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INVESTIGATION OF SPECULATIVE PRICE MOVEMENTS IN PRECIOUS METALS

DEĞERLİ METALLERDE SPEKÜLATİF FİYAT HAREKETLERİNİN İNCELENMESİ

Yaşar ALPTÜRK*

Abstract

Price movements in financial markets are shaped not only by fundamental economic indicators but also by investor behavior, risk perception, and global developments. Accordingly, the aim of this study is to empirically examine speculative price movements in precious metals during the post-COVID-19 period. Based on the results obtained from the application of RTADF, SADF, and GSADF tests, no statistically significant bubble formation was detected in gold, silver, platinum, or palladium over the period 05.05.2023–15.04.2025. Although no statistically significant evidence of bubbles was found, graphical trends suggest that gold may be more sensitive to behavioral reactions of investors, while silver appears to exhibit a more stable pattern. Overall, the findings indicate that speculative bubbles were absent in precious metals during the analyzed period; however, given the inherent volatility of these markets, the potential for future speculative fluctuations cannot be ruled out. Therefore, incorporating both behavioral factors and macroeconomic indicators into investment decisions is of critical importance for investors.

Keywords: Precious metals, speculative bubble, GSAFD test
JEL Classification: G10, G15, G40

Öz

Finansal piyasalardaki fiyat hareketleri yalnızca temel ekonomik göstergeler tarafından değil, aynı zamanda yatırımcı davranışları, risk algısı ve küresel gelişmeler tarafından da şekillenmektedir. Bu doğrultuda, bu çalışmanın amacı COVID-19 sonrası dönemde kıymetli metallerdeki spekülatif fiyat hareketlerini ampirik olarak incelemektir. RTADF, SADF ve GSADF testlerinin uygulanmasından elde edilen sonuçlara göre, 05.05.2023-15.04.2025 döneminde altın, gümüş, platin ve paladyumda istatistiksel olarak anlamlı bir balon oluşumu tespit edilmemiştir. Her ne kadar istatistiksel olarak anlamlı bir balon oluşumu kanıtı bulunamamış olsa da, grafiksel eğilimler altının yatırımcıların davranışsal tepkilerine daha duyarlı olabileceğini, gümüşün ise daha istikrarlı bir desen sergilediğini düşündürmektedir. Genel olarak, bulgular analiz edilen dönemde kıymetli metallerde spekülatif balonların olmadığını göstermektedir; ancak bu piyasaların doğasında var olan oynaklık göz önüne alındığında, gelecekte spekülatif dalgalanmaların potansiyeli göz ardı edilemez. Bu nedenle hem davranışsal faktörleri hem de makroekonomik göstergeleri yatırım kararlarına dahil etmek yatırımcılar için kritik öneme sahiptir.

Anahtar Kelimeler: Değerli metaller, spekülatif balon, GSAFD testi
JEL Sınıflandırılması: G10, G15, G40

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1. Introduction

Precious metals are rare elements in nature with high economic value (Xolo et al., 2021). Throughout history, they have held strategic importance for societies due to their unique physical and chemical properties. These metals play critical roles not only as jewelry and investment instruments but also in healthcare, energy, automotive, chemical, electronics, photonics, and aerospace industries. Owing to their durability, recyclability, and high efficiency, precious metals are indispensable both economically and in terms of sustaining technological advancements (Zysk, 1981, p. xiii). Moreover, they continue to maintain their significance today due to their central role in financial systems.

The price formation of precious metals is not limited solely to supply-demand dynamics and macroeconomic indicators; it is also influenced by geopolitical risks and environmental factors (Das et al., 2019). During global crisis periods characterized by heightened uncertainty, wars, pandemics, and inflationary pressures, precious metals serve as safe havens and have become one of the most preferred investment instruments for individual and institutional investors as well as governments (Dumlupınar & Kocabıyık, 2023, p. 263). In particular, the safe-haven role of gold has been extensively documented in the literature (Baur & Lucey, 2010; Baur & McDermott, 2010). Although there is no specific theoretical model explaining why gold is typically regarded as a safe haven, its historical function as one of the first forms of money, its traditional use as a hedge against inflation, and its relatively low correlation with other asset classes are important factors that reinforce its safe-haven role (Baur & Lucey, 2010, p. 218).

