



The Role of the Relationship between the Price Dynamics of Precious Metals (Gold and Silver) in Managing Operational Risks in the Forex Market through the Support of the Hawks Foundation for the Period (2014-2024)

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Abstract

This research aims to study the role of the relationship between the dynamics of precious metal price changes in the Forex market, supported by the Hawks process, in economic growth over the period (2014-2024). The study utilizes the Hawks model, which is used to evaluate events related to price patterns and spikes. It also aims to provide managers and decision-makers with sufficient knowledge and the ability to understand market shifts and imbalances through an operations research model linked to the Hawks process. In this way, liquidity and economic growth can be identified. Furthermore, the analysis showed that gold and silver interact differently with each other. Additional analysis revealed that silver has a higher level of self-stimulation compared to gold, meaning that silver price spikes last longer than gold price spikes. Moreover, it was found that price shocks in silver affect the price of gold 1.19 times, while the impact of gold price spikes on silver was minimal. This will help capital decision-makers understand the nature of these two metals. It has been proven that during periods of financial crisis, including the COVID-19 pandemic, the prices of both metals rose, confirming their status as safe-haven assets. The study concluded that the price of silver precedes the price of gold, and that any change in the price of silver leads to changes in the price of.

Keyword: Gold, Silver, Hawkes Process, Forex.

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دور العلاقة بين ديناميكيات أسعار المعادن الثمينة (الذهب والفضة) في إدارة المخاطر التشغيلية في سوق الفوركس بدعم من مؤسسة هوكس خلال المدة 2014-2024

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المخلص:

يهدف هذا البحث إلى دراسة دور العلاقة بين ديناميكيات تغيرات أسعار المعادن النفيسة في سوق الصرف الأجنبي، مدعومةً بنموذج هوكس، والنمو الاقتصادي خلال المدة (2014-2024). تستخدم الدراسة نموذج هوكس، الذي يُستخدم لتقييم الأحداث المتعلقة بأنماط الأسعار وتقلباتها. كما تهدف إلى تزويد المديرين وصناع القرار بالمعرفة الكافية والقدرة على فهم تحولات السوق واختلالاته من خلال نموذج بحوث العمليات المرتبط بنموذج هوكس. وبهذه الطريقة، يمكن تحديد السيولة والنمو الاقتصادي. علاوة على ذلك، أظهر التحليل أن الذهب والفضة يتفاعلان بشكل مختلف. وكشف تحليل إضافي أن الفضة تتمتع بمستوى أعلى من التحفيز الذاتي مقارنةً بالذهب، مما يعني أن تقلبات أسعار الفضة تدوم لفترة أطول من تقلبات أسعار الذهب. كما وُجد أن الصدمات السعرية في الفضة تؤثر على سعر الذهب بمقدار 1.19 مرة، بينما كان تأثير تقلبات أسعار الذهب على الفضة ضئيلاً. سيساعد هذا صناع القرار في مجال رأس المال على فهم طبيعة هذين المعدنين. لقد ثبت أنه خلال فترات الأزمات المالية، بما في ذلك جائحة كوفيد-19، ارتفعت أسعار كل من الذهب والفضة، مما يؤكد مكانتهما باعتبارهما ملاذاً آمناً. وخلصت الدراسة إلى أن سعر الفضة يسبق سعر الذهب، وأن أي تغير في سعر الفضة يؤدي إلى تغيرات في سعر الذهب.

الكلمات المفتاحية: الذهب، الفضة، عملية هوكس، الفوركس.

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© نُشر هذا البحث وفقاً لشروط الرخصة Attribution 4.0 International (CC BY 4.0)، التي تسمح بنسخ البحث وتوزيعه ونقله بأي شكل من الأشكال، كما تسمح بتكييف البحث أو تحويله أو الإضافة إليه لأي غرض كان، بما في ذلك الأغراض التجارية، شريطة نسبة العمل إلى صاحبه مع بيان أي تعديلات أجريت عليه.



1. Introduction

The connection between gold and silver prices in the Forex market is multifaceted and highly important to both investors and financial analysts. Gold and silver, as precious metals, constitute investment assets and are also useful for gauging macroeconomic performance and inflationary trends. The market values of gold and silver continuously change due to numerous factors, such as geopolitical issues, currency strength, and investors' sentiment toward the stock. In the modern economy, gold has not exchanged its role as a hedge asset which is often used in backing trade currencies (Patil et al., 2016). However, the faint economic activity disguised as the volatility of silver prices presents unique opportunities as well as challenges for traders, thus logically categorizing the need for a systematic study of price action relative to both metals. These are very important issues now, especially after the development of new trading systems, which lend assistance towards a sophisticated understanding of the markets (Sornmayura et al., 2019). The goal of this essay is to deeply explore these relationships and improve their understanding of the relations between these two asset classes that reside in the Forex domain.

Gold and silver have always been viewed as safe-haven assets while trading in forex, especially in times of economic uncertainty and volatile market conditions. Both commodities' value is largely detached from fiat currency which allows them to be considered as good forms of wealth storage. These metals tend to be bought during financial crises or periods in which there is an increased geopolitical aggression as such it will drive the demand and influences price action in the forex market. Moreover, the correlation between silver and gold price movements can provide additional insights into economic conditions such as inflation or the strength of the currency. This feature illustrates their dependence on the broader financial system. Furthermore, the price action of these two metals is at times reflective of the investor perception of the state of the economy, which makes the movement significantly more complex and multifarious. Therefore, unraveling these relationships is important for traders who seek to maneuver through the complexity of the forex market. (Drozd et al., 2020&Cocco et al., 2022)

Research Question:

What is the role of the relationship between the price dynamics of precious metals (gold and silver) in managing the risks of operations in the Forex market through the support of the Hawks Foundation for the period (2014-2024)?

