# Modeling the Relationship Between Gold Returns and Financial Risks: A Quantile Regression Approach for Egypt

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## Abstract

This article investigates the hypothesis that gold serves as a hedge and/or a safe- haven asset against financial risks associated with exchange rates, equity, oil prices, and inflation in Egypt, with its protective role depending on market conditions. To model this relationship, semi-parametric quantile regression (QR) is employed using weekly data from January 7, 1998, to July 26, 2023. QR captures the conditional effects of these risk factors across the distribution of gold returns, providing robust estimates that accommodate outliers and heavy-tailed data. Encompassing major events like the 2008 financial crisis and the COVID-19 pandemic, the Bai and Perron (1998) multiple breakpoints test, however, found no structural breaks, allowing the analysis to proceed with the full sample period. Key findings include: (1) no relationship between CPI inflation and gold returns across all quantiles is detected; potentially due to cultural factors such as wedding-related purchases and hoarding behaviour, (2) a negative association between gold return and EGX30 return is found across all market states ($5^{th}$ to $95^{th}$ quantiles), with significance primarily in normal market conditions ($50^{th}$ and $75^{th}$ quantiles); implying that gold serves as a safe haven in extreme market conditions, offsetting equity losses and hedging against stock return declines during stable periods, (3) an asymmetric relationship is found between gold returns and stock volatility, as measured by the conditional variance of stock returns derived from an AR(1)-GARCH(1,1) model, with negative correlations in lower quantiles and positive correlations in higher quantiles, (4) a positive but weak relationship is observed between gold and crude oil returns, significant in lower quantiles and insignificant in higher quantiles, suggesting that the link weakens under extreme market conditions, and (5) a consistent negative relationship is observed between gold and exchange rate returns, where an appreciation in exchange rates leads to lower gold returns, highlighting gold's role as an alternative investment during periods of currency depreciation. The robustness of these findings is confirmed by a slope equality test, which rejects the null hypothesis for all coefficients except inflation. These findings suggest that gold plays a significant role in hedging against stock volatility, currency risk, and extreme market conditions, and that both investors and the central bank should consider gold as a strategic tool for diversification and risk management in Egypt.

**Keywords:** gold return; quantile regression; oil prices; exchange rate; stock market; inflation
**JEL Classification: C14; C22; G19**

# نمذجة العلاقة بين عوائد الذهب والمخاطر المالية: مقاربة الانحدار الكمي في حالة مصر


## المستخلص

يختبر البحث فرضية أن الذهب يعمل كأداة تحوط وملاذ آمن ضد المخاطر المرتبطة بأسعار الصرف، وسوق الأسهم، وأسعار النفط، والتضخم في مصر، مع اختلاف دور الحماية التي يقدمها الذهب مع ظروف السوق. تم تطبيق أسلوب الانحدار الكمي شبه المعلمي لنمذجة العلاقة بين عوائد الذهب والمخاطر المرتبطة بأسعار الصرف، وسوق الأسهم، وأسعار النفط، والتضخم المقاس باستخدام مؤشر المستهلكين في مصر، اعتمادًا على بيانات أسبوعية تمتد من ٧ يناير ١٩٩٨ (وفقًا لتوافر البيانات) إلى ٢٦ يوليو ٢٠٢٣. يتيح الانحدار الكمي تحليل استجابة عوائد الذهب (كمتغير تابع) للمتغيرات المستقلة، عبر نقاط متعددة من التوزيع الشرطي للمتغير التابع، متجاوزًا التركيز على المتوسط الشرطي، مما يوفر تمثيلًا دقيقًا للعلاقة بين هذه المتغيرات، كما أنه يوفر **تقديرات حصينة** لمعاملات الانحدار، حيث لا تتأثر بالقيم الشاذة، آخذا في الاعتبار التوزيع ذي الذيل الثقيل للبيانات المالية. رغم أن فترة الدراسة قد شهدت تغييرات هيكلية، مثل الأزمة المالية العالمية في ٢٠٠٨ وجائحة كوفيد-١٩، فقد أظهرت نتائج اختبار التغيرات الهيكلية المتعددة الذي اقترحه Bai and Perron (1998) عدم رفض فرضية العدم، مما يشير إلى غياب التغيرات الهيكلية. وهكذا، تم نمذجة العلاقة بين المتغيرات باستخدام الفترة الزمنية الكاملة دون الحاجة لتقسيمها إلى فترات فرعية. وقد جاءت نتائج النموذج القياسي على النحو التالي: (١) لا توجد علاقة معنوية بين تضخم أسعار المستهلكين وعوائد الذهب في مصر عبر جميع نقاط توزيع العوائد، مما يمكن تفسيره بالعوامل الثقافية، مثل المشتريات المرتبط بالزواج وسلوك الاكتناز، (٢) ترتبط عوائد الذهب بعلاقة سالبة مع عوائد الأسهم المدرجة في مؤشر EGX30 عبر جميع حالات السوق (أي عند جميع النقاط المئوية للتوزيع الشرطي من ٥% وحتى ٩٥%)، مع وجود علاقة معنوية بشكل رئيسي في الظروف العادية للسوق (أي عند ٥٠% و٧٥% من التوزيع الشرطي للمتغير التابع). وفي ظل ظروف السوق المتطرفة، يعمل الذهب كملاذ آمن، مقللًا من الخسائر الناتجة عن الاحتفاظ بالأسهم، بينما يوفر أيضًا وسيلة للتحوط ضد انخفاضات عوائد الأسهم خلال الفترات المستقرة، (٣) توجد علاقة غير متماثلة بين عوائد الذهب وتقلبات عوائد الأسهم المدرجة في مؤشرEGX30 (المقاسة بالجذر التربيعي للتباين الشرطي لعوائد الأسهم المشتق من تقدير نموذج AR(1)-GARCH(1,1))، أي أنها علاقة سالبة في النقاط المئوية الدنيا للتوزيع الشرطي لعوائد الذهب، ولكنها علاقة موجبة في النقاط المئوية العليا للتوزيع الشرطي لعوائد الذهب، (٤) توجد علاقة موجبة، ولكنها ضعيفة، بين عوائد النفط الخام وعوائد الذهب، مع وجود معاملات انحدار معنوية إحصائيا في النقاط المئوية الدنيا للتوزيع الشرطي لعوائد الذهب، ومعاملات انحدار غير معنوية في النقاط المئوية العليا للتوزيع الشرطي، مما يدل على ضعف العلاقة في ظروف السوق المتطرفة، بالإضافة إلى ذلك، (٥) ترتبط عوائد الذهب وعوائد سعر الصرف بعلاقة سالبة معنوية إحصائياً عبر جميع النقاط المئوية في التوزيع الشرطي لعوائد الذهب، حيث يؤدي ارتفاع أسعار الصرف إلى انخفاض عوائد الذهب، مما يعكس دور الذهب كاستثمار بديل في أوقات انخفاض قيمة العملة. أخيرًا، تشير نتائج اختبار تساوي معاملات الانحدار الكمي إلى رفض الفرضية الصفرية لجميع المعاملات باستثناء معامل انحدار التضخم، مما يعزز مصداقية استخدام الانحدار الكمي في الدراسة الحالية. وهكذا، يمكن للمستثمرين والبنك المركزي المصري استخدام الذهب للتنويع، والتحوط من مخاطر سعر الصرف وتقلبات الأسهم.



**الكلمات الاستدلالية:** عوائد الذهب، الانحدار الكمي، أسعار النفط، سعر الصرف، سوق الأسهم، التضخم.

تصنيف JEL: **C14 ; C22 ; G19**

## 1- Introduction

Recent studies (e.g., Iqbal, 2017; Triki & Ben Maatoug, 2021; Mensi et al., 2023) have focused on safe haven assets in response to crises like the 2007-2009 Global Financial Crisis (GFC), the Covid-19 pandemic, and the Russian-Ukrainian conflict. These events, along with rising financial market integration, have prompted investors to seek assets that are weakly or uncorrelated with equities (Panagiotou, 2021). Gold, known for its ability to provide protection during market downturns and financial instability, remains a popular safe haven, hedge, and diversifier. Gold prices (returns) tend to increase during periods of uncertainty and stock market volatility, suggesting that investors shift away from risky stocks and seek the safety of gold. This behavior, referred to as flight-to-quality, occurs during financial market tightening, resulting in higher gold returns. This pattern has been supported by many scholars (e.g., Lucey & Li, 2015; Widjaja et al., 2023). Furthermore, while gold serves as a hedge and/or safe-haven against currency depreciation (Iqbal, 2017; Miyazaki, 2019), a stronger currency typically reduces the demand for gold as an alternative investment. Individual and portfolio investors purchase gold when its price is low relative to the local currency and profit when the price moves toward more favorable profit margins (Ali et al., 2020).

Gold has long been viewed as a store of wealth and a hedge during inflationary periods and economic crises, with its role established since the 1970s oil shocks, and during economic downturns. Investors increase their gold holdings in anticipation of rising inflation. Central banks also hold gold as a means of diversification to protect against economic instability (Baur & Lucey, 2010; Ali et al., 2020). While no comprehensive theoretical model explains its safe haven status, gold's historical use as currency and an inflation hedge, combined with its low correlation with other assets, contributes to its ongoing appeal (Baur & Luecy, 2010; Nikola & Miluti, 2019). Oil and gold prices have generally moved in parallel, especially since the early 2000s, both exhibiting an upward trend until the GFC in 2007. During the GFC, both markets saw significant declines, with oil prices dropping from $147 per barrel to $30, and gold falling from $1000 to $700 per ounce. Afterward, both prices recovered, but in 2020, oil prices experienced a sharp decline due to reduced demand driven by the Covid-19 pandemic, the Russia-Saudi Arabia oil price war, and limited storage capacity (Youssef & Mokni, 2021). The global Covid-19 pandemic significantly boosted gold demand, reaching 1083.8 tons in the first quarter of 2020. The outbreak, with its widespread economic impact, drove investors to seek safe-haven assets like gold (Ali et al., 2020).

