bohl et al. (2015)	Examine the impact of introducing Chinese stock index futures on the volatility of the underlying spot market.	GARCH (1,1), GJR-GARCH, and EGARCH.	CSI300, A50, and HSCEI spot markets	The introduction of Chinese CSI300 index futures decrease spot market volatility in all three spot markets considered (CSI300, A50, and HSCEI).
Alexakis (2007)	Investigate the impact of index futures trading on the underlying stock market volatility.	GARCH and GJR-GARCH models	FTSE/ASE-20 stock index market, S&P, FTSE, DAX, and DJ indices	The introduction of stock index futures trading does not have a detrimental effect on the spot market.
Dennis and Sim (1999)	Examine the impact of introducing individual share futures contracts on the Sydney Futures Exchange on the volatility of the underlying shares in the cash market.	Asymmetric exponential ARCH model	Australian Stock Exchange (ASX)	The introduction of futures trading has had very little impact on cash market volatility.
Debasish (2009)	Study the effects of the introduction of futures contracts on price volatility in the Indian capital market.	Dynamic linear regression models and GARCH models	NSE Nifty spot market	There is no structural change in volatility after the introduction of futures trading.

Xie and Huang (2014)	Investigate whether the introduction of index futures reduces spot price volatility.	GARCH models (GARCH-M and GJR-GARCH)	CSI 300 index	- The introduction of the CSI 300 index futures does not decrease the volatility of the spot market.
Moriarty and Tosini (1985)	Investigate if the introduction of GNMA futures trading has caused an increase in GNMA cash market volatility.	Correlation analysis and regression analyses	GNMA certificates, 10-year US bonds, and GNMA futures	The introduction of GNMA futures trading did not cause an increase in GNMA cash market volatility.
Antoniou and Foster (1992)	Investigate the effects of the introduction of a futures contract for Brent Crude Oil in 1988 on the price volatility in the spot market for Brent Crude.	GARCH and Dynamic linear regression model	Brent Crude Oil	No evidence of increased volatility in the spot market for Brent Crude Oil after the introduction of futures trading.
Kamara et al. (1992)	Investigate the effects of the S&P 500 stock index futures market on the stability of the underlying cash index.	Chen, Roll, and Ross (CRR) model Kolmogorov-Smirnov and Wilcoxon Rank Sum tests.	S&P 500 index	Volatility remained unchanged, indicating no destabilization of the market due to futures trading.
Gökbulut et al. (2009)	Investigate how index futures contracts affect the price volatility in the spot stock market.	GARCH (1,1)	ISE 100 index	There is no statistically significant change in the volatility of the stock market after the introduction of index futures.
Board et al. (2001)	Test the hypothesis that increases in futures market trading activity increase spot market price volatility.	Stochastic Volatility (SV) model	FTSE 100	No significant effect of futures market trading on spot market volatility.
Darrat and Rahman (1995)	Examine whether increased stock price volatility has been caused by futures trading and other relevant macroeconomic and financial variables.	Regression models Multivariate Granger-causality tests	S&P 500 index	Futures trading activity does not significantly cause an increase in jump volatility of stock prices.
Antoniou and Holmes (1995)	Examine the impact of trading in the FTSE-100 Stock Index Futures on the volatility of the underlying spot market.	GARCH (1,1)	FTSE 100	Futures trading has led to increased volatility in the spot market.
Spyrou (2005)	Investigate whether the introduction of futures trading affects the volatility of the underlying market in the Athens Stock Exchange (ASE).	ARCH and GARCH models	FTSE/ASE 20 index	The introduction of futures trading has no significant effect on the volatility of the underlying market.
Bae et al. (2004)	Investigate the effect of KOSPI 200 index futures and options trading on the volatility and operating efficiency of the underlying Korean stock market.	Regression models	KOSPI 200 index	The introduction of index futures trading in Korea increases spot price volatility.
Mallikarjunappa and Afsal (2007)	Investigate if the nature of volatility has changed after introducing index futures contracts.	GARCH (1, 1)	S&P CNX IT index	The introduction of futures trading has increased market volatility.
Pok and Poshakwale (2004)	Study the impact of futures trading on spot market volatility using data from both underlying and non-underlying stocks in the emerging Malaysian stock market.	GARCH (1,1) Vector Autoregressive (VAR) system Granger causality tests	KLSE CI and Second Board Index	The introduction of futures trading increases spot market volatility and the flow of information to the spot market.