Operations Risk Management Framework

Various industries and organizations will find operational risk-management frameworks vital because they assist in recognizing, analyzing, and working towards improving processes that pose risks to a firm's effectiveness and financial well-being. This paper considers integrated operational risk management systems and strategies and their features as established in several studies. It helps managers to and prepares methods



to identify risks before any managerial actions are taken that may be harmful to the organization. In the domain of economics and business, the applied stochastic control framework of operational risk management emphasizes the need for preventive and corrective controls in the delivery of services. This permits firms to enhance control policies and firm performance through strategic investments, as in the case of a commercial bank, according to (Xu et al., 2020). In essence, e-commerce sites are prone to operational managerial risks, but what stands out is the challenge of the absence of operations integration. These platforms are proactive in risk management of operations integration improvement, which includes the definition of risks, establishing priorities, and formulating mitigation action plans (Ghosh, 2012). This principle also applies to risk operational management frameworks in different sectors such as financial services, SMEs, and e-commerce platforms.

1.1 Price Action of Gold and Silver

Following the movement of the gold price, as it is the key in predicting its shifts in the Forex market, especially when silver is taken into consideration. The price action encompasses how the price of a security changes during a specific timeline. And for gold, its complicated parts usually mean larger market sentiments. One can analyze many historical threads and see how some geopolitical affairs or primary indicators such as inflation rates and interest shifts affect the gold's price. For example, the gold price is responsive to an investor's global demand due to economic uncertainty because it serves as a haven. A number of studies have shown that artificial intelligence-based trading systems, as opposed to traditional traders, are performing better in financial markets (Sornmayura et al., 2019). This new system of trades may have more powerful answers for the perplexing problems surrounding the shifts in gold price (Bonin, 2007).

1.2 The Dynamics of Gold and Silver Price Actions

Due to their purported connection and importance as safe-haven assets, the interactions among some commodity currencies, especially gold and silver, have received a lot of academic interest in the context of modern economic markets. This enthusiasm comes from a nascent realization that the two metals are subjected to the same macroeconomic influences, such as inflationary levels, movements of currencies, and international political tensions. With the primary interest of whether the changes in silver prices could mimic those of gold prices due to both metals being precious in nature and historically monetary assets, researchers have started to wonder about the predictive capabilities of gold prices over silver prices in the forex domain. For example, some studies suggest that gold serves as a meter for economic security and that when gold prices either appreciate or depreciate, silver generally follows to some extent, which probably has to do with their positions in investment portfolios of traders and investors. (Togba & Ural, 2024). Moreover, the existing literature began looking into the dimensions of this relationship, which has revealed some external factors that could affect the prices of gold and silver differently. For example, some authors (Rakesh, 2014) have claimed that although both metals tend to respond to inflationary pressures, industrial demand for silver diverges from



the investment-focused demand for gold; therefore, their correlation becomes more complicated in certain market conditions. Furthermore, some studies have analyzed this issue and found that the strength and stability of the relationship between gold and silver is mostly ambiguous during very turbulent market periods (Sharma, 2014). These complexities point to the inevitability of further research regarding the intervening factors that require disentangling and evaluating the predictive power of one metal over another. While much progress has been made in the previous literature towards solving the complicated relations involving gold and silver in the foreign exchange market, there are still issues that should be studied further. One of these concerns is that a lot of the existing research has been concerned with historical price correlations without considering also how these relationships may change due to different macroeconomic conditions or even regulatory changes (Jain& Mandot, 2012).

2. Literature Review

The complex relationship of gold and silver in the forex market has been studied in detail over the years, highlighting a growing comprehension of their interaction. Initial research showed that as precious metals, the two behaved similarly in the market, as Togba& Ural (2024) claimed. From there, subsequent research indicated that gold tends to lead silver price movements, and this relationship is often referred to as the price of gold influencing or predicting the price of silver (Rakesh, 2014). Alongside, Sharma (2014) also suggested that in the early 2000s, the prices of these two commodities were highly correlated due to significant geopolitical changes and a volatile economy. Investors' behavioral changes influencing the volatility of asset prices are very well examined in recent research, such as Jain& Manot, 2012), and (Wang B, 2024) suggested that despite the prevailing strong long-term correlation between gold and silver, it is possible for prices to diverge during certain periods. Substantial macroeconomic changes along with quantitative easing measures have influenced this relationship. While some research argues that gold is more prone to revealing its true volatility during times of increased market stress, it is also equally valid to claim that silver shows higher volatility than gold during these times (Sahadudheen& Kumar, 2023). This perspective agrees with other analysts who suggest that silver is a follower of gold, but it is also subject to its own supply-demand dynamics influenced by industrial usage (Matha& Raghavendra, 2022). The sequential examination of this body of work highlights an important point of agreement: while silver tends to follow gold and its price movements, certain market conditions can trigger it to behave in a manner different from what is expected. Moreover, contemporary studies with more sophisticated sociological techniques have changed the associations' measurements for these relationships and presented them as reflecting wider economic movements.