The relationship between gold, stocks, oil, and other commodity markets has been explored in various studies (e.g., Dee et al., 2013; Miyazaki, 2019; Balcilar et al., 2021; Salisu et al., 2021; Adekoya et al., 2021; Triki & Ben Maatoug, 2021; Vieira et al., 2023), with many scholars recognizing gold's role in optimal portfolio diversification. Mensi et al. (2023), focusing on the MENA region, found that gold and stock markets showed positive correlations during bullish conditions and negative correlations during bearish periods, with risk spillovers from gold intensifying during crises. However, gold's effectiveness as a safe haven varied across MENA markets, suggesting that its protective function is conditional and requires adjustments in portfolio strategies based on market conditions. The research conducted by Baur and Lucey (2010), Baur and McDermott (2010), Triki and Ben Maatoug (2021), and Mensi et al. (2023) offer different perspectives on gold’s role as a hedge and safe haven asset, with these variations stemming from differences in market conditions, geographical context, and timeframe.

Since the 1990s, Egypt’s macroeconomic policies have undergone profound transformations, marked by significant challenges and reforms. In 1990/1991, the economy teetered on the brink of collapse due to persistent macroeconomic imbalances, including structural inefficiencies such as price distortions, an overvalued exchange rate, limited non-petroleum exports, and chronic budget deficits. The Central Bank of Egypt (CBE) primarily used policy tools to finance the public deficit, leading to a 21% inflation rate, while external debt surged to 151% of GDP, with debt servicing consuming 45% of export earnings and foreign reserves covering only three weeks of imports. In response, Egypt launched the Economic Reform and Structural Adjustment Program (ERSAP) to address these imbalances and enhance the stock market’s role in driving economic growth. These reforms yielded an average growth rate of 4.6% between 1991/92 and 1998/99, supported by the privatization of one-third of state-owned enterprises, the liberalization of foreign exchange and capital controls, and the correction of exchange rate misalignment. The current account improved from a 5% GDP deficit to a 1% surplus, foreign reserves increased, and inflation dropped from 19.7% (1991/92) to 2.4% (2000/01) due to a dollar-pegged exchange rate policy, which stabilized prices but caused a 40% real appreciation of the Egyptian pound. From 1999 to 2003, Egypt experienced a significant decline in its economic growth rate, which fell to approximately 3% during the first three years of this period, translating to a mere 1% in per capita terms. This slowdown was largely attributed to a series of external shocks, including the

1997 East Asian Financial Crisis, the 1997 terrorist attack in Luxor, a sharp decline in oil prices in 1998, the global repercussions of the September 11 attacks in 2001, and the invasion of Iraq in 2003. In response to these challenges, the Egyptian government implemented expansionary fiscal policies, which resulted in an increase in budget deficits from 3.9% of GDP in 1999/2000 to an average of 6.1% of GDP by 2002/2003 (Ahmed, 2014, 2017, 2018).

Pegging the Egyptian pound to the U.S. dollar initially weakened the country's competitiveness, putting pressure on the exchange market and leading to the reactivation of the parallel market. In response, the government floated the pound in January 2003, resulting in a 31% depreciation and a significant real exchange rate correction. This depreciation contributed to rising inflation, which reached 10.3% in 2003/2004 and 11.4% in 2004/2005, further exacerbated by rising energy prices and the avian flu epidemic. In the years that followed, Egypt's economic challenges deepened, particularly with the onset of the global financial crisis in 2008. As the economy struggled to recover, political instability emerged in 2011, beginning with the January revolution, followed by the 2012 presidential election, the ousting of the president in 2013, and violent clashes between supporters of the ousted president and the police. These events severely disrupted the economy, particularly capital and foreign exchange markets. In the two consecutive trading days following 25th of January 2011, panic selling led to a sharp decline in the stock market, with share values falling by nearly US $12 billion, or 12% of market capitalization, prompting an eight-week suspension of trading. Over the period from 2011 to 2015, the economy continued to struggle, with market capitalization dropping by 18%, the Egyptian pound depreciating by 34.3% against the U.S. dollar, and net foreign reserves shrinking by 52%. By 2015, real GDP growth had dropped from 3.1% in 2015 to 1.7% in the first quarter of 2016/2017. International reserves fell from $36 billion in 2010 to $15.4 billion by January 2015, largely due to declines in tourism, FDI outflows, and weakened exports. Despite efforts by the CBE to defend the pound, it continued to depreciate, reaching EGP 6.70/USD in March 2013 and EGP 13/USD in November 2016, following the currency’s flotation. Inflation surged to 23.3% by December 2016 (Ahmed, 2017; Helmy et al., 2018; Ahmed & Naguib, 2018).

Thus, the Egyptian economy has faced significant challenges over the past decade, marked by volatility in key indicators such as the exchange rate, inflation, international reserves, and the stock market. The Egyptian pound (EGP) depreciated sharply, with the exchange rate against the US dollar rising from 8.86 in 2015/16 to 30.89 in 2022/23, driven by external imbalances and global shocks such as the COVID-19 pandemic and the Russia-Ukraine conflict. This depreciation fueled inflationary pressures, with inflation surging to 37.5% in 2022/23, far exceeding the CBE' 7% target. Other factors driving this surge in inflation include global price increases and domestic supply disruptions. In response, the CBE raised interest rates three times between March and August 2023. Net international reserves fluctuated significantly, declining from $26.6 billion in 2010/11 to $17.5 billion in 2015/16, before rebounding to $44.5 billion in 2018/19, supported by IMF programs and foreign investment. However, reserves dropped again to $34.8 billion in 2022/23 due to currency pressures and external debt obligations. The stock market, represented by the EGX-30 index, recovered from a low of 5,373 points in 2010/11 following the political turmoil of the Arab Spring to reach 17,665 points in 2022/23, despite significant volatility, including a drop to 10,257 points in 2020/21 during the pandemic. In 2022/23, GDP growth slowed to 3.8%, primarily due to weak performances in the manufacturing and petroleum refining sectors, though private consumption and exports provided some support. On the fiscal front, the deficit slightly decreased to 6% of GDP, supported by higher tax revenues, which helped achieve a primary surplus of 1.6% of GDP. However, central government debt rose to 95.7% of GDP, largely due to the pound's devaluation. Meanwhile, the current account deficit improved, narrowing to 1.2% of GDP, as tourism receipts and Suez Canal revenues increased. During the COVID-19 pandemic, which disrupted global production, supply chains, and consumption patterns, the CBE implemented proactive measures, including a 300-basis point rate cut in March 2020, targeted credit initiatives for sectors such as agriculture, industry, and tourism, and a 20-billion-pound stock purchase program to stabilize the stock market. Additionally, Egypt sought financial assistance from the IMF and World Bank, issued foreign currency bonds, and promoted digital banking initiatives to ensure business continuity during lockdowns (ECE, 2024; African Development Bank Group, 2024; Emam, 2024).

Table no. (1) displays gold production in Egypt over the period 2010-2021. Production witnessed remarkable growth over the past decade, jumping from 4.67 metric tons in 2010 to a peak of 17.14 metric tons in 2016, an increase of around 267%. The expansion of Sukari Gold Mine is most likely to cause such an overwhelming increase. However, gold output steadily dropped after 2016, reaching 12.92 metric tones in 2021. Following the departure of foreign companies after the 1952 Revolution, Egypt's gold mining industry has faced remarkable challenges because Egypt focus shifted towards the oil and gas industries. Egypt's gold deposits are historically associated with geological formations like the Arabian-Nubian Shield, and mining activities date back to the Roman period. Firms such as Minex and the Pharaonic Company have expanded gold exploration employing advanced techniques since the 1980s. International enterprises, including Centamin, started gold exploration investments in the 1990s, which resulted in the Sukari mine— endowed with significant reserves and resources—becoming Egypt's only major producing mine. The Sukari gold mine produced 5.2 million ounces by February 2023, yielding an estimated $7.5 billion in income. Notwithstanding this progress, "Dahaba," illegal mining, spread and caused environmental damage and uncontrolled extraction. To attract foreign investments and control the industry, the Egyptian government passed regulatory changes and started international bidding rounds. Eleven companies had acquired exploration rights for eighty-two gold areas by 2020, suggesting a comeback of interest in Egypt's gold potential (El-Wardany & Jiao, 2023).

**Table no. 1 Production of gold mines in Egypt: 2010-2021**

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Production(1) | 4.67 | 6.31 | 8.18 | 11.1 | 11.73 | 13.66 | 17.14 | 16.94 | 14.69 | 14.95 | 14.07 | 12.92 |

(1) Measured in metric tones
Source: https://www.statista.com/statistics/792513/egypt-gold-mine-production/

The old 1956 mining law, creating the persistence of illegal mining practice, that frequently resulted in environmental harm, was replaced by the 2019 mining law. Significant amendments have been made to mining law, including the elimination of the requirement for legislative permission for exploratory contracts and the replacement of the profit-sharing model with a more straightforward tax and royalty-based system. It is anticipated that these changes will promote a more favorable investment environment for both domestic and foreign businesses. These reforms are anticipated to generate $10 billion in exports by 2040 and create up to 180,000 jobs (AmCham Egypt, 2021; Egypt Today, 2021). Gold exports represented around 37.1% of Egypt’s semi-finished exports (corresponding to 7% of total exports) in 2020/2021. The primary destination for Egypt’s gold exports, receiving approximately 50%, were Arab countries (National Bank of Egypt, 2022). Egypt's gold and jewelry industry has numerous competitive advantages that make it a significant center for the production and export of gold products to Arab and African nations. In this context, Egypt began the process of launching the City of Gold in the New Administrative Capital, as a specialized industrial hub for gold products. This hup is equipped with all the necessary infrastructure for manufacturing, production, high-end exhibitions, and training for craftsmen to refine their skills. Additionally, logistical considerations will be prioritized, particularly selecting a site that is connected to the new network of roads and axes (National Bank of Egypt, 2022).