Arisoy (2008)	Examine the effect of futures introduction in a foreign exchange on the domestic spot market using a unique sample.	GARCH, GARCH-M, EGARCH, TARCH	Chinese index futures (FTSE Xinhua A50 index)	The introduction of the FTSE Xinhua A50 index futures leads to a significant increase in spot volatility and liquidity.
Kumar and Mukhopadhyay (2007)	Investigate whether the introduction of Index Futures trading has changed the nature of return volatility of the NSE Nifty Index.	GARCH model	NSE Nifty Index (India)	The introduction of Index Futures trading significantly alters the structure of spot market volatility.
Lee and Ohk (1992)	Investigate whether the introduction of stock index futures trading leads to changes in market efficiency using the switching GARCH model.	Modified Levene test Switching GARCH model	Australia, Hong Kong, Japan, United Kingdom, United States	Stock market volatility increases significantly after the introduction of stock index futures, except in Australia and Hong Kong.
Sarkar (2012)	Reviews the history of gold ETF innovation, explains its characteristics, and the benefits and risks associated with investing in gold ETFs in an international market and India	Descriptive and comparative analysis	International and India	- Gold ETF provides the investor with all the benefits of investing in gold while eliminating disadvantages related to physical gold possession. - Gold ETF has a bright future in India.
Baur (2013a)	Determine if gold ETFs influence the price and volatility of gold.	Regression model, GARCH	50 allocated and 34 unallocated ETFs, gold price	The introduction of gold ETFs has led to a structural demand shift affecting the price, volume traded, and volatility of gold.
Baur (2013b)	Perform a theoretical and econometric analysis of the fundamental drivers of gold.	Regression analysis	China, India, US, Brazil, Russia, Italy, Germany, France, Australia, UK	Gold is mainly influenced by traditional drivers like inflation, currency changes, and interest rates, as well as new drivers like ETF.
Demidova-Menzel and Heidorn (2007)	Examine the key drivers of gold investment and analyze possible investment forms in gold.	Correlation analysis Regression model	Physical gold, gold Pool Account, futures, gold backed securities (e.g. Xetra-Gold), Gold Mining Companies	Gold Backed Securities, Xetra-Gold, offers advantages over traditional gold investments.
Pule (2013)	Examines the potential benefits and risks of investing in gold (by Comparing the performance of different gold investment avenues) from a South African investor's perspective, focusing on its relationship with macroeconomic variables and its role in portfolio diversification.	Regression model	South Africa(JSE listed gold mining companies, gold price, Krugerrand coin, NewGold ETF, FTSE/JSE all share index, gold mining index, unit trust index (gold & precious metals), real GDP, rand/dollar exchange rate, repo rate, and CPI)	Gold ETF yields a comparable return to gold bullion investment and an abnormal return compared to the other investment forms

Appendix 3

For Chapter 4

Stationarity Test for variables Daily Returns

Augmented Dicky Fuller (ADF) Test				
Variables	t-Statistics/(P-value)	Critical values		Decision
Log Return Gold	-68.1367/(0.0000)	At 10%	-2.577815	Reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	
Log Return SPDR	-68.2336/(0.0000)	At 10%	-2.577815	Reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	
Log Return S&P 500	-15.0759/(0.0000)	At 10%	-2.577815	Reject the null hypothesis
		At 5%	-2.882748	
		At 1%	-3.478911	

Table 5.4 Vector Error Correction Model (VECM) estimation results (gold prices → ETFs' holdings)

Panel A. Monthly Data				
Variables	Coefficient	Std. Error	t-ratio	p-value
constant	0.177323***	0.0503106	3.525	0.0005
ΔGP_{t-1}	0.0892217**	0.0433412	2.059	0.0408
$\Delta GETFh_{t-1}$	0.281186***	0.0695074	4.045	<0.0001
$LVIXS\&P500_t$	0.0207299***	0.00558127	3.714	0.0003
ECT_{t-1}	-0.0369143***	0.00815883	-4.524	<0.0001
Panel B. Quarterly Data				
Variables	Coefficient	Std. Error	t-ratio	p-value
constant	1.01515***	0.308028	3.296	0.0016
ΔGP_{t-1}	0.127682	0.154227	0.8279	0.4110
ΔGP_{t-2}	0.182124	0.151246	1.204	0.2332
$\Delta GETFh_{t-1}$	0.101835	0.155080	0.6567	0.5139
$\Delta GETFh_{t-2}$	-0.132399	0.148306	-0.8927	0.3755
$LVIXS\&P500_t$	0.0777651***	0.0243161	3.198	0.0022
ECT_{t-1}	-0.283112***	0.0737511	-3.839	0.0003

Note: The optimal lag selection for monthly data is 2, and for quarterly data is 3 lags. *, **, and *** mean statistically significant at 10%, 5%, and 1%, respectively.