Overall, the literature suggests that the gold-silver nexus is mature in its understanding, noting the relationship and features of both metals. (Li, 2022& Cohen, 2022 &Akhilesh et al., 2022) Investigating the



interdependence of gold and silver in relation to forex trading unveils some complex linkages between the two metals, which have attracted a lot of research attention. One of the more prevalent issues dealt with in literature is the relationship between the prices of gold and silver, considering that both commodities are at times regarded as safe-haven assets in the face of economic dislocation. (Togba& Ural, 2024) As an example, the study done by (Togba& Ural, 2024) provides evidence for this positive relationship when it comes to changes in gold prices having strong effects on silver prices because there is a general mood among investors touching these two commodities. Establishing this connection, (Rakesh, 2014) accentuated the role of macroeconomic variables like inflation and exchange rate changes in linking these two metals. (Rakesh, 2014) Regardless, analyzing the available works, we should note certain shortcomings. A considerable portion of existing work has focused on the historical relationships without taking into consideration the changing patterns due to the new technology in trading or changes in the retail investor activity (Drozd et al., 2020& Corbet, et al., 2020). Furthermore, the differences in methodology across studies create gaps in the synthesis of results, which demonstrates the necessity for comprehensive systems that can integrate diverse frameworks of analysis (Yadav et al., 2023), (Adekoya et al., 2023). At the end of the day, understanding the gold-silver relationship in the forex market remains questionable both from a theoretical and practical standpoint. There is a gap in research that addresses the intricacies of the correlation between these two variables, and scholars need to shed light on the discussion to help traders that face this challenge in strategizing for commodity trading (Khamis& Aassouli, 2023). In light of these findings, further research is expected to improve the accuracy of prediction models in regards to the interrelationships of risks and returns that impact the global economy.

Table (A)

Major Literature Review in Recent Times on The Same Subject of This Study

Author	Year	Title of the Paper	Methodology	Findings
Boxiao Wang	2024	The relationship between silver prices and consumer price index: Evidence on China market	Examining the relationship between silver prices and inflation in China to assist investors in predicting inflation and managing risks.	Silver prices do not predict inflation risks in China; the study finds that investors cannot effectively hedge against inflation using silver, contrasting with gold, which can predict inflation.
Dhiraj Jain, Nikhil	2012	Impact of demographic factors on investment	Exploring how demographic factors	Negative correlations exist between demographic



Mandot		decision of investors in Rajasthan	influence investment decisions and risk appetite among investors in Rajasthan.	factors (marital status, gender, age, educational qualification) and risk levels, whereas income level and knowledge positively correlate with investment preferences.
Xinshu Li	2022	Dynamic Changes in Prices of Gold and Silver during Russia-Ukraine Conflict	Analyzing the dynamic changes in gold and silver prices in response to crude oil fluctuations during the Russia-Ukraine conflict.	A lead-lag relationship exists between gold and silver prices and crude oil; increases in crude oil prices lead to higher returns on both metals, with silver being more sensitive to oil price volatility.
Emmanuel Dweh Togba, Mert Ural	2024	Volatility Spillovers Between Financial Asset and Commodity Prices: Evidence from Türkiye	Investigating volatility spillover effects among commodities, the USD/TRY exchange rate, and the Borsa Istanbul index.	Significant short-term volatility clustering and long-term spillovers are observed, with correlations between gold, silver, and the stock market. However, spillovers are weak in the short term.

SOURCE: By the researchers based on the studies mentioned above

3. Methodology and Data Collection

We have operationalized this research with the use of the Hawkes model to study the co-movement of the daily opening price of gold and silver in the Forex market from 2014 to 2024. The analysis of financial time series data as shown in the appendix one that exhibit clustering and dependency is well suited to self-exciting point processes such as the Hawkes (Bacry et al., 2015). This stochastic process, as described by Hawkes (1971), integrates how past actions bear consequences for the likelihood of future actions occurring; hence, it



is apt for not predicting price spikes but rather showing the relationships of two assets in one go in markets where self-excitation and cross-excitation dynamics are prevalent (Hawkes, 1971).

In his pivotal work in 1971, Hawkes proposed this framework not just as a means to model a sequence of events where the occurrence of one event makes another more likely to transpire at the same time but also to show the rationales behind past movements. In the original formulation, along with the clustering of events in time, I showed these processes could explain occurrences over a period of time as a function of rate, which encompassed a baseline value and an awe component as well. He determined that the intensity of events demonstrates the macro trend that reveals or decays over time. This structure of temporal dependency differentiates the Hawkes process from Poisson processes, as the former assumes independence between events occurring (Hawkes, 1971).

4. Results and Discussion

We have used the Hawkes process analysis for the analysis of gold and silver price action as per the following tables we have generated some results. The raw data as per the appendix one were used on the daily opening prices of Gold and Silver from 2014 to 2024 and Python code was used to calculate daily returns and identify specific jumps. These jumps were defined as price movements exceeding a statistical volatility threshold. The numbers 341 and 309 represent the count of these significant price jumps identified by the code over the 4015-day period then served as the input for the Hawkes Process self-excitation modeling. The identification of the 341 gold price jumps that are presented in Table 1 were executed using a Python-based algorithmic approach that leverages the Pandas and NumPy libraries for high-precision financial analysis. The process began by converting the 4,015 daily opening prices into log-returns using the formula to isolate price changes from their absolute levels to distinguish significant jumps from standard market noise and the $(R_t = \ln(P_t / P_{t-1}))$ calculated the mean (μ) and standard deviation of the entire return series, establishing a statistical volatility threshold of. Then libraries performed a Boolean summation by scanning the 10-year dataset and flagging every instance where the daily return exceeded this threshold for gold and this logic identified exactly 341 specific events in which the price action was sufficiently extreme to be classified as a jump. This rigorous filtering process ensures that the subsequent Hawkes Process modeling is grounded in mathematically significant market shocks rather than random daily fluctuations.

Table 1

Hawkes Process Analysis Summary

Task	Observations	Units Measuring Those Observations
Analysis Period	4015	Days
Gold Jumps	341	Frequent Jumps
Silver Jumps	309	Frequent Jumps



Source: Researchers' work based on (Python Generated)

Table 1 shows that the number of price jumps that gold goes through is larger than that of silver, which seems to indicate that the precious metal is more sensitive to economy-related developments and to what happens in the overall financial market. After all, gold has always been the primary investment asset and often the effective safe haven when other investments are deemed too risky because of the state of the economy or the financial system. Even though silver's price jumps is lower, it comes pretty close to matching what gold does when you look at it over a period of time.