The outbreak of COVID-19 in 2020 affected not only the field of public health but also deeply disrupted global economic activities (Gülhan, 2020, p. 1114; Ordu, 2022). During this period, dramatic changes in investors' risk perceptions led to significant fluctuations in gold prices (Sarı & Kartal, 2020, pp. 94–95). In February 2022, the escalation of military tensions between Ukraine and Russia increased geopolitical risks, and the effects of the conflict spread globally, influencing businesses, consumers, and governments in multiple ways (Hossain et al., 2024). Moreover, this situation also had a direct impact on the prices of precious metals (TRT Haber, 2022).

The COVID-19 pandemic has had a profound impact not only on the global economy but also on the gold market. The spread of the virus and the implementation of lockdowns and economic restrictions by governments prompted investors to turn to gold as a safe haven. As a natural consequence of this process, demand for gold increased and prices rose. Similarly, the conflict between Russia and Ukraine also affected the gold market, as geopolitical tensions and the possibility of armed conflict heightened economic uncertainty and risk perception, driving investors toward safe-haven assets such as gold (Morina, 2024, pp. 17–18). During periods of uncertainty, investors typically exit their long-term investments and shift toward short-term investments, preferring investment instruments with high liquidity levels. This situation can lead to increased demand for precious metals. Additionally, uncertainty can cause sudden and sharp price fluctuations (Çetikaya & Yenice, 2021, p. 46). Therefore, the value of precious metals may become sensitive not only to fundamental economic factors but also to speculative price movements. As investors prioritize short-term profits

in environments of increased uncertainty, excessive price fluctuations and speculative tendencies may be observed in the markets.

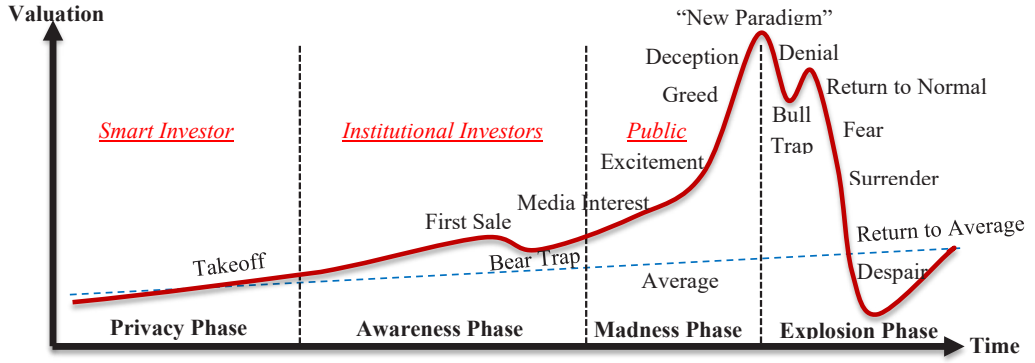
The traditional finance paradigm assumes that investors are rational (Barberis & Thaler, 2003). Within this approach, human psychology is assigned no role in decision-making processes. According to the theory, investors are expected to behave rationally under all circumstances, avoid uncertainty, protect their own interests, and seek to maximize profits. This perspective treats all investors as homogeneous individuals who, by evaluating the available market information, make decisions based solely on risk and return variables in order to achieve utility maximization (Akdeniz & Turan, 2021, p. 1017).

Behavioral finance, on the other hand, offers an alternative framework to the basic assumptions of traditional finance. From this perspective, people are not fully rational but rather "normal," meaning that their decision-making processes are influenced by cognitive biases and emotions. Markets, while difficult to beat, are not perfectly efficient, and prices may occasionally deviate from fundamentals due to irrational behavior. Investors construct their portfolios not only according to the risk-return trade-off, but also in line with the principles of behavioral portfolio theory, shaped by their psychological tendencies and personal objectives. Moreover, expected returns are determined not only by differences in risk, as argued by classical theory, but also by variations explained by investor psychology and behavioral factors (Statman, 2014, p. 65). In summary, behavioral finance proceeds from the assumption that individuals do not always act rationally. It investigates market anomalies that traditional finance theories fail to explain and, in doing so, draws on disciplines such as psychology, sociology, and anthropology to better understand financial decision-making processes (Aytekin & Aygün, 2016, p. 144).