Table 5.5 Chapter 4 Literature review summary

Authors	Objective	Method	Countries/Markets	Main findings
Baur (2013c)	Demonstrate changes in dependence patterns over time across different asset classes. Assess the benefits of diversification by understanding the structure of dependence in both normal and crisis times.	Quantile regression	currencies, gold, and 54 equity indices of Industrial and emerging countries	• The study demonstrates substantial differences in dependence patterns among asset classes and over time, particularly during the global financial crisis. • The analysis of global equity markets shows that understanding the structure of dependence is crucial for assessing diversification benefits during crises. • The global financial crisis led to changes in the degree and structure of dependence, with evidence of contagion in emerging markets but not in large industrial markets
Tang and Xiong (2012)	Analyze the effects of the financialization process in commodities markets.	Regression analysis, Panel regression, Difference-in-difference analysis	Commodities, developed and emerging markets indices.	• Financialisation increased price co-movements. • The synchronized rise and fall in prices of oil and non-energy commodities is attributed to the financialization of commodities markets. • The increasing presence of index investors has led to a significant increase in return correlations between commodities and financial assets like stocks and the US dollar.
Demidova-Menzel and Heidorn (2007)	Examine the key drivers of gold investment and analyze possible investment forms in gold.	Correlation analysis Regression model	Physical gold, gold Pool Account, futures, gold backed securities (e.g. Xetra-Gold), Gold Mining Companies	• Gold Backed Securities, Xetra-Gold, offers advantages over traditional gold investments.
Sarkar (2012)	Reviews the history of gold ETF innovation, explains its characteristics, and the benefits and risks associated with investing in gold ETFs in an international market and India	Comparative analysis	International and India	• Gold ETF provides the investor with all the benefits of investing in gold while eliminating disadvantages related to physical gold possession. • Gold ETF has a bright future in India.
Pule (2013)	Examines the potential benefits and risks of investing in gold (by Comparing the performance of different gold investment avenues) from a South African investor's perspective, focusing on its relationship with	Regression model	South Africa (JSE listed gold mining companies, gold price, Krugerrand coin, NewGold ETF, FTSE/JSE all share index, gold mining	• Gold ETF yields a comparable return to gold bullion investment and an abnormal return compared to the other investment forms

	macroeconomic variables and its role in portfolio diversification.		index, unit trust index (gold & precious metals), real GDP, rand/dollar exchange rate, repo rate, and CPI)	
Singh and Nadda (2013)	Compare the returns and risks of investing in the National Stock Exchange (NSE) Index and Gold to determine which is riskier.	Comparative analysis	India	• Gold consistently yielded positive returns with lower volatility and higher returns compared to the NSE Index, making it a less risky and more rewarding investment option in India
Naylor et al. (2011)	Investigate the price efficiency of six commodity exchange-traded funds (ETFs).	Sharp-Linter-Mossin model based on capital asset pricing model (CAPM)	GLD, SLV, IAU, DBS, DGL, and AGQ	• Gold and silver ETFs, particularly GLD and SLV, have a small but significant risk-adjusted return and are valuable for portfolio diversification due to their low correlation with equity markets.
Aggarwal et al. (2013)	Compare the performance (returns and volatility) between Gold ETFs and physical gold in India.	mean, standard deviation, variance, and coefficient of variation (CV)	Indian spot gold market and listed Gold ETFs	• Gold ETFs outperformed physical gold in terms of risk-adjusted returns (lower CV)
Kumar and Ram (2019)	Examines the relationship between gold and Gold ETFs in India	Statistical models: alpha, beta, Sharpe's index, Treynor's index, Jensen's index, Sortino ratio, Fama's model. Correlation analysis.	India	• Gold ETFs have higher returns compared to physical gold. • There is a strong positive correlation between physical gold and Gold ETFs, suggesting ETFs as a viable alternative.
Aarthi (2020)	Compare the performance of Gold ETFs and CPSE ETFs against their benchmarks and the CNX Nifty50 index.	Risk and return analysis Performance evaluation	India	• Gold ETFs have generated more returns than the CNX Nifty50 index. • CPSE ETFs are riskier than Gold ETFs and the CNX Nifty50 index. • Gold ETFs are less risky than the CNX Nifty50 index and can serve as efficient risk diversifiers.
Ivanov (2013)	Examine the relationship between gold, silver, and oil ETFs and their respective futures instruments and underlying commodities.	Engle-Granger cointegration Hasbrouck (1995) price discovery Vector Error Correction Model (VECM)	Gold, silver, and oil spot, ETF, and futures prices series	• The gold, silver, and oil ETFs closely track the performance of their underlying assets. • Price discovery for gold and silver has shifted from the futures market to the ETF market.

		Tracking Error (TE) and Pricing Deviation (PD) metrics		
Baur (2013b)	Perform a theoretical and econometric analysis of the fundamental drivers of gold.	Regression analysis	China, India, US, Brazil, Russia, Italy, Germany, France, Australia, UK	• Gold is mainly influenced by traditional drivers like inflation, currency changes, and interest rates, as well as new drivers like ETF.
Baur (2013a)	Determine if gold ETFs influence the price and volatility of gold.	Regression model, GARCH	50 allocated and 34 unallocated ETFs, gold price	• The introduction of gold ETFs has led to a structural demand shift affecting the price, volume traded, and volatility of gold.
Durham (2013)	Examine popular assertions about gold as an investment, assess gold's role in asset allocation, and evaluate gold's effectiveness as an inflation hedge, currency hedge, alternative to low real-return assets, and safe haven.	Regression analysis	United States, China, Russia, India, Germany, Italy, France, Switzerland, United Kingdom)	• Gold is not an effective hedge for inflation or currency fluctuations in the short or long term. • Gold can be part of a portfolio due to potential demand from developing markets and its role in a diversified commodity portfolio.
Fassas (2012)	Investigate whether the introduction of precious metal-related ETPs affects the respective returns of gold, silver, platinum, and palladium.	Regression analysis Granger causality tests	gold, silver, platinum, palladium	• There is a strong positive contemporaneous relationship between the inflows and outflows in precious metal ETPs and the returns of the underlying metals, particularly for gold, silver, and platinum, but rules out causality, indicating that ETP flows are associated with but do not cause changes in metal prices.