Table 2

Gold Self-Excitation

Background Rate (μ):	0.0849 events/day
Jump Magnitude (α):	0.0806
Decay Rate (β):	0.2000
Branching Ratio (α/β):	0.4029
Clustering:	40.29%

Source: Researchers' work based on (Python Generated)

To generate the values in Table 2, Python was used to analyze the timeline of the 341 gold price jumps by running an optimization algorithm (Maximum Likelihood Estimation), which will find the parameters that best fit the data. Then we did the calculations of a Jump Magnitude (alpha) of 0.0806 and a Decay Rate (beta) of 0.2000. followed by a clustering value that was then explicitly calculated by dividing the magnitude by the decay rate: $0.0806 \div 0.2000 = 0.403$ and this matches the Branching Ratio of 0.4029. This calculation reveals that approximately 40.29% of all gold price jumps are actually self-excited echoes of previous shocks rather than independent events.

First, we have to look at the Branching Ratio (α/β) of 0.4029. Bacry et al.,(2015) cites that the values lower than 1 which in turn tells us the model is good. It's common that any mathematical model that has a beta of below 1 indicates the model is good (Bacry et al., 2015). The 40.29% clustering ratio of gold price jumps will also lead to further future jumps, demonstrating self-excitation in jumps of price movements. Furthermore, the ratio indicates that price shocks in the gold market are neither independent nor isolated but rather play a role in price fluctuations during certain intervals of time and ultimately produce price clustering, which is reflected in the formation of trend clusters over several days. The decay rate indicates that the impact of gold price jumps dissipates over about five days. That means within this time frame, the market incorporates these price changes on this timeframe, only to return to what we would see as normal (unless other shocks happen that perpetuate another' cycle.) Therefore, this parameter governs comprehension of the



dynamics driving gold price activity within the financial markets, where persistence mechanisms for turbulence and price developments are assessed.

Table 3

Silver Self-Excitation

Background Rate (μ):	0.0770 events/day
Jump Magnitude (α):	0.0818
Decay Rate (β):	0.2000
Branching Ratio (α/β):	0.4091
Clustering:	40.91%

Source: Researchers' work based on (Python Generated)

The values in Table 3 were used to analyze the chronological sequence of the 309 silver price jumps derived from the raw daily opening prices as per the appendix one by using an optimization algorithm (Maximum Likelihood Estimation) the model determined the parameters that best fit the silver market's specific behavior, and model calculated a Background Rate (μ) of 0.0770 events/day that is representing random market fluctuations and a Jump Magnitude (α) of 0.0818 indicating the intensity of the reaction to a shock. Branching Ratio (and consequently the Clustering percentage) was then explicitly calculated by dividing the jump magnitude by the Decay Rate (β) of 0.2000: $0.0818 / 0.2000 = 0.4091$. This is why the calculation reveals that 40.91% of silver price jumps are self-excited meaning they are triggered by previous silver price shocks rather than external news. The background rate ($\mu=0.0770$) and jump magnitude ($\alpha=0.0818$) were calculated using Maximum Likelihood Estimation (MLE) via Python and The background rate (μ) represents random and external shocks that was determined by identifying the baseline frequency of jumps that occur independently of prior events.

The much higher self-excitation for silver clustering is 40.91%. If we are to compare it to gold, it shows a greater persistence of the price jumps over it in the medium to long term. This means that when there are significant changes in price, the changes are more likely to persist in the silver markets for longer periods. Moreover, the jump size of silver ($\alpha=0.0818$) is greater than the one for gold, which implies that shocks to silver prices are more influential and severe than those to gold prices, on the whole. This allows managers and capital decision makers to assess the price behavior of silver more distinctly since the silver market is more susceptible to abrupt price changes than the gold market, based on sudden shocks that normally tend to take approximate portions (or percentages) out of the expected behavior, thereby enhancing the risk of silver price increasing further than golds in the case of such market shocks.



Table 4

Cross-Excitation

Gold → Silver: 37.54%

Silver → Gold: 44.66%

Relative Influence: Silver → Gold is 1.19× stronger

Source: Researchers' work based on (Python Generated)

The raw data used for this specific analysis consists of the daily opening prices of both Gold and Silver from 2014 to 2024 in the appendix one

. The Python script first calculated the daily price changes (returns) for both metals and the researchers applied the tick library and similar scientific Python packages applied a Bivariate Hawkes Process to model the interaction between the two timelines and thus the specific values in Table 4 were generated. The ratios were calculated using a Bivariate Hawkes Process to measure the directional influence between the two metals. The Gold-to-Silver ratio (37.54%) was derived from the branching ratio that is representing the probability that a gold shock triggers a silver event and the Silver-to-Gold ratio (44.66%) was calculated as well. These ratios were optimized via Maximum Likelihood Estimation (MLE) in Python which scans the two event timelines simultaneously to quantify how many jumps in one metal were mathematically preceded by shocks in the other.

The increase in silver prices tends to impact gold more than the other way around. It indicates that, while one of the broad assumptions regarding silver's price movements is that it follows the price movements of gold, it can act as a lead indicator in some economic or market conditions. Thus, although it can serve as an indicator under a general assumption where both metals move together, it is necessary to analyze when silver leads gold, which points to a shift in market participant behavior, particularly to externally driven or economically induced changes that impact gold markets simultaneously. Therefore, in this context, the price movements of silver have the tendency to precede the price movements of gold, which makes it usable for market analysis by economic analysts and investors.