Parallel with the development of gold production and export infrastructure, the CBE has significantly expanded its gold reserves as part of its strategy to enhance monetary resilience and hedge against external shocks. Table no.2 shows gold reserve held by the CBE over the period 2015-2023. Egypt has deliberately strengthened its gold reserves over the aforementioned period, with central bank holdings rising steadily from 75.61 metric tons in 2015 to 125.86 metric tons by mid-2023, representing an increase of 66%. The most significant surge occurred in the first quarter of 2022, when 80.91 to 125.02 metric tons. According to the World Gold Council (2023), this jump placed the CBE to the third place globally in gold reserves at the time, following the Central Bank of Turkey and the People's Bank of China respectively. This aligns with the Egypt's efforts to diversify foreign reserves and hedge against economic uncertainty. Bearing in mind that gold production in Egypt peaked at 17.14 metric tons in 2016 but later declined to 12.92 tons by 2021, implying that reserve growth can be attributed, mainly, to imports than domestic production. Accordingly, Egypt seeks to expand d its domestic mining (e.g., Sukari Mine) while aggressively accumulates its reserves to strengthen macroeconomic stability.

**Table no. 2 Gold Reserves Held by the CBE: 2015Q4-2023Q2**

| **Year** | **Gold Reserves (Tons)** |
|---|---|
| 2015Q1 | 75.61 |
| 2016Q4 | 75.61 |
| 2017Q4 | 76.44 |
| 2018Q4 | 78.38 |
| 2019Q4 | 79.31 |
| 2020Q4 | 80.23 |
| 2021Q4 | 80.91 |
| 2022Q1 | 125.02 |
| 2023Q2 | 125.86 |
| Source : Trading Economics https://tradingeconomics.com | |

Gold remains a crucial element of Egypt's economy, especially as a store of value. During economic crises, including inflation, currency devaluation, and geopolitical events such as Russia's invasion of Ukraine, gold has emerged as a favored safe-haven for Egyptians. Gold consumption has risen substantially over the years, especially during periods of economic uncertainty, as many Egyptians tend to purchase the yellow metal in the form of jewelry, bullion, or coins to preserve their money. According to the World Gold Council, Egyptians bought more than 362 tons of gold over the period extending 2010 to 2019, mainly for jewelry. In 2023, concerns of currency devaluation and higher rates of inflation have induced gold prices to jump by more than 50%. Thus, Egyptian tended to purchase the yellow metal to protect the value of their money, despite gold market volatility. Due to the scarcity of the US dollar that hinder gold imports, where the priority was given to critical goods, the Egyptian gold market has become locked. Gold market imbalance has deteriorated because gold holders increasingly prefer to hoard it rather than sell and, thus, the current demand exceeds supply by a 3: 1 ratio. To lessen price pressures, given the limited domestic supply and soaring demand, the Egyptian Ministry of supply considered a proposal to permit citizens to import limited amounts of gold from abroad, restricted at $10,000 per person. However, such a proposal seems to address hoarding behaviors and supply shortages but is unlikely to fully resolve the crisis (Farouk, 2019; Khalid, 2023).

Egyptian women tend to purchase gold jewelry for adornment and saving purposes. Moreover, rural residents and those of low-income view the yellow metal as a safe-haven during crises. For religious purposes, farmers do not prefer traditional savings instruments and, hence, they tend to convert their post-harvest earnings into gold with the aim of preserving the long-term value over interest-based returns. In Egypt, the role of the yellow metal goes beyond mere financial gain; it serves as a haven against economic uncertainty, ensuring that savings retain purchasing power despite market volatility. During times of uncertainty, different forms of gold, e.g. jewelry, bullion, or coins, represent a trusted store of value, highlighting its status as a preferred asset for both savers and crisis-weary citizens (Farouk, 2019). Traditionally, Egyptians have purchased gold jewelry as a long-term saving strategy, however; speculators have now turned to coins and ingots trying to reap a quick profit (Yee & Rashwan; 2024). Egypt's per capita gold consumption was 0.703 grams in 2010, then it plummeted to 0.452 grams in 2011 amid political instability, then it fluctuated over the decade, hitting a low of 0.232 grams in 2020 during the COVID-19 pandemic. By 2023, it increased to 0.541 grams which is still far below the higher, more stable levels seen in Gulf states like the UAE and Saudi Arabia (World Gold Council, 2023; Ahmed; 2023).

Based upon the above discussion, the current article addresses the following question: Do gold's responses to the risks associated with exchange rates, stocks, oil, and inflation in Egypt vary under different conditions in the gold market? Thus, it hypothesizes that gold serves as a protective asset, functioning as both a hedge and/or a safe-haven against risks associated with exchange rates, stock markets, oil prices, and inflation. Furthermore, the extent of this protection is hypothesized to vary depending on prevailing conditions in Egypt's gold market. To test this hypothesis, the current study employs the Quantile regression (QR) to model the relationship between gold returns and risks associated with exchange rates, stock markets, oil prices, and CPI inflation in Egypt, using weekly data from January 7, 1998, to July 26, 2023. QR enables the examination of relationships across various lower and higher quantiles of the gold return distribution. In contrast to the regression approach commonly employed in literature (e.g., robust OLS), which provides a partial view of the relationship between gold and other assets, QR offers a more comprehensive and nuanced perspective (Iqbal, 2017). QR is preferred over the Markov switching model, as the latter operates primarily within two regimes, thus failing to capture the full distributional heterogeneity of dependent variable responses—such as those occurring during bullish, bearish, or neutral (neither bullish nor bearish) market conditions. In other words, the benefit of using QR is its ability to offer insights into tail dependence (i.e., both upper and lower tails), in addition to the median (or normal state) (Korley & Giouvris, 2022).

The remainder of the paper is organized as follows: Section 2 reviews the relevant literature, whereas Section 3 describes the data and research methodology. Section 4 presents and analyzes the results. Finally, Section 5 concludes by addressing policy implications, limitations of the study, and areas for further research.

## 2- Brief Literature Review

Baur and Lucey (2010) were the pioneers in defining the concepts of hedging, diversifying, and safe-haven assets. They described hedging assets as financial instruments that help investors shield their portfolios during stable market conditions. Diversifying assets, on the other hand, are those that allow investors to lower portfolio risk and improve diversification in both normal market environments and times of stress. In contrast, safe-haven assets are financial assets that provide protection to investors' portfolios during periods of economic instability, market volatility, or geopolitical crises. The literature on the relationship between gold and key economic factors identifies several influential channels, including inflation (e.g., Aye et al., 2017; Baur & Lucey, 2010; Baur & McDermott 2010; and Beckmann et al., 2015), exchange rate movements (e.g., Le & Chang, 2016; Iqbal, 2017; Miyazaki, 2019), and portfolio allocation with the latter often explored in the context of whether gold serves as a safe haven against stock market volatility by comparing risk–return characteristics (e.g., Reboredo, 2013). Furthermore, the link between gold, stock, and oil, among other commodity markets, have been investigated (e.g., Dee et al., 2013; Miyazaki, 2019; Salisu et al., 2021; Adekoya et al., 2021; Triki & Ben Maatoug, 2021; Vieira et al., 2023). Gold's role in optimal portfolio diversification has been recognized by many scholars, e.g. Jaffe (1989), Chua et al. (1990), and Hillier et al. (2006). Jaffe (1989) suggested that its allocation should not exceed 10% of a portfolio. Chua et al. (1990), analyzing data from 1971–1988, found that gold exhibits a low CAPM beta and does not comove with stock prices, making it an effective hedge against portfolio risk. Hillier et al. (2006) further explored gold's diversification benefits using a GARCH model, and concluded that gold reduces stock price volatility, although its hedging effectiveness is contingent on market conditions. They found that gold did not offer superior hedging benefits during bearish markets, and a buy-and-hold strategy with a 9.5% allocation to gold outperformed a switching strategy in stock portfolios. Ourir et al. (2023) introduced a spectral analysis method for estimating hedge ratios and compared it with the DCC-GARCH model. Their findings showed that both methods reduce variance compared to unhedged portfolios, but spectral analysis outperforms DCC-GARCH in constructing hedge portfolios. Moreover, gold was found to significantly reduce risk, especially in Egypt, Dubai, Jordan, and Saudi Arabia, with reductions of over 70%. The optimal gold-stock allocation depends on the spectral density, with stable markets requiring more gold investment.

Baur (2011) examined the properties of gold and found that it has a hedge function against the depreciation of the US dollar, but not against consumer price inflation. Furthermore, he claimed that gold's use as a safety asset is a recent phenomenon. In addition, Beckmann et al. (2015) argued that gold's effectiveness as an inflation hedge may vary depending on the specific economic context. Employing the extreme value theory, Piplack and Straetmans (2010) empirically investigated the flight to quality or flight to liquidity hypotheses examining the tail dependence between US equities, government bonds, Treasury bills, and gold. Their empirical findings indicated that gold, to a certain degree, serves as a protective asset, mitigating the adverse effects of declines in the value of other assets. The studies by Baur and Lucey (2010), Baur and McDermott (2010), Triki and Ben Maatoug (2021), and Mensi et al. (2023) offer varying insights into gold's role as a hedge and safe-haven asset, reflecting differences in market conditions, geographical focus, and time periods. Baur and Lucey (2010) found that gold acts as a safe haven for stocks in the U.S., U.K., and Germany, but this property is temporary, dissipating as markets stabilize, and gold does not serve as a hedge for bonds. Baur and McDermott (2010) extended this analysis, finding gold to be a strong safe-haven during the global financial crisis in developed markets but less effective in emerging markets, because market imperfections and irrational investor behavior limit gold's protective role.