References

- Aarthi B. (2020) AN EMPIRICAL STUDY ON COMPARATIVE PERFORMANCE OF GOLD ETFs AND CPSE ETF AS AGAINST CNX NIFTY50 INDEX. 11.
- Adams Z and Glück T. (2015) Financialization in commodity markets: A passing trend or the new normal? *Journal of Banking & Finance* 60: 93-111.
- Aggarwal VK, Jain S and Aggarwal A. (2013) Gold vs Gold ETFs: Evidences from India. *International Journal of scientific research and management* 2: 758-762.
- Akhtaruzzaman M, Boubaker S, Lucey BM, et al. (2020) Is gold a hedge or safe haven asset during COVID–19 crisis? *Available at SSRN 3621358*.
- Alexakis P. (2007) On the effect of index futures trading on stock market volatility. *International Research Journal of Finance and Economics* 11: 7-29.
- Anand R. (2017) A Comparative Study on Gold vs Gold ETF's and an Analysis of Gold ETF's as an Effective Investment Tool for Indian Retail Investors. *International Journal of Management & Business Studies* 7: 26-34.
- Antoniou A and Foster AJ. (1992) The effect of futures trading on spot price volatility: evidence for Brent crude oil using GARCH. *Journal of Business Finance & Accounting* 19: 473-484.
- Antoniou A and Holmes P. (1995) Futures trading, information and spot price volatility: evidence for the FTSE-100 stock index futures contract using GARCH. *Journal of Banking & Finance* 19: 117-129.
- Apak S, Akman V, Çankaya S, et al. (2012) The Case for Gold Revisited: A Safe Haven Or A Hedge? *EMAJ: Emerging Markets Journal* 2.
- Arisoy YE. (2008) Index futures, spot volatility, and liquidity: Evidence from FTSE Xinhua A50 index futures. *Working paper*.
- Athma P and Mamatha B. (2012) ETFs Vs Index Funds: Growth and Progress, Arth Prabhand: A Journal of Economics and Management.
- Athma P and Mamatha B. (2017) Performance of Equity Exchange Traded Funds in India: An Analysis. *International Journal of Business and Management Invention (IJBMI)* Volume 6 59-66.
- Auger IE and Lawrence CE. (1989) Algorithms for the optimal identification of segment neighborhoods. *Bulletin of mathematical biology* 51: 39-54.
- Bae SC, Kwon TH and Park JW. (2004) Futures trading, spot market volatility, and market efficiency: The case of the Korean index futures markets. *Journal of Futures Markets: Futures, Options, and Other Derivative Products* 24: 1195-1228.
- Bai J and Perron P. (1998) Estimating and testing linear models with multiple structural changes. *Econometrica*: 47-78.
- Bandivadekar S and Ghosh S. (2003) Derivatives and volatility on Indian stock markets. *Reserve Bank of India Occasional Papers* 24: 187-201.
- Baur DG. (2012) Asymmetric volatility in the gold market. *The Journal of Alternative Investments* 14: 26-38.
- Baur DG. (2013a) Exchange-traded funds on gold-a free lunch? *FIRN Research Paper*.
- Baur DG. (2013b) Gold-Fundamental drivers and asset allocation.
- Baur DG. (2013c) The structure and degree of dependence: A quantile regression approach. *Journal of Banking & Finance* 37: 786-798.
- Baur DG and Dimpfl T. (2020) A Safe Haven Index. *Available at SSRN 3641589*.
- Baur DG and Glover KJ. (2012) The destruction of a safe haven asset? *Available at SSRN 2142283*.
- Baur DG, Hoang LT and Hossain MZ. (2022) Is Bitcoin a hedge? How extreme volatility can destroy the hedge property. *Finance Research Letters* 47: 102655.
- Baur DG and Lucey BM. (2010) Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. *Financial Review* 45: 217-229.
- Baur DG and McDermott TK. (2010) Is gold a safe haven? International evidence. *Journal of Banking & Finance* 34: 1886-1898.