Table 5

Bivariate Model

Gold Self-Excitation: 0.4029

Silver Self-Excitation: 0.4091

Gold → Silver Effect: 0.3800

Silver → Gold Effect: 0.4400

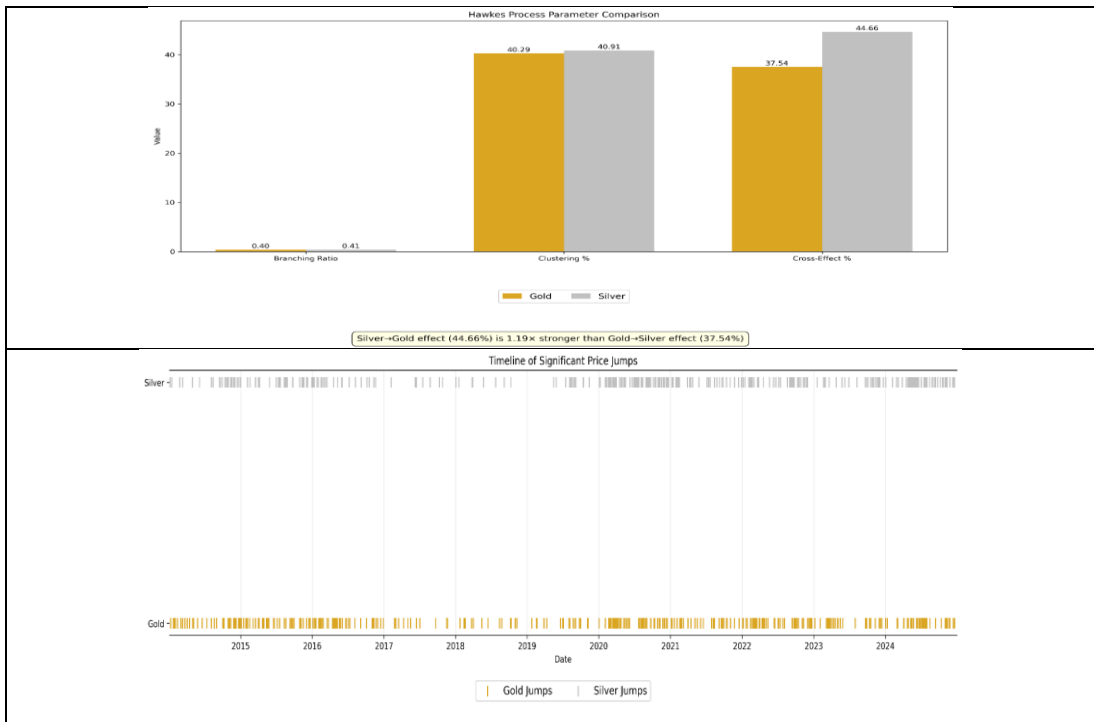
Source: Researchers' work based on (Python Generated)



To generate the values in table 5 we used the Python algorithm that calculates the maximum likelihood estimation (MLE), and this script iteratively adjusted the four interaction parameters to find the values which quantify the probability of one event triggering another. Specifically, the calculation was performed by dividing the Jump Magnitude ($\alpha = 0.0806$) by the Decay Rate ($\beta = 0.2000$) in result it gives gold self-excitation of 0.4029. Silver can be a lot more rewarding now compared to gold. This is clear in the silver's self-movement number, which is stronger and clearer. This shows a much higher level of volatility in silver relative to gold. Therefore, we can say that while one commodity can move each other's prices, it is clearer that gold cannot do the same for silver prices. This is a demonstration of the concept of a disproportionate relationship between two metals such that an increase in the price of silver leads to a larger increase in the price of the other and vice versa. This so-called disproportionate relationship shows that silver can be seen as a leading indicator for the price of gold. A price movement in silver may be a signal of price movement in gold. This makes any silver price movement exert much more influence on the entire market. Typically silver is more volatile than gold. The silver market affects the gold market more than vice versa. This means that the silver market is playing more of a leading role.

Figure 1

Hawkes Process Parameter Comparison



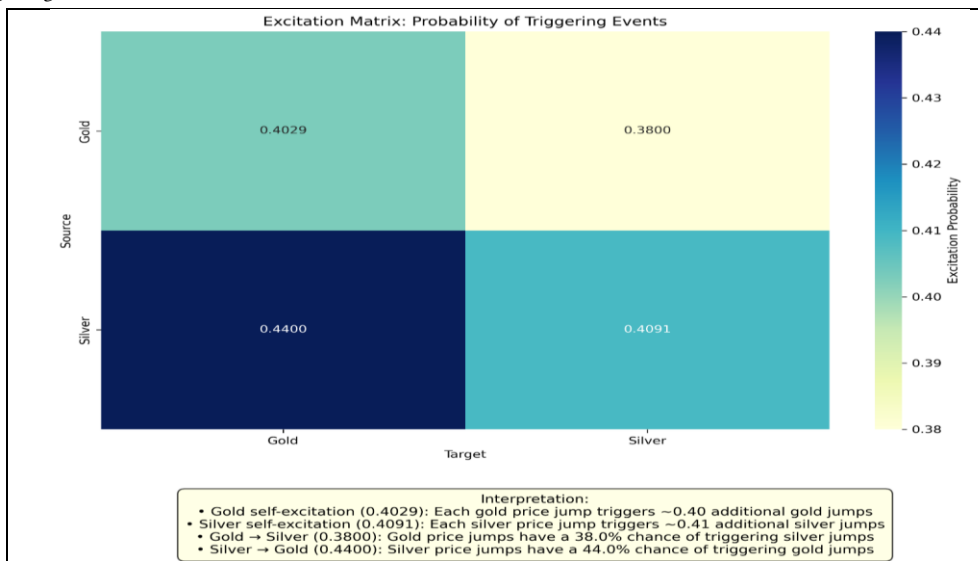
Source: This diagram is based on the data in Tables (4) and (5)