The view that financial markets are efficient, along with the extensive body of research conducted within this framework, constitutes one of the most important intellectual foundations developed against claims that markets are vulnerable to excessive exuberance or bubbles (Shiller, 2005, p. 171). The "Efficient Market Hypothesis" introduced by Fama (1970) argues that all publicly available information is instantly and fully reflected in security prices as soon as it becomes known (Fama, 1970, p. 383). Accordingly, although prices may at times appear higher or lower than they should be, this situation is regarded merely as an illusion under the efficient market theory (Shiller, 2005, p. 171). In contrast, behavioral finance suggests that speculative price movements in financial markets are fundamentally driven by investors' irrational behaviors, such as positive feedback trading and other cognitive biases (Vasile et al., 2012, p. 793).

Speculative price movements that occur well above the fundamental value of an asset are referred to as bubbles (Brunnermeier, 2008, p. 1). During a bubble, the market undergoes a structural transformation, and a new order emerges that is entirely based on emotional influences and does not reflect the true fundamental value. In this situation, prices are shaped more by investor psychology and speculation than by rational analysis (Sornette & Cauwels, 2014, p. 7). This irrational rise typically culminates in the final stage, known as the "bubble burst," at which point sudden and sharp

value losses occur, leaving investors facing significant financial losses (Agosto & Cafferata, 2020, p. 1). Figure 1 illustrates the life cycle of bubbles.



Source: Rodrigue, J.-P. (2025)

Figure 1: The Life Cycle of Balloons

When examining Figure 1, it can be seen that investors acted with excessive optimism and greed during the mania phase, ignoring the risks. After the bubble burst, they initially found it difficult to accept the situation. Following this process, it is observed that the initial enthusiasm and excitement gradually gives way to feelings of fear, surrender and helplessness. Therefore, being able to identify price bubbles and their locations in assets at an early stage is of critical importance in terms of implementing appropriate policies to reduce the consequences of disaster scenarios that will occur when bubbles burst (Su et al., 2017, p. 2).

The price changes in precious metals that began with the COVID-19 pandemic gained momentum under the influence of global economic uncertainties and crisis environments, and this trend has continued up to the present, accompanied by various geopolitical tensions such as the Russia-Ukraine war and the U.S.-China trade conflicts. The war between Russia and Ukraine created significant global pressures, particularly on commodity and energy prices, supply chains, and overall economic stability, which in turn exerted upward pressure on the prices of precious metals such as gold and silver. Geopolitical uncertainties–including the potential risk of war escalation and the imposition of economic sanctions–further strengthened investors' risk-averse behavior, thereby increasing demand for precious metals. Similarly, global trade conflicts, especially the tensions between the United States and China, adversely affected expectations for economic growth, leading investors to turn to precious metals as a safe haven.

On May 5, 2023, the World Health Organization (WHO) announced that COVID-19 is no longer considered a "global health emergency" but rather an ongoing health issue (WHO, 2023). In this context, this study aims to investigate whether price movements in precious metals in the post-COVID-19 period deviated from market fundamentals, in other words, whether they carried speculative price movements. In the literature, the majority of studies examining speculative price movements have focused on stock markets, foreign exchange, and cryptocurrencies (Dezhbakhsh & Demirguc-Kunt, 1990; Kaizoji, 2000; Jiang et al., 2010; Jarrow & Protter, 2011; Malhotra & Maloo, 2014; Phillips et al., 2015; Souza et al., 2017;

Shu & Zhu, 2020; Gülcan et al., 2021; Göçmen Yağcılar, 2022; Yaman & Topaloğlu, 2023; Doğru, 2024; M'bakob, 2024; Söker, 2024; Jawad et al., 2025). However, research on precious metals–which hold a significant place for investors due to their safe-haven properties–remains relatively limited. This study aims to address this gap by investigating the presence of speculative price movements in precious metals using the RTADF, SADF, and GSADF tests. By focusing on the post-COVID-19 period, the study is important in revealing how investor behavior reflects the normalization process following a global crisis. The examined time frame, the set of variables employed, and the diversity of methods used distinguish this research from similar studies in the literature and provide an original contribution.

In addition, the findings to be obtained from this study will serve as an important guide for investors. Investors generally prefer gold and other precious metals as safe-haven assets during periods of market uncertainty. However, determining whether these assets have also been subject to speculative pressures in the post-COVID-19 period is of great importance, both for reassessing safe-haven strategies and for grounding portfolio diversification decisions on more solid foundations. In the subsequent sections of the study, the literature review will first be presented, examining previous research on speculative price movements in precious metals. This will be followed by the introduction of the dataset and variables, along with a detailed explanation of the methodology employed. In the application section, the analyses will be conducted, and the empirical findings will be presented and discussed. Finally, the study will conclude with a summary of the results and the implications drawn for both the academic literature and investors.