Balcilar et al. (2021) applied the Diebold and Yilmaz (2012) spillover index to monthly data from January 1986 to August 2018 to analyze return and volatility spillovers among the S&P 500, crude oil, and gold. Their findings revealed bidirectional spillovers among these assets, with oil playing a central role in the information transmission process. The roles of oil and gold as safe havens fluctuated during periods of financial and economic turbulence. The study also showed that return spillovers are significantly higher during extreme positive and negative shocks, whereas volatility spillovers are primarily elevated during extreme positive shocks. Triki and Ben Maatoug (2021) documented a significant negative volatility spillover from the S&P 500 to gold, indicating the influence of stock market movements on the gold market, though no spillover from gold to stocks was detected. Mensi et al. (2023), focusing on the MENA region, found that gold and stock markets showed positive correlations during bullish conditions and negative correlations during bearish periods, with risk spillovers from gold intensifying during crises. However, gold's effectiveness as a safe-haven varied across MENA markets, suggesting that its protective function is conditional and requires adjustments in portfolio strategies based on market conditions. Overall, these studies underscore gold's potential as a safe-haven and hedge, though its efficacy varies significantly by region, market conditions, and asset class. Moreover, Miyazaki and Hamori (2016) found that gold exhibited asymmetric correlations with stocks and the U.S. dollar, but not with bonds. Their study highlighted that these correlations showed significant time variation, particularly in exceedance correlations, even under similar market conditions across different asset pairs. The authors concluded that the dependence structure between gold and other financial assets was influenced by market conditions, with asymmetries emerging depending on whether the market was in an upward or downward trend. These findings highlight the importance for investors and fund managers to consider these asymmetric relationships to more effectively manage risk exposure.

Iqbal (2017) expanded on the frameworks of Baur and McDermott (2010) and Baur and Lucey (2010) to assess gold's hedging potential against stock market fluctuations, inflation, and exchange rate movements in India, Pakistan, and the United States. Using an EGARCH model to explain average gold returns and a quantile regression approach to examine the strength of gold's hedging potential in various market conditions, the study found robust evidence that gold acts as a safe-haven against exchange rate risk in Pakistan and India. However, gold's ability to hedge stock market risk was not consistently strong across different market conditions in the three countries.

Additionally, gold was found to hedge inflation risk in the U.S. only under average and bearish conditions, but not during bullish trends. The study also highlighted that gold offers a strong hedge against currency depreciation in Pakistan and India, particularly in daily data.

Dee et al. (2013) investigated the role of gold as a hedge against stock and inflation risks within mainland China's financial market. Their empirical analysis revealed that, for short-term investors, gold was consistently ineffective in mitigating stock and inflation risks. However, it proved to be an effective hedge for long-term investors. Despite this, gold was found to lack the characteristics of a safe-haven asset when investors faced stock, and inflation risks in the Chinese capital market. Adopting the robust quantile regression, Miyazaki (2019) explored the dynamic relationship between gold returns and key financial indicators, such as stock returns, stock market volatility, market stress, crude oil prices, and the US dollar. By utilizing quantile regression, the study goes beyond traditional mean-based analyses to capture how gold behaves in extreme market conditions, thereby providing a more nuanced understanding of its role as a hedging or safe-haven asset. The empirical results highlighted the instability of gold's relationship with financial variables over time, revealing multiple structural breaks. Notably, the study found that gold returns tend to increase during sharp declines in stock prices and heightened market stress, supporting the hypothesis that investors engage in "flight-to-quality" behavior. Bouri et al. (2017), Das et al. (2020), and Wu et al. (2019), among others, utilized the quantile regression (QR) model to assess gold's effectiveness as a hedge and a safe-haven asset against different market risks, such as disaggregated oil price shocks, economic policy uncertainty shocks, and financial stress. Their results demonstrate that gold's hedging effectiveness is contingent upon the prevailing state of the gold market (bearish, bullish, or normal) and is influenced by the nature of the oil price shocks driving the market forces. Moreover, the findings of Youssef and Mokni (2021) indicated that the reaction of gold returns to fluctuations in oil prices is contingent upon the nature of oil shocks and the prevailing conditions in the gold market. In a distinct context and utilizing a different methodology, Reboredo (2013) employed a copula approach to assess the hedging and safe haven properties of gold in relation to oil prices. Analyzing data from January 2000 to September 2011, the study revealed a positive and statistically significant correlation between the gold and oil markets; however, it found no evidence of tail dependence. This implies that gold does not offer effective hedging benefits against fluctuations in oil prices.

Hammoudeh and Yuan (2008) analyzed the volatility dynamics of three metals—gold, silver, and copper—using GARCH family models. Their findings indicated that oil shocks exert differential effects on the volatility of these metals, not influencing them uniformly. Madani and Ftiti (2022) explored the role of gold as a hedge or safe-haven against oil price and currency fluctuations under both stable and volatile market conditions, utilizing a rolling window approach to assess the time-varying relationships between gold-oil and gold-currency, based on high-frequency data (5-minute intervals) from 2017 to 2019. They found that gold acts as a weak hedge against oil price fluctuations but a strong hedge for currency movements across all market participants. It shows strong safe-haven properties against extreme currency fluctuations and short-term oil price changes. The study also highlights gold's scale-dependent role in reducing portfolio risk, offering both hedging and safe-haven benefits. These findings underscore the importance of considering market conditions and time scales when evaluating gold’s hedging potential for investors, financial institutions, and policymakers.

Salisu et al. (2021), Adekoya et al. (2021), and Vieira et al. (2023) investigated gold's role as a hedge and safe haven asset during times of financial uncertainty, with varying degrees of effectiveness based on the market and crisis. Salisu et al. (2021) found that gold serves as a significant safe-haven against oil price volatility during the COVID-19 pandemic. Similarly, Adekoya et al. (2021) demonstrated that gold effectively hedges risks related to both the oil and stock markets during the same crisis, with its effectiveness depending on market conditions, particularly when oil and stock prices were high. Vieira et al. (2023) focused on European markets, showing that gold acted as a strong hedge for European equities, particularly after the 2008 Lehman Brothers collapse, and as a safe-haven during extreme negative returns, such as the Greek bailout and Brexit referendum. However, gold’s safe-haven properties were less evident during the COVID-19 pandemic, and its hedge and safe-haven qualities for sovereign bonds were weaker. These studies emphasize gold’s potential as a risk mitigation tool, but its effectiveness as a safe-haven depends on the specific economic and market context.

Widjaja et al. (2024) investigated the safe-haven properties of gold and cryptocurrency, represented by the Cryptocurrency Uncertainty Index (UCRY) price, for stocks and bonds in both conventional and Islamic markets, encompassing stock indices, government bonds, Islamic stock indices, and Islamic bonds (IB). Employing a nonadditive panel quantile regression model, the study assessed the safe-haven characteristics of these assets under varying levels of cryptocurrency uncertainty over the period from March 11, 2020, to December 31, 2021. The findings highlighted three key results: (1) gold consistently served as a strong safe haven for both stocks and bonds in conventional and Islamic markets during bearish conditions; (2) UCRY Price proved to be a strong safe haven for conventional stocks and bonds but only weakly for Islamic stocks under high cryptocurrency uncertainty; and (3) gold demonstrated its safe haven capacity across both emerging and developed markets, whereas UCRY Price was more effective in developed countries. The study suggests that gold is a valuable asset for risk mitigation, particularly during economic instability, and should be incorporated into investment portfolios, including those seeking Shariah-compliant options. In contrast, cryptocurrencies are more widely adopted in developed markets, and emerging economies require enhanced regulatory guidance to foster greater literacy and understanding of cryptocurrency's potential as a limited safe-haven asset. Manzli and Jeribi (2024) assessed the hedging and safe-haven roles of gold and Bitcoin against G7 stock market indices during three global crises: the COVID-19 pandemic, the Russia-Ukraine conflict, and the collapse of Silicon Valley Bank (SVB). Using a Quantile-VAR connectedness approach, they found that both gold and Bitcoin acted as effective hedges and safe havens during crises, with gold outperforming Bitcoin, particularly during the war and the SVB collapse. U.S. and Japanese stocks were identified as risk diversifiers, while other G7 stocks were considered "risk-on" investments. The results were largely consistent across different quantiles, except for the S&P 500. The study concluded that the financial impacts of the pandemic and the war were more significant than the banking crisis, highlighting gold as a primary safe-haven and emphasizing the need for appropriate risk diversification strategies.

## 3- Data and methodology

### 3-1 Data Description and Sources

The focus of the current study is to model the relationship between gold retunes and a set of financial variables, specifically stock market return, stock market return volatility, returns of crude oil, the foreign exchange rate of the Egyptian pound and CPI inflation. According to (Miyazaki, 2019), a weekly frequency seems to be a proper option to ensure a large number of observations and eliminate noise associated with daily frequency. Hence, the current study employs a weekly dataset that extends from 7$^{th}$, January 1998 (determined by the availability of data) to 26$^{th}$, July 2023. The description of data and their sources are listed in Table (3). Returns of employed variables are calculated as the log difference between two consecutive periods. Monthly inflation, computed as percent change in year-over-year natural logarithm of consumer price index, is interpolated using the **quadratic method** to convert data into weekly observations. Moreover, stock market volatility is computed as the square root of the estimates obtained by applying an AR(1)-GARCH (1,1) model to the EGX30 Index returns, as will be discussed in the empirical results section.