- Baur DG and McDermott TK. (2012) Safe haven assets and investor behaviour under uncertainty. *Institute for International Integration Studies*.
- Baur DG and McDermott TK. (2016) Why is gold a safe haven? *Journal of Behavioral and Experimental Finance* 10: 63-71.
- Baur DG and Smales LA. (2018) Gold and geopolitical risk. Available at SSRN 3109136.
- Beckett S and Roberts DJ. (1990) Will increased regulation of stock index futures reduce stock market volatility? *Economic Review-Federal Reserve Bank of Kansas City* 75: 33.
- Beckmann J, Berger T and Czudaj R. (2015) Does gold act as a hedge or a safe haven for stocks? A smooth transition approach. *Economic Modelling* 48: 16-24.
- Beckmann J and 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.
- Bekiros S, Boubaker S, Nguyen DK, et al. (2017) Black swan events and safe havens: The role of gold in globally integrated emerging markets. *Journal of international money and finance* 73: 317-334.
- Bernstein PL. (2012) *The power of gold: the history of an obsession*: John Wiley & Sons.
- Bessembinder H and Seguin PJ. (1992) Futures-trading activity and stock price volatility. *The Journal of Finance* 47: 2015-2034.
- Bhunia A and Das A. (2012) Association between gold prices and stock market returns: Empirical evidence from NSE. *Journal of Exclusive Management Science* 1: 1-7.
- Board J, Sandmann G and Sutcliffe C. (2001) The effect of futures market volume on spot market volatility. *Journal of Business Finance & Accounting* 28: 799-819.
- Bohl MT, Diesteldorf J and Siklos PL. (2015) The effect of index futures trading on volatility: Three markets for Chinese stocks. *China Economic Review* 34: 207-224.
- Bok F. (2012) The risk-return trade-off of precious metals ETFs.
- Boubaker H, Cunado J, Gil-Alana LA, et al. (2020) Global crises and gold as a safe haven: Evidence from over seven and a half centuries of data. *Physica A: Statistical Mechanics and its Applications* 540: 123093.
- Bredin D, Conlon T and Poti V. (2015) Does gold glitter in the long-run? Gold as a hedge and safe haven across time and investment horizon. *International Review of Financial Analysis* 41: 320-328.
- Bulut L and Rizvanoglu I. (2020) Is gold a safe haven? The international evidence revisited. *Acta Oeconomica* 70: 531-549.
- Çağlayan E. (2011) The impact of stock index futures on the Turkish spot market. *Journal of Emerging Market Finance* 10: 73-91.
- Cai J, Cheung YL and Wong MC. (2001) What moves the gold market? *Journal of Futures Markets: Futures, Options, and Other Derivative Products* 21: 257-278.
- Capie F, Mills TC and Wood G. (2005) Gold as a hedge against the dollar. *Journal of International Financial Markets, Institutions and Money* 15: 343-352.
- Chang M-S, Kung C-C, Chen M-W, et al. (2021) Volatility regime, inverted asymmetry, contagion, and flights in the gold market. *Pacific-Basin Finance Journal* 67: 101522.
- Cheema MA, Faff RW and Szulczuk K. (2020) The 2008 global financial crisis and COVID-19 pandemic: How safe are the safe haven assets? *Covid Economics, Vetted and Real-Time Papers*: 88-115.
- Cheng I-H and Xiong W. (2014) Financialization of commodity markets. *Annu. Rev. Financ. Econ.* 6: 419-441.
- Cheng W-H, Chen C-D and Lai H-P. (2020) Revisiting the roles of gold: Does gold ETF matter? *The North American Journal of Economics and Finance* 54: 100891.
- Chiarella C, Kang B, Nikitopoulos CS, et al. (2016) The return–volatility relation in commodity futures markets. *Journal of Futures Markets* 36: 127-152.
- Choudhry T, Hassan SS and Shabi S. (2015) Relationship between gold and stock markets during the global financial crisis: Evidence from nonlinear causality tests. *International Review of Financial Analysis* 41: 247-256.
- Choudhury T, Kinatader H and Neupane B. (2022) Gold, bonds, and epidemics: a safe haven study. *Finance Research Letters* 48: 102978.