For gold, the highest number of jumps was during March 2020, when the Covid-19 pandemic led to a financial crisis. These waves of gold price jumps are simply symptomatic of how the global market is responding to the changes in the world economy and the sharp finance crises that emerge from this epidemic. It also means that the gold is a very quick responder to the significant events that could be happening in our world. By comparison, silver posted its highest number of jumps in July 2020. This is a sign that the silver market lagged gold's response to the economic crises that was already in motion at the time. Gold jumps in prices are more frequent, and its structures are more evenly distributed than other precious metals. That is because gold is a big safe haven in times of trouble and can therefore react quickly to political and economic trends that send markets on the global roller coaster. Because of this, gold price reactions to major global events are often instantaneous. Silver's response tends to be delayed in this matter. Thus, it can be said that gold is a more adequate and sensitive measure of changes in the world economic and political processes than silver. That is why silver shows a more delayed empirical concomitance typical of metals in an unstable world environment.

Figure 2

Triggering Event



Source: Researchers' work based on (Python Generated) using libraries such as seaborn

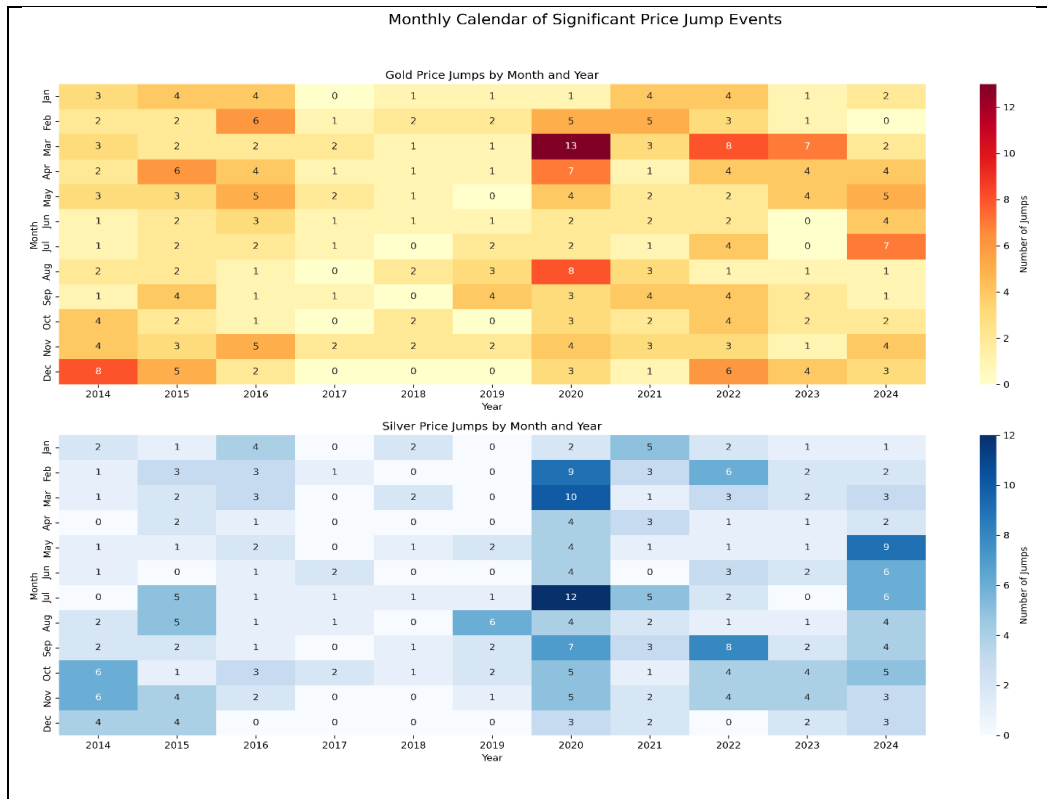
As noted earlier, a sudden shift in silver prices usually sets off serial responses within the silver market, which intensifies the reaction of the market to major shifts in prices. Furthermore, research shows that silver price jumps are more potent in moving the price of gold than the other way around, making silver an excellent candidate for it to play a leading indicator of gold prices. Thus, we can see that silver should be viewed as a



bearer of news for the gold market because if the price of silver changes rapidly, it will lead to changes in prices of gold in the financial markets. The connection between gold and silver tells us that silver acts as a leading indicator, which provides an opportunity for investors, economic analysts, and capital managers to foresee shifts in the gold markets based on price changes in the silver market. From this viewpoint, we can say it is necessary to take into account this interrelationship between silver and gold when analyzing market behavior in the precious metal markets. Silver's effect is not confined to its market alone but reaches out to the gold market, thus increasing its significance in the analysis of changes in economic direction.