**Table (3): Data Description and Sources**

| Variable | Description | Source |
|---|---|---|
| Gold Price | Weekly spot gold price per troy ounce – local currency | World Gold Council (WGC) website: https://www.gold.org/goldhub/data/gold-prices |
| Stock Price | Weekly closing prices of EGX30 index | The Egyptian exchange website: https://www.egx.com.eg/en/homepage.aspx |
| Foreign Exchange rate | Weekly nominal effective exchange rate. It is the value of the Egyptian pound against the weighted basket of currencies of Egypt's trading partners. An increase of nominal effective exchange rate indicates an appreciation of the local currency against the weighted basket of foreign currencies. | DataStream |
| Oil Prices | Weekly nominal spot price of oil (West Texas Intermediate) | Federal Reserve Bank of St. Louis https://fredhelp.stlouisfed.org |
| CPI | Monthly consumer price index | https://datacatalog.worldbank.org/dataset/global-economic-monitor |
| Stock return Volatility | The square root of the estimates obtained by applying an AR(1)-GARCH (1,1) model to the EGX30 Index returns | Authors' calculations using EViews 12 |

## 3-2 Methodology

### 3-2-1The symmetric GARCH(1,1): A measure stock return volatility

ARCH-family models have been widely used to explore the dynamics of the conditional variance of financial variables (e.g., volatility clustering) [see, for example, Hillier et al., 2006; Iqbal, 2017]. Bollerslev *et al.* (1992) showed that the GARCH(1,1) specification works well in most applied situations. Thus, the symmetric GARCH(1,1) model with conditional normal distribution is considered in the current study. Specifically, we employ the

AR(1)-GARCH(1,1) to generate the estimates of the conditional variance as a measure of stock return volatility.

$$Mean\ Equation: \quad SRET_t = \mu_0 + \mu_1 SRET_{t-1} + \varepsilon_t \quad (1)$$

$$\varepsilon_t = z_t\sqrt{h_t}\ , \quad z_t \sim IID(0,1)$$

$$\text{Variance Equation } h_t = \omega_0 + \omega_1\varepsilon_{t-1}^2 + \omega_2 h_{t-1} \quad (2)$$

$$\text{With } \omega_0 \geq 0,\ \omega_1 \geq 0,\ \omega_2 \geq 0 \text{ and } (\omega_1 + \omega_2) \prec 1$$

$SRET$ represents stock returns. In this framework, the conditional variance, $h_t$, is a function of three terms: the constant term $\omega_0$, the ARCH term measured by the lag of residuals from the mean equation, $\varepsilon_{t-1}^2$, representing news about volatility from the previous period, and the GARCH term, $h_{t-1}$, the last period's forecast variance. The estimate of $\omega_1$ shows the impact of current news on the conditional variance whereas the estimate of $\omega_2$ represents the persistence of volatility to a shock, in other words, the effect of old news on volatility. The persistence of shocks to volatility depends on the sum of ARCH and GARCH coefficients (i.e., $\omega_1 + \omega_2$). The closer the sum to unity the greater the persistence of shock to volatility is. A preliminary step before fitting this model to stock returns is to assess the stationarity properties of the returns using the ADF and PP unit root tests, introduced by Dickey and Fuller (1981) and Phillips and Perron (1988), respectively.

## 3-2-2 ROLS and QR

The relationship between the dependent variable and regressors is modeled using the Ordinary Least Squares (OLS) and Robust OLS (ROLS) methods. Equation (3) illustrates the *classical linear regression model*. By giving each observation equal weight and minimizing the sum squared residuals of the regression, as indicated by equation (4), the OLS technique estimates the unknown parameters.

$$Y_t = X_t\,\beta + u_t \quad (3)$$

$$\min_{\beta \epsilon R} \sum_{t=1}^{n} (Y_t - X'\beta_t)^2 \quad (4)$$

Where: $n$ is the number of observations, $Y_t$ is the $n \times 1$ vector of the dependent variable, $X_t$ is the $k \times 1$ vector of regressors including the constant, $\beta$ is the $k \times 1$ vector of the coefficients of the model to be estimated, and $u_t$ is the $n \times 1$ vector of the unobservable stochastic error term $(u_t \sim N(0, \sigma^2))$.

To lessen the influence of outliers on the results, the ROLS method reduces their weight. With different emphasis, ROLS approaches include the M-estimation of Huber (1973), S-estimation of Rousseeuw & Yohai (1984), and MM-estimation of Yohai (1987). S-estimation deals with outliers in the regressor variables (high leverage), M-estimation targets outliers in the dependent variable (big residuals), and MM-estimation combines the two methods. Outliers in both dependent and independent variables are thus considered by MM-estimation. MM-estimation is used in this study. The Bisquare weight function indicated by equation (5) is selected in accordance with Miyazaki (2019).

$$\begin{cases} \frac{c^2}{6}\left(1-\left(1-\left(\frac{X}{c}\right)^2\right)^3\right), & if\ |X| \le c, \\ \frac{c^2}{6} & otherwise. \end{cases} \qquad (5)$$

Where c is an arbitrary positive tuning constant, specified as c=4.685

The return distributions of financial assets often exhibit the statistical characteristics of heavy tails and asymmetry, deviating from the assumption of normality. In such a case, inference based on classical regression models may result in misleading conclusions. Thus, QR, introduced by Koenker and Bassett (1978), has been widely applied to model the returns of financials assets and commodities including, inter alia, stocks, foreign exchange, gold, and oil (e.g., Ahmed et al., 2024; Miyazaki, 2019; Iqbal, 2017; Tsai, 2012; Ali et al., 2020; Korley & Giouvris, 2022). QR facilitates the examination of the effects of explanatory variables at various quantiles of the endogenous variable distribution, offering insights beyond the average effect (Ahmed et al., 2024). Hence, QR enables the exploration of the effects of stock returns, stock return volatility, foreign exchange increments, oil price changes, and CPI inflation under different conditions of gold market (i.e., extremely bearish ($5^{th}$ quantile), bearish ($10^{th}$ and $25^{th}$ quantiles), normal ($50^{th}$ and $75^{th}$ quantiles) and bullish ($90^{th}$ and $95^{th}$ quantiles)). Equation (6) represents the conditional quantile function of Y. Estimating the conditional quantile functions requires solving equation (7) by minimizing the expression defined in equation (8) (Tsai, 2012; Ali et al, 2020).

$$Q_Y(\tau|X) = X'\beta(\tau) \qquad (6)$$

$$\min_{\beta \epsilon R^{p}} \sum_{t=1}^{n} \rho_\tau (Y_t - X'\beta_t) \tag{7}$$

$$\min_{\hat{\beta}} \left[ \tau \sum_{Y_t \geq \hat{\beta} X_t} |Y_t - \hat{\beta} X_t| + (1 - \tau) \sum_{Y_t < \hat{\beta} X_t} |Y_t - \hat{\beta} X_t| \right] \tag{8}$$

Where $X_t' \hat{\beta}_\tau$ approximates the $\tau - th$ conditional quantile of $Y$, when $\tau$ approaches zero (one), $X_t' \hat{\beta}_\tau$ characterizes the behaviour of $Y$ (Tsai, 2012)

## 4- Empirical Results

To obtain a measure of stock market volatility, an AR(1)- GARCH(1,1) model is to be fitted for stock returns. However, a preliminary step before fitting this model for stock returns is to check the stationarity properties of stock returns using ADF and PP unit root tests introduced by Dickey and Fuller (1981) by Phillips and Perron (1988), respectively. Equations of ADF and PP regressions include only an intercept given that the time plots of these variables, shown in Figure no.1, provide a clue that they seem to have intercepts but not a trend. **Table (4)** shows the results of these two tests which agree that all employed variables, including stock returns, are stationary at levels given that the null hypothesis that the series under consideration contains a unit root has to be rejected beyond 1% level of significance. Thus, we could proceed to model stock returns using the AR(1)-GARCH(1,1) model.

**Table (4): Results of ADF and PP tests for employed variables**

| **Variable in levels** | ADF | | PP | | Order of integration |
|---|---|---|---|---|---|
| | Test Stat(1) | lag | Test Stat(1) | Bandwidth | |
| GRET<br>p-value | -39.59<br>(0.000) | 0 | -39.59<br>(0.000) | 0.338 | GRET ~ I(0) |
| ORET<br>p-value | -35.90<br>(0.000) | 0 | -35.90<br>(0.000) | 0.111 | ORET ~I(0) |
| SRET<br>p-value | -35.34<br>(0.000) | 0 | -35.34<br>(0.000) | 0.136 | SRET ~I(0) |
| FRET<br>p-value | -24.86 | 1 | -40.67<br>(0.000) | 0.898 | FRET ~I(0) |
| INF | -6.98 | 10 | -14.88 | 5.17 | INF ~I(0) |