2. Literature Review

The role of precious metals in financial markets remains a topical area of research in the literature, particularly due to their perception as a haven during times of crisis and uncertainty. In recent years, a growing body of evidence has suggested that the price movements of these assets may be driven not only by economic fundamentals but also by speculative dynamics. In this context, there has been growing interest in the literature regarding the identification of speculative price movements; however, studies specific to precious metals remain limited compared to those on stock, foreign exchange, and cryptocurrency markets. In this section, we will first review empirical studies on speculative price movements and highlight the gaps in the existing literature.

A review of the literature reveals that studies on speculative bubbles and price anomalies have primarily focused on stock markets. In this context, Diba & Grossman (1985), Dezhbakhsh & Demirguc-Kunt (1990), Chan et al. (1998), Kaizoji (2000), Brooks & Katsaris (2003), Jiang et al. (2010), Phillips et al. (2015), Chang et al. (2016), Watorek & Stawiarski (2016), Akkaya (2018), Anavatan & Kayacan (2018), Shu & Zhu (2020), Yaman & Topaloğlu (2023), Kutlu & Çakır (2024), Özbey et al. (2024), Doğru (2024), and Söker (2024) analyze bubble formations in stock markets and the dynamics of these bubbles during specific periods. On the other hand, with the rapid increase in the popularity of cryptocurrencies in recent years, studies examining the speculative price movements of these assets have also gained an important place in the literature. Malhotra & Maloo (2014), Cheung et al. (2015), Landgraf (2016), Souza et al. (2017), Songur (2019), Şahin (2020), Agosto & Cafferata (2020), Caferra et al. (2021), Buğan (2021), Yılmaz (2022), Göçmen Yağcılar (2022), Altunöz (2023), Náñez

Alonso (2024), and M'bakob (2024) contribute to the evaluation of cryptocurrencies, particularly in terms of volatility, bubble formation, and speculative dynamics.

Although the vast majority of studies on speculative price movements have focused on stock markets and cryptocurrencies, the literature in this field is still in its infancy in the context of precious metals. In this context, the relevant studies are listed below to summarize the approaches in the existing literature.

Table 1: Literature Review

Authors	Variables	Time Period	Method	Findings
Bertus & Stanhouse (2001)	Gold	1975 – 1999	Dynamic Factor Analysis	It has been determined that speculative bubbles may exist in the gold futures market. Dynamic Factor Analysis
Bialkowski et al. (2011)	Gold	1978 – 2010	Markov Switching ADF	No speculative bubble has been detected in gold prices.
Baur & Glover (2012)	Gold	January 1970 – August 2012	RTADF, SADF and GSADF	The existence of speculative bubbles in the gold market has been empirically determined.
Pan (2017)	Gold, Silver	January 1990 – October 2017	SADF and GSADF	Bubbles were identified during the crisis periods of 2007–2009 and 2011.
Çelik et al. (2019)	Gold, Silver, Platinum, Palladium	01.01.2010 – 19.02.2019	RTADF, SADF and GSADF	While bubbles were detected in gold, silver, and platinum, no bubbles were detected in palladium.
Öncü (2021)	Silver	11.03.2020 – 30.08.2021	GSADF	Multiple bubbles were observed in the third quarter of 2020.
Işıldak (2022)	Gold, Dollar ve BIST-Tüm	29.07.2018 – 24.07.2022	GSADF	Three bubbles were detected for gold, five for the dollar, and six for the BIST-Tüm.
Maghyereh & Abdoh (2022)	Gold, Silver, Platinum, Palladium	January 1985 – August 2020	BSADF	A bubble was observed in gold and palladium during the COVID-19 pandemic.
Ural (2022)	Gold, Oil, and Game Stop Corp Stock	02.01.2020 – 27.10.2021	GSADF	It has been determined that a price bubble forms in gold prices in March every year, and in oil prices as well.
Samırkaş & Samırkaş Komşu (2022)	Gold, Silver, Oil, Natural Gas, Dow Jones (Grains, Metals, All Commodities) Indices	17.11.2019 – 26.06.2022	SADF and GSADF	While bubbles were found in silver, oil, and commodity indices, no bubbles were detected in gold prices.
Hosseini Jahromi et al. (2025)	Gold, Stock Market, Housing, and Exchange Rate	2001Q1 – 2022Q4	BSADF and TVP-VAR	It has been determined that monetary policies affect asset market bubbles differently over time.
Zhou & Liang (2025)	Gold and Geopolitical risk	January 2002 – December 2023	LPPLS	While positive bubbles were frequently observed between 2002 and 2006, it has been determined that peaks in geopolitical risk coincided with both positive and negative gold price bubbles.