- Christie–David R, Chaudhry M and Koch TW. (2000) Do macroeconomics news releases affect gold and silver prices? *Journal of Economics and Business* 52: 405-421.
- Ciner C, Gurdgiev C and Lucey BM. (2013) Hedges and safe havens: An examination of stocks, bonds, gold, oil and exchange rates. *International Review of Financial Analysis* 29: 202-211.
- Coudert V and Raymond H. (2011) Gold and financial assets: are there any safe havens in bear markets. *Economics Bulletin* 31: 1613-1622.
- Darrat AF and Rahman S. (1995) Has futures trading activity caused stock price volatility? *The Journal of Futures Markets (1986-1998)* 15: 537.
- Debasish SS. (2009) Effect of futures trading on spot-price volatility: evidence for NSE Nifty using GARCH. *The journal of risk finance* 10: 67-77.
- Dee J, Li L and Zheng Z. (2013) Is gold a hedge or a safe haven? Evidence from inflation and stock market. *International Journal of Development and Sustainability* 2: 1-16.
- Demidova-Menzel N and Heidorn T. (2007) Gold in the investment portfolio. Frankfurt School-Working Paper Series.
- Dennis SA and Sim AB. (1999) Share price volatility with the introduction of individual share futures on the Sydney Futures Exchange. *International Review of Financial Analysis* 8: 153-163.
- Ding S, Cui T, Zheng D, et al. (2021) The effects of commodity financialization on commodity market volatility. *Resources Policy* 73: 102220.
- Dinh T, Goutte S, Nguyen DK, et al. (2022) Economic drivers of volatility and correlation in precious metal markets. *Journal of Commodity Markets* 28: 100242.
- Drake PP. (2022) The gold-stock market relationship during COVID-19. *Finance Research Letters* 44: 102111.
- Durham N. (2013) The Truth about Gold: Why It Should (or Should Not) Be Part of Your Asset Allocation Strategy.
- Echaust K and Just M. (2022) Is gold still a safe haven for stock markets? New insights through the tail thickness of portfolio return distributions. *Research in International Business and Finance* 63: 101788.
- Erb CB and Harvey CR. (2013) The golden dilemma. *Financial Analysts Journal* 69: 10-42.
- Faff R and Hillier D. (2004) An international investigation of the factors that determine conditional gold betas. *Financial Review* 39: 473-488.
- Fassas AP. (2012) Exchange-traded products investing and precious metal prices. *Journal of Derivatives & Hedge Funds* 18: 127-140.
- Faugere C and Van Erlach J. (2005) The price of gold: A global required yield theory. *The Journal of Investing* 14: 99-111.
- Feder-Sempach E, Szczepocki P and Bogolebska J. (2024) Global uncertainty and potential shelters: gold, bitcoin, and currencies as weak and strong safe havens for main world stock markets. *Financial Innovation* 10: 67.
- Filiz YILDIZ CONTUK HB, Bener GÜNGÖR. (2013) EFFECT OF GOLD PRICE VOLATILITY ON STOCK RETURNS: EXAMPLE OF TURKEY. *INTERNATIONAL JOURNAL OF ECONOMICS AND FINANCE STUDIES* 5.
- Foroohar R. (2016) *Makers and takers: How wall street destroyed main street*: Currency.
- Fortune P. (1989) An assessment of financial market volatility: Bills, bonds, and stocks. *New England Economic Review*: 13-28.
- Galloway TM and Miller JM. (1997) Index futures trading and stock return volatility: Evidence from the introduction of mid cap 400 index futures. *Financial Review* 32: 845-866.
- Ghazali MF, Lean H-H and Bahari Z. (2013) Is gold a hedge or a safe haven? An empirical evidence of gold and stocks in Malaysia. *International Journal of Business and Society* 14: 428.
- Ghosh D, Levin EJ, Macmillan P, et al. (2004) Gold as an inflation hedge? *Studies in Economics and Finance*.
- Gökbulut İ, Köseoğlu S and Atakan T. (2009) The effects of the stock index futures to the spot stock market: a study for the Istanbul Stock Exchange. *istanbul Üniversitesi İşletme Fakültesi dergisi* 38: 84-100.

- Gokmenoglu KK and Fazlollahi N. (2015a) The interactions among gold, oil, and stock market: Evidence from S&P500. *Procedia Economics and Finance* 25: 478-488.
- Gokmenoglu KK and Fazlollahi N. (2015b) The Interactions among Gold, Oil, and Stock Market: Evidence from S&P500. *Procedia Economics and Finance* 25: 478-488.
- Goyal M. (2014) Accelerating growth of gold ETF in India. *International journal of innovative research and development* 3.
- Gürgün G and Ünalmış İ. (2014) Is gold a safe haven against equity market investment in emerging and developing countries? *Finance Research Letters* 11: 341-348.
- He Z, O'Connor F and Thijssen J. (2018) Is gold a Sometime Safe Haven or an Always Hedge for equity investors? A Markov-Switching CAPM approach for US and UK stock indices. *International Review of Financial Analysis* 60: 30-37.
- Hillier D, Draper P and Faff R. (2006) Do precious metals shine? An investment perspective. *Financial Analysts Journal* 62: 98-106.
- Hood M and Malik F. (2013) Is gold the best hedge and a safe haven under changing stock market volatility? *Review of Financial Economics* 22: 47-52.
- Ibrahim MH. (2012) Financial market risk and gold investment in an emerging market: the case of Malaysia. *International Journal of Islamic and Middle Eastern Finance and Management*.
- Inclan C and Tiao GC. (1994) Use of cumulative sums of squares for retrospective detection of changes of variance. *Journal of the American Statistical Association* 89: 913-923.
- Iqbal J. (2017) Does gold hedge stock market, inflation and exchange rate risks? An econometric investigation. *International Review of Economics & Finance* 48: 1-17.
- Ivanov SI. (2013) The influence of ETFs on the price discovery of gold, silver and oil. *Journal of Economics and Finance* 37: 453-462.
- Jaffe JF. (1989) Gold and gold stocks as investments for institutional portfolios. *Financial Analysts Journal* 45: 53-59.
- Ji Q, Zhang D and Zhao Y. (2020) Searching for safe-haven assets during the COVID-19 pandemic. *International Review of Financial Analysis* 71: 101526.
- Joy M. (2011) Gold and the US dollar: Hedge or haven? *Finance Research Letters* 8: 120-131.
- Kamara A, Miller Jr TW and Siegel AF. (1992) The effect of futures trading on the stability of Standard and Poor 500 returns. *The Journal of Futures Markets (1986-1998)* 12: 645.
- Kasman A and Kasman S. (2008) The impact of futures trading on volatility of the underlying asset in the Turkish stock market. *Physica A: Statistical Mechanics and its Applications* 387: 2837-2845.
- Kaul A and Sapp S. (2006) Y2K fears and safe haven trading of the US dollar. *Journal of international money and finance* 25: 760-779.
- Killick R and Eckley I. (2014) changepoint: An R package for changepoint analysis. *Journal of statistical software* 58: 1-19.
- Killick R, Fearnhead P and Eckley IA. (2012) Optimal detection of changepoints with a linear computational cost. *Journal of the American Statistical Association* 107: 1590-1598.
- Killick R, Haynes K and Eckley I. (2016) changepoint: An R package for changepoint analysis. R package version 2.2. 2. Comprehensive R Archive Network. <https://CRAN.R-project.org/package=changepoint>
- Klein T. (2017) Dynamic correlation of precious metals and flight-to-quality in developed markets. *Finance Research Letters* 23: 283-290.
- Kopyl KA and Lee JB-T. (2016) How safe are the safe haven assets? *Financial Markets and Portfolio Management* 30: 453-482.
- Korkusuz B, Kambouroudis D and McMillan DG. (2023) Do extreme range estimators improve realized volatility forecasts? Evidence from G7 Stock Markets. *Finance Research Letters*: 103992.
- Krippner GR. (2005) The financialization of the American economy. *Socio-economic review* 3: 173-208.