| | | | | | |
|---|---|---|---|---|---|
| p-value | (0.000) | | (0.000) | | |

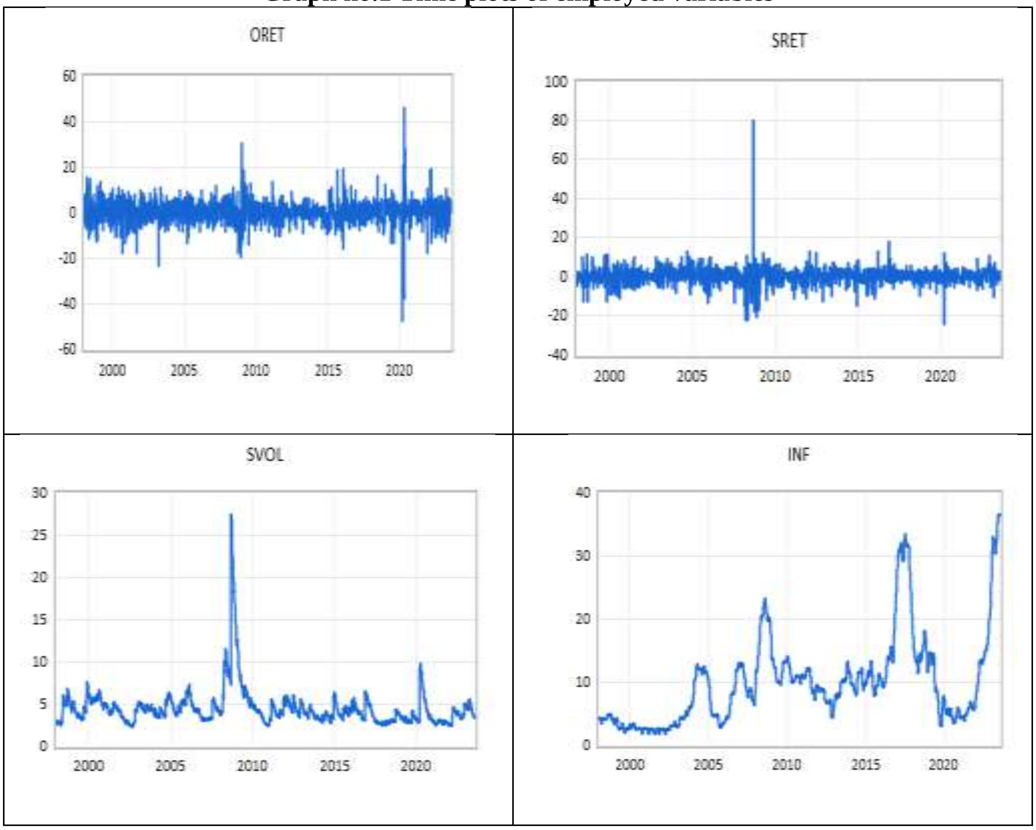
Notes: (1) ORET is oil returns, SRET is stock market returns, INF stands for inflation, GRET is gold returns, and FRET indicates foreign exchange returns. (2) Critical values are -3.435(1%), -2.863(5%), -2.568(10%) for a regression that includes intercept only. Automatic lag selection for ADF test is based on SIC and the automatic bandwidth selection, for PP test, is Andrew's automatic using Bartlett Kernel. (3) A regression that includes only an intercept is used taking into consideration the plot of variables shown in Figure no.1. (4) The null hypothesis of nonstationary has to be rejected for all variables beyond 1% level of significance.

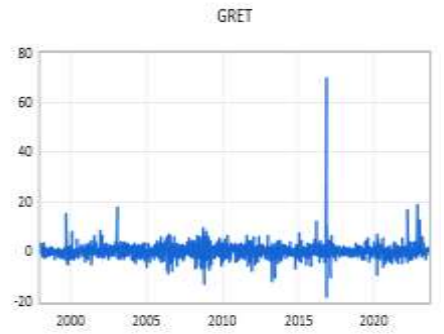
**Source**: Authors' calculations based on EViews 12.

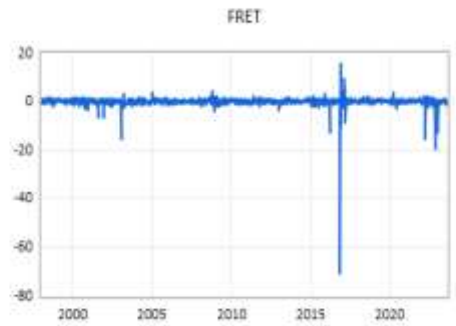
Table (5) displays the parameter estimates of the employed AR(1)-GARCH(1,1) model, their corresponding *p*-values, log-likelihood, and diagnostic tests. Diagnostic tests include the Box-Pierce portmanteau statistic for the first eight autocorrelations of standardized residuals (i.e., LBQ (8)) and squared standardized residuals (i.e., $LB^2Q(8)$, and the LM-ARCH(8) test technique introduced by Engle (1982) that evaluates the joint significance of the regression coefficients of the squared residuals on their own past values up to lag eight. The LM-ARCH test statistic is distributed as $\chi^2(p)$ where p represents the number of lags. In addition, diagnostic tests include the joint bias test of Engle and Ng (1993), i.e., JB test, that evaluates the null of no leverage effects in standardized residuals. This is tested through regressing squared residuals on lagged positive and negative shocks. It is worth mentioning that estimates of AR(1)-GARCH(1,1) model are computed through employing the quasi-maximum likelihood estimator of Bollerslev and Woolbridge (1992).

The AR(1)-GARCH(1,1) model is found adequate in capturing the dynamics of the first-two moments of stock returns because both standardized residuals and squared standardized residuals up to lag eight are free from autocorrelation and since squared standardized residuals are free from ARCH effects up to eight lags. In addition, the estimated AR(1)-GARCH(1,1) model is found to be stable given that the joint Nyblom-Hansen test statistic (i.e., joint LC) is lower than its corresponding critical value at 1% level of significance. The joint LC statistic tests the null hypothesis that the entire vector of parameters is stable against the alternative hypothesis that this vector may not be stable (i.e., follows a martingale process). Nyblom (1989) argues that this hypothesis encompasses the case of one or more structural breaks. The joint LC test statistic is robust for heteroscedasticity and has an asymptotic distribution, which is tabulated in Nyblom (1989) and Hansen (1990), depends solely upon the number of estimated parameters. Furthermore, there is no evidence for misspecification in the GARCH model since the *p*-value accompanying the joint bias test of Engle and Ng (1993) is significantly higher than all conventional levels of significance. Thus, negative and positive shocks have the same effect on stock returns volatility. In addition, the estimated GARCH(1,1) model satisfies the non-negativity condition of the conditional variance given that all estimated coefficients in the variance equation are positive and also it satisfies the stationarity condition given that the sum of the ARCH term (i.e., $\omega_1$) and GARCH term (i.e., $\omega_2$) is less than to one.

**Graph no.1 Time plots of employed variables**






ORET is oil returns. SRET denotes stock market returns. SVOL stands for stock market volatility. INF stands for inflation. GRET is gold returns. FRET is depreciation/appreciation of the Egyptian pound.

**Table (5): Estimates of AR(1)-GARCH(1,1) of stock returns volatility under normal distribution**

$$Mean\ Equation: \quad SRET_t = \mu_0 + \mu_1\, SRET_{t-1} + \varepsilon_t$$

$$\varepsilon_t = z_t\sqrt{h_t} \quad z_t \sim IID(0,1)$$

$$h_t = \omega_0 + \omega_1 \varepsilon_{t-1}^2 + \omega_2 h_{t-1}$$

$$\text{With } \omega_0 \geq 0,\ \omega_1 \geq 0,\ \omega_2 \geq 0 \text{ and } (\omega_1 + \omega_2) \prec 1$$

| **Mean Equation** | | |
|---|---|---|
| **Parameters** | **Estimates** | **Computed test statistic (p-value)** |
| $\mu_0$ | 0.234 | 2.016 (0.035)** |
| $\mu_1$ | 0.1058 | 2.881 (0.004)* |
| **Variance Equation** | | |
| **Parameters** | **Estimates** | **Computed test statistic (p-value)** |
| $\omega_0$ | 0.367 | 0.706 (0.47) |
| $\omega_1$ | 0.1105 | 4.258 (0.000)* |
| $\omega_2$ | 0.8870 | 17.446 (0.000)* |
| **Diagnostics** | | |
| **Tests** | **Computed test statistics** | **p-value** |
| LB Q(8) | 9.741 | 0.234 |
| LB2 Q(8) | 1.293 | 0.996 |
| ARCH(8) | 1.290 | 0.99 |
| Joint $L_C$ | 0.5398 | Critical values of Hansen (1990): 1.880 (1%), 1.470 (5%) and 1.280 (10%) |
| JB test | 0.5089 | 0.916 |

**Notes**: (1) Standard errors are calculated using the robust method of Bollerslev and Wooldridge (1992). (2) LB $Q_{(8)}$ and $LB^2$ $Q_{(8)}$ are the Box-Pierce portmanteau statistic for the first eight autocorrelations of standardized residuals and squared standardized residuals, respectively. (3) $ARCH_{(8)}$ is the Lagrange multiplier statistic of Engle (1982) up to lag 8, which is asymptotically distributed as $\chi^2(q)$, tests for autoregressive conditional heteroscedisticity (ARCH) in the residuals. (4) Joint $L_C$ indicates the test statistics of Nyblom (1989), which is asymptotically robust to heteroscedasticity, tests the null hypothesis of stability of the entire vector of estimated parameters against an alternative that the entire vector may be unstable. The critical values of Hansen (1990), which depends on the number of estimated parameters, are reported in the third column. (6) JB test presents the joint bias test of Engle and Ng (1993) that tests the null of no leverage effects in standardized residuals. * and ** indicate that computed coefficients are significantly different from zero at 1% and 5% levels of significance, respectively. **Source: Authors' calculations based on EViews 12.**

Panels A and B of Table (6) show, respectively, descriptive statistics and correlation matrix of variables employed in the following empirical analysis. The mean returns on gold, oil, and EGX30 are 0.311, 0.117 and 0.216, respectively. The mean inflation rate is 0.186. A variable's unconditional standard deviation gives an indication of how much it varied during the study period. Bearing in mind that all variables expressed in a natural logarithmic form, it is possible to compare the degree of variation across these variables. Oil returns display the highest level of weekly volatility followed by EGX30 Index return, gold returns, exchange rate returns, and inflation, respectively. Inflation (INF), gold returns (GRET) and stock returns (SRET) and stock market volatility (SVOL) display positive skewness. Hence, distributions of these variables have a heavy right tail, implying that they occasionally exhibit a sharp rise. In contrast, returns on oil (ORET) and the trade-weighted exchange rate (FRET) exhibit negative skewness and thus their distributions have a heavy left tail, indicating that they occasionally exhibit a big negative return. Furthermore, all employed variables are leptokurtic showing excess kurtosis. Thus, the Jarque–Bera test statistics reject the null hypothesis of unconditional normality, beyond 1% level of significance for all variables, confirming results obtained from the coefficients of skewness and kurtosis.