Table 1 shows that studies by Bertus & Stenhouse (2001), Baur & Glover (2012), Işıldak (2022), and Ural (2022) reveal that gold prices have exhibited speculative movements in various periods. On the other hand, Pan (2017), Öncü (2021), and Samırkaş & Samırkaş Komşu (2022) have identified speculative price movements in silver prices during various periods. In one of the few studies on precious metals, Çelik et al. (2019) observed speculative movements in gold, silver, and platinum prices, excluding palladium. Similarly, Maghyereh and Abdoh (2022) found that speculative price behavior emerged in gold and palladium during the COVID-19 period. In contrast, Bialkowski et al. (2011) and Samırkaş & Samırkaş Komşu (2022) noted that speculative bubbles were not observed in gold prices during specific periods.

3. Data Set and Method

The aim of this study is to examine the presence of speculative price movements in precious metals during the post-COVID-19 period. In this context, the daily closing prices in U.S. dollars of gold (Au), silver (Ag), platinum (Pt), and palladium (Pd) between 05.05.2023 and 15.04.2025 are included in the analysis. The period was chosen because it reflects the post-COVID-19 environment, during which precious metals exhibited high volatility and their safe-haven role became even more significant for investors. In this timeframe, global financial markets were shaped by both geopolitical developments and uncertainties in monetary policies, providing a suitable ground for investigating speculative price movements. The data employed in the study were obtained from the Investing.com platform and used in the analyses. Summary statistics of the dataset are presented in Table 2, while the time-series visualizations of the variables are provided in Figure 2.

Table 2: Summary Statistics

Asset	n	Mean	Median	Std. Deviation	Min	Max
Au	505	2316.09	2319.01	356.52	1820.01	3236.21
Ag	505	27.17	27.34	3.81	20.90	34.83
Pt	573	963.70	959.40	48.66	848.85	1123.1
Pd	573	1066.14	1009.85	151.82	826.20	1599.10

When examining the data set presented in Table 2, it becomes apparent that gold and palladium stand out as the most volatile precious metals, with high standard deviation values. In contrast, platinum is considered the most stable metal, with both a narrow price range and low standard deviation. In gold and palladium, where volatility is high, the likelihood of speculative price movements occurring is higher compared to other metals. When considering average price levels, gold has by far the highest average, while silver has the lowest average price and ranks last on the list.