- Kumar KK and Mukhopadhyay C. (2007) Impact of futures introduction on underlying index volatility: Evidence from India. *Journal of Management Science* 1.
- Kumar S and Ram R. (2019) Gold vs gold exchange traded funds: An empirical study in India. *Economic Affairs* 64: 295583.
- Lamoureux CG and Lastrapes WD. (1990) Heteroskedasticity in stock return data: Volume versus GARCH effects. *The Journal of Finance* 45: 221-229.
- Le Thi Thuy V, Oanh TTK and Ha NTH. (2024) The roles of gold, US dollar, and bitcoin as safe-haven assets in times of crisis. *Cogent Economics & Finance* 12: 2322876.
- Lee SB and Ohk KY. (1992) Stock index futures listing and structural change in time-varying volatility. *The Journal of Futures Markets (1986-1998)* 12: 493.
- Levin EJ, Montagnoli A and Wright R. (2006) Short-run and long-run determinants of the price of gold.
- Liebi LJ. (2020) The effect of ETFs on financial markets: a literature review. *Financial Markets and Portfolio Management* 34: 165-178.
- Lucey BM and Li S. (2015) What precious metals act as safe havens, and when? Some US evidence. *Applied Economics Letters* 22: 35-45.
- Lucey BM and Tully E. (2003) International portfolio formation, skewness and the role of gold. *Skewness and the Role of Gold (September 2003)*.
- Mallikarjunappa T and Afsal E. (2007) Futures Trading and Market Volatility in Indian Equity Market: A Study of CNX IT Index. *Asian Academy of Management Journal of Accounting and Finance* 3: 59-76.
- McKenzie MD, Brailsford TJ and Faff RW. (2001) New insights into the impact of the introduction of futures trading on stock price volatility. *Journal of Futures Markets: Futures, Options, and Other Derivative Products* 21: 237-255.
- Moriarty EJ and Tosini PA. (1985) Futures trading and the price volatility of GNMA certificates further evidence. *The Journal of Futures Markets (pre-1986)* 5: 633.
- Mukul MK, Kumar V and Ray S. (2012) Gold ETF performance: A comparative analysis of monthly returns. *The IUP Journal of Financial Risk Management* 9: 59-63.
- Naylor M, Wongchoti U and Gianotti C. (2011) *Abnormal returns in gold and silver exchange traded funds*: The Journal of Index Investing.
- Nguyen QN, Bedoui R, Majdoub N, et al. (2020) Hedging and safe-haven characteristics of Gold against currencies: An investigation based on multivariate dynamic copula theory. *Resources Policy* 68: 101766.
- O'Connell R. (2007) Gold exchange traded funds: their evolution and their role. *ETFs and Indexing 2007*: 129-135.
- P.K. Mishra JRD, S K Mishra. (2010) Gold Price Volatility and Stock Market Returns in India. *American Journal of Scientific Research Issue 9(2010)*, pp.47-55: 47-55.
- Pok WC and Poshakwale S. (2004) The impact of the introduction of futures contracts on the spot market volatility: the case of Kuala Lumpur Stock Exchange. *Applied financial economics* 14: 143-154.
- Pukthuanthong K and Roll R. (2011) Gold and the Dollar (and the Euro, Pound, and Yen). *Journal of Banking & Finance* 35: 2070-2083.
- Pule BP. (2013) Evaluation of gold as an investment asset: The South African context. University of the Witwatersrand, Faculty of Commerce, Law and Management
- Qureshi S, Rehman IU and Qureshi F. (2018) Does gold act as a safe haven against exchange rate fluctuations? The case of Pakistan rupee. *Journal of Policy Modeling* 40: 685-708.
- Reboredo JC. (2013a) Is gold a hedge or safe haven against oil price movements? *Resources Policy* 38: 130-137.
- Reboredo JC. (2013b) Is gold a safe haven or a hedge for the US dollar? Implications for risk management. *Journal of Banking & Finance* 37: 2665-2676.
- Reboredo JC and Rivera-Castro MA. (2014) Can gold hedge and preserve value when the US dollar depreciates? *Economic Modelling* 39: 168-173.
- Reyes MG. (1996) Index futures trading and stock price volatility: Evidence from Denmark and France. *Journal of Economics and Finance* 20: 81-88.