**Table (6): Descriptive Statistics and Correlation Matrix**

| **Panel A: Descriptive Statistics** | | | | | | |
|---|---|---|---|---|---|---|
| **Variables** | **GRET** | **ORET** | **SRET** | **FRET** | **INF** | **SVOL** |
| Mean | 0.3112 | 0.1174 | 0.2168 | -0.1380 | 0.1861 | 4.4767 |
| Minimum | -18.019 | -48.099 | -24.556 | -70.808 | -1.812 | 2.243 |
| Maximum | 69.635 | 46.232 | 80.311 | 15.449 | 2.444 | 27.359 |
| Std. Dev | 3.232 | 5.691 | 4.744 | 2.421 | 0.294 | 2.304 |
| Skewness | 7.618 | -0.3914 | 3.085 | -19.528 | 0.8933 | 4.985 |
| Kurtosis | 164.08 | 13.655 | 65.170 | 553.789 | 10.717 | 38.053 |
| Jarque-Bera Statistic (p-value) | 1452999 (0.000)* | 6335.2 (0.000)* | 216630 (0.000)* | 16921632 (0.000)* | 3482.6 (0.000)* | 73656.6 (0.000)* |
| Num. of Obs. | 1332 | 1332 | 1332 | 1332 | 1332 | 1332 |

| **Panel B: Correlation Matrix** | | | | | | |
|---|---|---|---|---|---|---|
| **Variables** | **GRET** | **ORET** | **SRET** | **FRET** | **INF** | **SVOL** |
| **GRET** | 1 | | | | | |
| **ORET** | 0.130* | 1 | | | | |
| **SRET** | 0.089* | 0.098* | 1 | | | |
| **FRET** | -0.769* | -0.058** | -0.155* | 1 | | |
| **INF** | 0.064** | 0.0328 | 0.0229 | -0.094* | 1 | |
| **SVOL** | 0.015 | -0.067** | -0.0625 | 0.0237 | -0.0237 | 1 |

Notes: ORET is oil returns. SRET denotes stock market returns. SVOL stands for stock market volatility (obtained from the GARCH(1,1) model). INF stands for inflation. GRET is gold returns. FRET is depreciation/appreciation of the Egyptian pound. * and ** indicate that computed coefficients are significantly different from zero at 1% and 5% levels of significance, respectively.
Source: Authors' calculations based on EViews 12.

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Panel B of Table (6) presents the correlation matrix between employed variables. Gold's return is strongly negatively correlated with the change in the trade-weighted exchange rate as expected. However, it is weakly positively correlated with oil returns, stock returns, inflation and stock market volatility. Oddly, the EGX30 Index returns, and its volatility show a weak negative, but insignificant, correlation.

**Table (7): Results of OLS and Robust OLS Regressions**

| **Panel A: Results of OLS Regressions** | | |
|---|---|---|
| | Estimates | Test statistics (p-value) |
| Constant | -0.054 | -0.4238 (0.671) |
| ORET | 0.05231* | 5.276 (0.000) |
| SRET | -0.0255** | -2.1244 (0.033) |
| FRET | -1.0295* | -43.783 (0.000) |
| INF | -0.0767 | -0.4015 (0.688) |
| SVOL | 0.0529** | 2.1724 (0.030) |
| $Adj\ R^2$ | 0.60 | |
| Breusch–Pagan–Godfrey test: $\chi^2(4)$: | 7.515 (0.111) | |
| White test: $\chi^2(20)$: | 239.64 (0.000) | |
| **Panel B: Multiple breakpoint test:** Bai-Perron test of L+1 vs. L sequentially determined breaks | | |
| H0: No break vs. Ha: one-time break<br>Scaled F-stat = 13.525 and critical value = 20.08 (5%) | | |
| **Panel C: Results of Robust OLS Regression** | | |
| **Variable** | **Estimates** | **Test statistic (p-value)** |
| Constant | -0.267 | -1.870 (0.061) |
| ORET | 0.045* | 4.726 (0.000) |
| SRET | -0.029* | -2.729 (0.006) |
| FRET | -1.014* | -49.74 (0.000) |
| INF | -0.013 | -0.770 (0.938) |

| | | |
|---|---|---|
| SVOL | 0.108* | 3.510 (0.000) |
| $Adj\ R^2$ | 0.70 | |

Notes: (1) * and ** indicate that estimated coefficients are significantly different from zero at 1% and 5% level of significance, respectively. (2) The relationship between gold return series and other independent variables is allowed a maximum of five breaks in the estimation using the multiple breakpoints test of Bai & Perron (1998). The number of structural changes considered in test rises gradually. First, the null hypothesis of "no breaks" is evaluated against the alternative hypothesis of "one-time break." If the null is rejected, then, the “null hypothesis of one-time break” against the alternative hypothesis of two times break is evaluated. If the null is rejected, the technique proceeds to test $H_0$ 2 times break vs. Ha: 3 times break, and so on.

**Source: Authors’ calculations based on EViews 12.**

Panels A and C of Table (7) provide the estimation results based on OLS and robust OLS regression using the full sample period. Structural breaks are likely to impact the variables' relationships, potentially biasing slope variables (Korley & Giouvris, 2022). The study's span, characterized by shocks like the 2008 financial crisis and COVID-19 pandemic, may suggest structural breaks in dependence. Thus, the multiple breakpoints test developed by Bai and Perron (1998), is employed to identify these multiple breakpoints. Results of multiple breakpoints, shown in panel B of Table (7), reveal no evidence of structural breaks given that the calculated F-scaled statistic (that equals 13.525) is lower than its corresponding critical value (equals to 20.08) at 5% level of significance. Accordingly, we could use the results of full sample period in our analysis.

Results of the significance of OLS and robust OLS estimates are roughly similar. In both regressions, EGX30 Index returns, and nominal trade-weighted exchange rate have significant negative impacts on gold returns. In contrast, both oil return and stock market volatility have significant positive influence on gold return whereas gold return has a negative but insignificant correlation with inflation rate in OLS and robust OLS regression. Positive association between gold return and oil return indicates that investors are likely to consider these two commodities to belong to the same asset class. The coefficient for the exchange rate is approximately one in absolute terms, implying that the gold return changes almost in a one-to-one negative association with the exchange rate. These results are in line with the results of Miyazaki (2019). According to (Triki & Ben Maatoug, 2021), the positive influence of stock market volatility on gold return indicates that increased financial risk is likely to cause share prices to decline and gold prices to rise. It is worth mentioning that coefficients of oil and stock returns in the robust OLS regression are lower than their counterparts in the OLS regression.

Hence, it seems that the estimates obtained by the OLS have a bias caused by the existence of outliers. According to the result of the White test, the null hypothesis of homoscedasticity is to be rejected and, thus, the robust OLS regression results are more reliable than the OLS.

**Table (8): Results of Quantile Regression**

| **Coefficient** | **Quantiles** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0.05** | **0.10** | **0.25** | **0.50** | **0.75** | **0.90** | **0.95** |
| Constant | **-1.992**<br>[-5.666] * | **-1.318**<br>[-4.032] * | **-0.704**<br>[-2.554] * | **-0.086**<br>[-2.554] | **0.519**<br>[2.462] ** | 1.391<br>[7.0971] * | 2.124<br>[6.596] * |
| ORET | **0.0924**<br>[6.402] * | **0.0613**<br>[3.543] * | **0.070**<br>[3.831] * | **0.048**<br>[3.530] * | **0.032**<br>[2.634] * | 0.0116<br>[0.591] | 0.0016<br>[0.070] |
| SRET | -0.004<br>[-0.105] | -0.011<br>[0.418] | -0.006<br>[-0.398] | **-0.027**<br>[-2.025] ** | **-0.0399**<br>[-2.634] * | -0.0264<br>[-1.298] | -0.0376<br>[-0.963] |
| FRET | **-1.025**<br>[-95.64] * | **-0.٨٩٧**<br>[-25.95] * | **-1**<br>[-33.17] * | **-0.8٢8**<br>[-17.52] * | **-1.0٩**<br>[-18.15] * | **-1.٢٠٢**<br>[-15.86] * | **-0.944**<br>[-11.88] * |
| INF | 0.656<br>[1.287] | -0.006<br>[-0.020] | 0.056<br>[0.180] | 0.094<br>[0.457] | 0.0578<br>[0.2683] | -0.1259<br>[-0.3635] | -0.0834<br>[-0.165] |
| SVOL | **-0.265**<br>[-4.51] * | **-0.188**<br>[-2.504] ** | **-0.068**<br>[-1.042] | 0.0569<br>[1.0143] | **0.1881**<br>[3.937] * | **0.2388**<br>[6.505] * | **0.2464**<br>[4.451] * |
| Pseudo $R^2$ | 0.231 | 0.202 | 0.185 | 0.196 | 0.241 | 0.320 | 0.394 |

Notes: (1) ORET is oil returns. SRET denotes stock market returns. SVOL stands for stock market volatility (obtained from the GARCH(1,1) model). INF stands for inflation. GRET is gold returns. FRET is depreciation/appreciation of the Egyptian pound. (2) The numbers in brackets beneath each coefficient estimate are the calculated t- statistic. * and ** denote statistical significance at the 1% and 5% levels, respectively.

**Source: Authors' calculations based on EViews 12**.

Following previous research (e.g., Das et al., 2020; Miyazaki, 2019; Widjaja et al., 2024), quantiles are classified into three phases, namely, lower ($5^{th}$ –$25^{th}$), middle (50%) and upper ($75^{th}$ –$95^{th}$) quantiles. Under a bearish market, a negative insignificant (significant) coefficient indicates that gold acts as a weak (strong) safe-haven asset, whereas it implies that gold functions as a weak (strong) hedge under bullish and normal conditions. Furthermore, if the coefficient is positive, then gold functions as diversifier (Widjaja et al., 2024).