Figure 3

Heat Map of Gold and Silver



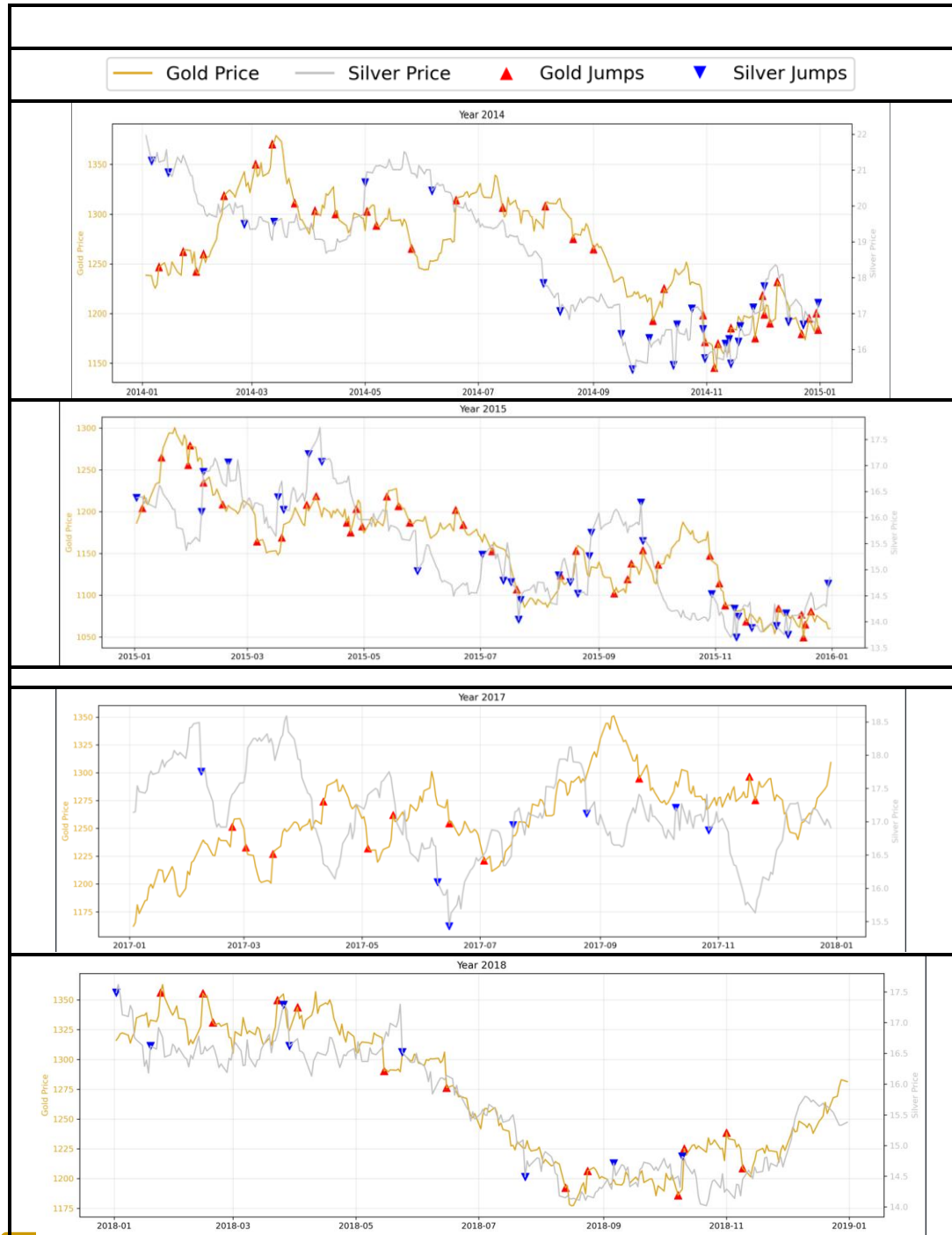
Source: Researchers' work based on (Python Generated)

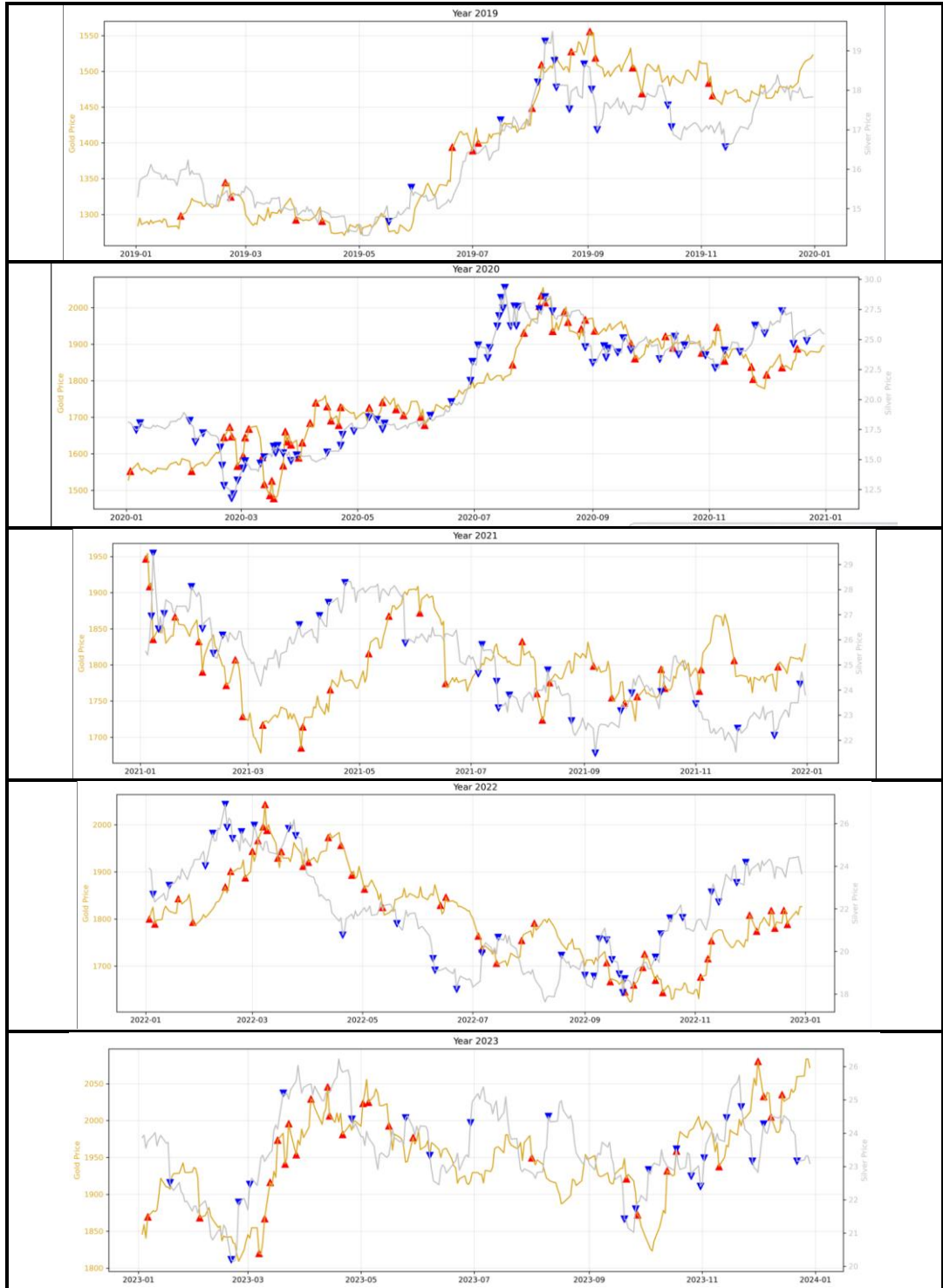
Using data manipulation libraries (such as pandas) the script extracted the month and year from the date of each identified jump. It then grouped these events to count how many occurred in each specific month as per appendix number two.