- Robbani MG and Bhuyan R. (2005) Introduction of futures and options on a stock index and their impact on the trading volume and volatility: Empirical evidence from the DJIA components. *Derivatives Use, Trading & Regulation* 11: 246-260.
- Robiyanto R. (2018) Gold vs bonds: What is the safe haven for the Indonesian and Malaysian capital market? *Gadjah Mada International Journal of Business* 20: 277-302.
- Ross SA. (1989) Information and volatility: The no-arbitrage martingale approach to timing and resolution irrelevancy. *The Journal of Finance* 44: 1-17.
- Ryan M, Corbet S and Oxley L. (2024) Is gold always a safe haven? *Finance Research Letters* 64: 105438.
- Sarkar S. (2012) The 'Glittering' Gold ETFs. *Management Accountant*: 65.
- Scott AJ and Knott M. (1974) A cluster analysis method for grouping means in the analysis of variance. *Biometrics*: 507-512.
- Seetharam Y and Bodington L. (2015) Gold in the South African market: A safe haven or hedge. *Applied Economics Quarterly* 61: 331-352.
- Selmi R, Mensi W, Hammoudeh S, et al. (2018) Is Bitcoin a hedge, a safe haven or a diversifier for oil price movements? A comparison with gold. *Energy Economics* 74: 787-801.
- Sen A and Srivastava MS. (1975) On tests for detecting change in mean. *The Annals of statistics*: 98-108.
- Shahzad SJH, Bouri E, Roubaud D, et al. (2020) Safe haven, hedge and diversification for G7 stock markets: Gold versus bitcoin. *Economic Modelling* 87: 212-224.
- Sherman EJ. (1982) Gold: a conservative, prudent diversifier. *The Journal of Portfolio Management* 8: 21-27.
- Singh B and Nadda J. (2013) Gold vs stock market: A comparative study of risk and return. *International Journal of Management and Research* 2: 103-110.
- Sinha S and Dutta M. (2013) Performance analysis of returns of Goldman Sachs gold exchange traded fund. *Global Journal of Management and Business Studies* 3: 793-800.
- Śmiech S and Papież M. (2017) In search of hedges and safe havens: Revisiting the relations between gold and oil in the rolling regression framework. *Finance Research Letters* 20: 238-244.
- Spyrou SI. (2005) Index futures trading and spot price volatility: Evidence from an emerging market. *Journal of Emerging Market Finance* 4: 151-167.
- Sunkara S and Srinivasa Reddy M. (2017) A Comparative Study on the Performance of Physical Gold, Gold, ETF's, Gold Bonds and Gold. *International Journal Of Core Engineering & Management* 4.
- Tang K and Xiong W. (2012) Index investment and the financialization of commodities. *Financial Analysts Journal* 68: 54-74.
- Tarchella S, Khalfaoui R and Hammoudeh S. (2024) The safe haven, hedging, and diversification properties of oil, gold, and cryptocurrency for the G7 equity markets: Evidence from the pre-and post-COVID-19 periods. *Research in International Business and Finance* 67: 102125.
- Tiwari AK, Aye GC, Gupta R, et al. (2020a) Gold-oil dependence dynamics and the role of geopolitical risks: Evidence from a Markov-switching time-varying copula model. *Energy Economics* 88: 104748.
- Tiwari AK, Aye GC, Gupta R, et al. (2020b) Gold-oil dependence dynamics and the role of geopolitical risks: Evidence from a Markov-switching time-varying copula model. *Energy Economics* 88.
- Todorova N. (2017) The asymmetric volatility in the gold market revisited. *Economics Letters* 150: 138-141.
- Triki MB and Maatoug AB. (2020) The GOLD market as a safe haven against the stock market uncertainty: Evidence from geopolitical risk. *Resources Policy*: 101872.
- Triki MB and Maatoug AB. (2021) The GOLD market as a safe haven against the stock market uncertainty: Evidence from geopolitical risk. *Resources Policy* 70: 101872.

- Tully E and Lucey BM. (2007) A power GARCH examination of the gold market. *Research in International Business and Finance* 21: 316-325.
- Umar Z, Bossman A, Choi S-Y, et al. (2023) The relationship between global risk aversion and returns from safe-haven assets. *Finance Research Letters* 51: 103444.
- Van den Burg GJ and Williams CK. (2020) An evaluation of change point detection algorithms. *arXiv preprint arXiv:2003.06222*.
- Wagner H and Matanovic E. (2012) Volatility Impact of Stock Index Futures Trading-A Revised Analysis.
- Xie S and Huang J. (2014) The impact of index futures on spot market volatility in China. *Emerging Markets Finance and Trade* 50: 167-177.
- Yilgor AG and Mebounou CLC. (2016) The effect of futures contracts on the stock market volatility: An application on Istanbul stock exchange. *Journal of Business Economics and Finance* 5: 307-317.
- Yu S-W. (2001) Index futures trading and spot price volatility. *Applied Economics Letters* 8: 183-186.