According to quantile regression results, shown in Table (8), the coefficient of inflation is not significantly different from zero in all quantiles, confirming results obtained from both the OLS and robust OLS regressions. The absence of association between CPI-inflation and gold returns in Egypt could be attributed to the fact that gold purchases are driven by cultural and traditional aspects, such as wedding rather than financial aspects, and the hoarding behaviour. This finding is in line with the conclusion of Baur (2011) who finds that gold does not have a hedging function against the CPI-inflation in the US economy. Similarly, Hoang et al (2016) find evidence that gold did not help to protect against inflationary risk in the long run in China, India, Japan, France, the United Kingdom and the United States of America in periods ranging from1955 to 2015. The lack of significant inflation-hedging behavior in Egypt can be attributed to cultural factors and the traditional uses of gold, in addition to the fact that inflation in Egypt is not predominantly driven by domestic factors. Inflation in Egypt is often influenced by currency depreciation, external trade imbalances, and the prices of imported goods, particularly oil. In economies where inflation is primarily imported rather than domestically generated, gold may be less effective as an inflation hedge compared to economies where inflation expectations are more closely tied to domestic economic policies.

We find negative gold coefficients to EGX30 Index return under all market conditions ($5^{th}$ –$95^{th}$ quantiles). They are significant only under normal market conditions (i.e., $50^{th}$ and $75^{th}$ quantiles) but insignificant under extremely bearish ($5^{th}$ quantile), bearish ($10^{th}$ and $25^{th}$ quantiles) and bullish ($90^{th}$ and $95^{th}$ quantiles) conditions. These findings indicate that gold offers a safe haven in extremely bearish, bearish, and bullish conditions. In extreme market situations, a negative correlation between gold and stocks suggests that the price of gold rises, thus compensating investors for losses incurred from share investments. Moreover, our results indicate that gold servs as a hedge against stock return drops during tranquil times. These conclusions are in line with the results of Widjaja et al., (2024) and Baur and Lucey’s (2010). Regarding the association between stock return volatility and gold returns, the estimated coefficients are significantly different from zero across all quantiles except for 25th and 50th quantiles. Moreover, these coefficients are negative for lower quantiles whereas positive for upper quantiles, indicating that gold return reacts asymmetrically to the share return volatility. This finding is in line with empirical findings of (Miyazaki, 2019). The conclusion that gold returns increase when stock market volatility rises suggests that investors tend to shift away from stocks, which are perceived as risky, and instead seek the safety of gold. To put it another way, during periods of financial market tightening, gold returns increase. This pattern indicates that investors engage in flight-to-quality, moving their investments to the safer haven of gold. This conclusion has been corroborated by other researchers (e.g., Lucey & Li, 2015; Widjaja et al., 2024). Similarly, Beckmann et al. (2015) highlight the importance of the gold market when analyzing trading strategies for investors holding portfolios of stocks and gold. Their findings emphasize that gold is a valuable component for both policymakers and investors, as it offers significant benefits for portfolio diversification due to its hedge or safe-haven status.

Concerning the link between crude oil and gold returns, the estimated coefficients are positive irrespective of quantile, but they are insignificant in the upper quantiles, i.e., the 90th and 95th quantiles. Empirical studies (e.g. Reboredo, 2013; Miyazaki, 2019) consistently show a positive association between gold and oil returns. This means that when oil prices rise, gold prices are likely to move in the same direction, and vice versa. This relationship is often attributed to the fact that both commodities are influenced by similar macroeconomic factors, such as economic growth and geopolitical events. The insignificance in the upper quantiles suggests that the association between oil and gold returns weakens during periods of extreme market conditions. With respect to the relation between gold returns and exchange rate increments, all estimated coefficients are negative and significantly different from zero regardless of the quantile. The negative coefficients across all quantiles indicate that when exchange rates appreciate, gold returns decrease. This inverse relationship can be attributed to the fact that a stronger currency generally reduces the demand for gold as an alternative investment. Iqbal (2017) also highlighted that gold offers a strong hedge against currency depreciation in Pakistan and India, particularly in daily data.

## Robustness Check:

To check the robustness of our empirical results, the slope equality test introduced by Koenker and Bassett (1982) is employed, and the results are presented in Table 9. The null hypothesis of slope equality is rejected, at conventional levels of significance, for all coefficients except the inflation coefficient. Thus, the use of the quantile regression technique in our analysis is validated.

**Table (9): Slope Equality Test**

| Coefficients | Wald Test (Chi-sq. Statistic) | Chi-sq. d.f | p-value |
|---|---|---|---|
| Constant | 17.396 | 6 | 0.007* |
| ORET | 20.286 | 6 | 0.002* |
| SRET | 25.22 | 6 | 0.000* |
| FRET | 11.381 | 6 | 0.077** |
| INF | 3.807 | 6 | 0.702 |
| SVOL | 99.352 | 6 | 0.000* |

Note: * and ** indicate rejecting the null hypothesis of equality at 1% and 10%, respectively.
Source: Authors' calculations based on EViews 12.

## 5- Conclusion, Policy Implications, Limitations, and Areas for Further Research:

The paper employs a semi-parametric Quantile Regression (QR) approach using weekly Egyptian data from January 7, 1998 (based on data availability) to July 26, 2023, to investigate the relationships between gold returns and the risks associated with exchange rates, stock returns, stock return volatility, oil prices, and CPI inflation. A weekly frequency is deemed the most appropriate option to ensure a sufficiently large number of observations while mitigating the noise inherent in daily data. The returns of the employed variables are computed as the log difference between two consecutive periods. Monthly inflation, defined as the percent change in the year-over-year natural logarithm of the consumer price index, is interpolated using the quadratic method to convert the data into weekly observations. Furthermore, stock market volatility is computed as the square root of the estimates derived from an AR(1)-GARCH(1,1) model applied to the EGX30 Index returns.

OLS and ROLS methods were employed to examine the relationships between variables over the entire sample period, with similar results from both regressions. Both methods indicate that EGX30 Index returns, and the nominal trade-weighted exchange rate are negatively related to gold returns. In contrast, oil returns and stock market volatility are positively related to gold returns. The positive correlation between gold and oil suggests they belong to the same asset class. Inflation shows a negative but insignificant relationship with gold returns, and the exchange rate exhibits a near one-to-one negative correlation with gold. The coefficients from the ROLS are lower, suggesting potential bias in the OLS estimates due to outliers. The White test confirms heteroscedasticity, thus making the ROLS results more reliable. Given significant events such as the 2008 financial crisis and the COVID-19 pandemic, potential structural breaks were assessed using Bai and Perron's (1998) multiple breakpoints test. The results indicate no structural breaks, thereby allowing the analysis with quantile regression to proceed over the full sample period.

The QR results confirm that CPI inflation has no significant relationship with gold returns, consistent with OLS and ROLS findings. This lack of association may stem from cultural factors, such as gold purchases for traditional purposes, rather than as a financial hedge. In other words, gold may not effectively protect against inflation in the Egyptian context due to cultural preferences for physical gold, rather than financial hedging motives. Traditionally, Egyptians have purchased gold jewelry as a long-term saving strategy, however; speculators have now turned to coins and ingots trying to reap a quick profit. This finding is in line with the results of Baur (2011), Dee et al., (2013) and Hoang et al., (2016). The lack of significant inflation-hedging behavior in Egypt can be attributed to cultural factors, traditional uses of gold, and the fact that inflation is primarily driven by external factors like currency depreciation, trade imbalances, and imported goods prices. In economies where inflation is imported rather than domestically generated, gold is less effective as an inflation hedge compared to economies where inflation expectations are tied to domestic economic policies.

Furthermore, the QR findings reveal that gold returns are negatively correlated with EGX30 Index returns, with statistical significance observed only during normal market conditions. However, this relationship does not hold under extremely bearish, bearish, or bullish market conditions, suggesting that gold serves as a safe-haven during extreme market scenarios. These findings are consistent with the results of Widjaja et al., (2024) and Baur and Lucey (2010). Additionally, gold returns exhibit an asymmetric reaction to stock return volatility, with negative coefficients for lower quantiles and positive coefficients for higher quantiles, suggesting a "flight-to-quality" effect. These findings align with previous studies (Miyazaki, 2019; Lucey & Li, 2015; Widjaja et al., 2024), emphasizing gold's role in portfolio diversification as a hedge and safe-haven. The relationship between crude oil and gold returns shows positive coefficients across all quantiles, but they are insignificant in the upper quantiles (90th and 95th), suggesting that the link weakens during extreme market conditions. This positive association, consistent with previous studies (e.g., Reboredo, 2013; Miyazaki, 2019), reflects the influence of macroeconomic factors like economic growth and geopolitical events. Regarding the exchange rate, all coefficients are negative and statistically significant across quantiles, indicating that gold returns decrease when the exchange rate appreciates. This inverse relationship is attributed to a stronger currency reducing gold's appeal as an alternative investment. Iqbal (2017) also pointed out that gold provides a robust hedge against currency devaluation in Pakistan and India.

Based upon our empirical results, investors should incorporate gold into diversification strategies, particularly during periods of financial uncertainty, as it offers protection against stock market volatility and currency depreciation. Moreover, the central bank may consider gold as part of its foreign reserve strategy considering the importance of gold in hedging against currency risk. Given the positive correlation between oil and gold returns, both assets should be considered together in the context of geopolitical risk and economic shocks. A synchronized approach to managing oil and gold in portfolios could provide greater resilience against global crises.

The limitations of the current study include the exclusion of the specific nature of oil-related risks, particularly demand-side and supply-side shocks. Additionally, the study does not address information transmission—both in terms of returns and volatility—across the assets analyzed, which is especially critical during periods of financial instability. Consequently, a promising direction for future research involves jointly considering the conditions of the oil and gold markets. This could be achieved by building on the work of Youssef and Mokni (2021), who applied the methodology of Ready (2018) to decompose oil prices into distinct types of oil shocks and utilized the combination of Markov switching-regime and quantile regression models. Such an approach would enable the examination of gold price responses to various oil shocks under regime changes while accounting for differing gold market conditions. Furthermore, the scope of the current research could be expanded by employing the Diebold and Yilmaz (2012) spillover index to investigate information transmission—both returns and volatility—across various assets in Egypt and other emerging economies.

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