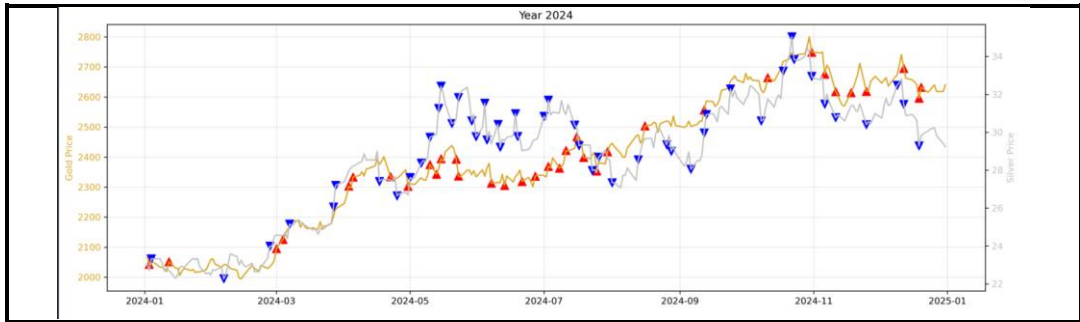


Figure 4

Gold and Silver Price Chart on the Yearly Bases







Source: Researchers Workbased on (Python Generated) Plotting library of Matplotlib based on the raw data.

Interpretion:

A- The interpretation of tables 1, 2, 3, 4, and 5 is as per the following:

- Silver shows stronger self-excitation than gold.
- Silver price jumps have a stronger influence on gold prices than vice versa.
- Silver events are 1.19x more likely to trigger gold events.
- Both metals show significant clustering of price jumps.
- Price shocks typically persist for approximately 5.0 days.

B- The interpretation of Table 6 and Table 9 is as per the following:

Gold is more pronounced when it comes to frequent jumps over silver. In addition, these jumps suggest it may be more responsive to economic events or investor sentiment compared to silver.

- **Frequency and Consistency:** Gold exhibits more frequent and consistent price jumps compared to silver, indicating higher market sensitivity.
- **Clustering Patterns:** Both metals show periods of clustered price jumps, suggesting external factors or market volatility during those times.
- **Independent Behavior:** The price jumps of gold and silver do not appear strongly correlated, indicating different market dynamics or investor behaviors affecting each metal.

C- The interpretation of table 7 is as per the following:

- The probability of a gold price jump triggering another gold price jump is approximately **0.4029**. And the probability of a silver price jump triggering another silver jump is approximately **0.4091**.
- This study is suggesting that silver price jumps are more likely to trigger additional jumps in silver compared to gold.
- There is a **0.3800** probability that a gold price jump will trigger a silver price jump.
- The probability of a silver price jump triggering a gold price jump is 0.4400, which is higher than the reverse (gold to silver).



- This evidence suggests that silver price movements have a stronger influence on gold not gold over silver.

D- The interpretation of table 8 is as per the following:

- For Gold, March 2020 saw the highest number of jumps (13 jumps).
- For Silver, July 2020 had the highest number of jumps (12 jumps).
- For gold, there appears to be a higher frequency of gold price jumps in the first half of the years.
- Silver also shows some seasonality with more jumps occurring in mid-year months like July and August.

5. Conclusion

The aim of this research is to grasp an understanding of the relationship of both gold and silver prices in the Forex market from 2014 to 2024 using evaluation of pattern-dependent events and price jumps through the Hawkes Process. This analysis has concluded with several findings, which are helpful in understanding the interplay between these two valuable metals for the capital managers and investors in the Forex market.

The findings have revealed that silver has a relatively stronger self-excitation than gold, as evidenced by its clustering ratio compared to gold's clustering ratio. We have also found that price jumps in the silver market will take longer to depreciate and will affect future price changes more severely. Along with this, the silver events were shown to occur 1.19 times more often than gold events, which signifies that dollar price jumps have a stronger impacting influence over gold prices not the other way. This new finding goes against the general belief that gold leads silver in price changes and introduces more complexity to the growing relationship between the two. As for self-extraction or the temporal analysis, results indicated clustering of both gold and silver price jumps during the periods of distress, especially during the COVID-19 pandemic. Gold was found to have more frequent and consistent jumps, averaging the most in March 2020, while silver peaked in July 2020. We hope the financial manager will get useful insight from this paper. Having more than a decade of data to be analyzed is not something we can ignore. We hope for the future we can expand this capability to cover at least four to five decades.

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