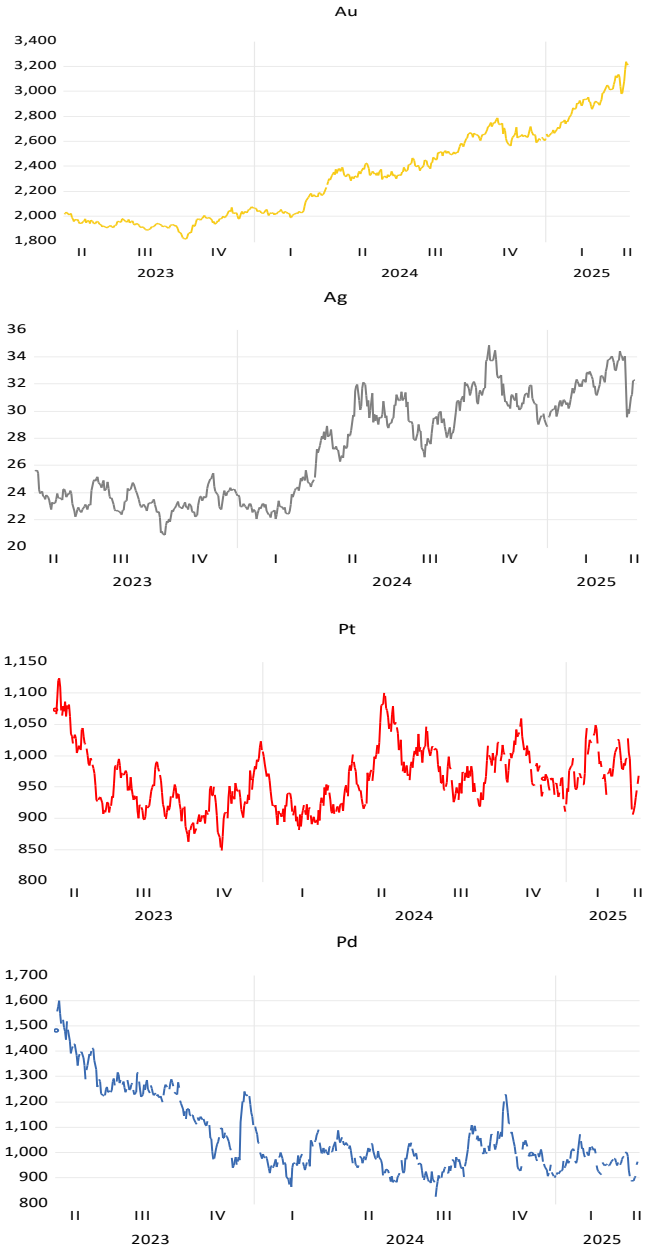


Figure 2: Time Series Visualizations

When the time series visualizations presented above are examined, precious metals have exhibited price dynamics in different directions in the 2023–2025 period. While gold has been following a steady upward trend due to geopolitical risks and inflation expectations, silver appears to have gained significant value after 2024 due to the recovery in industrial demand. Platinum has been observed to

be flat and volatile due to imbalances in supply and demand, while palladium may have lost value due to the acceleration of the transition to electric vehicles and the impact of the demand contraction.

In order to identify potential speculative movements in the price series and to determine their starting and ending periods, the RTADF, SADF, and GSADF tests were applied. These tests were chosen because they are among the most widely used and reliable econometric tools for detecting speculative bubbles in financial assets. Moreover, the joint application of these methods enhances the robustness of the findings and allows for both period-specific and overall examinations of speculative price movements in precious metal markets.

RTADF is based on the positive roots (right-tailed) form of the ADF test, assuming that the alternative hypothesis has a weak explosive dynamic (Caspi, 2017). The aim of this test is to test whether a time series exhibits an explosive movement. The autoregressive model given below is estimated using the ordinary least squares (OLS) method as in Equation 1 (Phillips et al., 2011, p. 7):

$$x_t = \mu_t + \delta x_{t-1} + \sum_{j=1}^{j} \phi_j \triangle x_{t-j} + \varepsilon_{x,t}, \varepsilon_{x,t} \sim NID(0, \sigma_x^2) \tag{1}$$

Equation (1) represents the asset price, while the parameters "μ, δ, and ϕ" are estimated using the OLS method. Here, "j" denotes the maximum number of lags to be included in the model, which is determined based on information criteria.

The SADF test was proposed by Phillips et al. (2011) and is based on the calculation of recursive ADF statistics using a window approach that expands from a fixed starting point. The test is calculated as follows:

$$SADF(r_0) = \sup_{r_2 \in [r_0, 1]} \{ADF_{r_2}\}. \tag{2}$$

The ability of SADF to detect a single bubble formation and its inability to detect multiple bubble periods in long series significantly limits the predictive power and interpretability of the test (Zeren & Esen, 2018, p. 442). The GSADF test, a new approach developed by SADF, is widely accepted in the literature, especially with its capacity to detect multiple bubble formations in time series, thanks to its flexible and variable window size structure (Ahmed, 2022, p. 11).

Phillips et al. (2015) proposed the GSADF test, which enables the detection of multiple bubbles in time series using Monte Carlo simulation techniques, as part of their work.

$$GSADF\ (r_0) = \sup_{\substack{r_2 \in [r_0, 1] \\ r_1 \in [0, r_2, r_0]}} \{ADF_{r1}^{r2}\}. \tag{3}$$

Here, r_0 denotes the window of the smallest sample; r_1 denotes the starting point of the sample at which the estimation is made; and r_2 denotes the end point of this window.

This study investigates the existence of speculative price movements in precious metal markets during the post-COVID-19 period. The main hypotheses developed within this framework are as follows:

H_0: There are no speculative price movements in precious metal markets during the post-COVID-19 period.

H_1: There are speculative price movements in precious metal markets during the post-COVID-19 period.

In addition to the main hypotheses, the following sub-hypotheses are formulated for each individual precious metal market:

H_{1a}: There are speculative price movements in the gold market during the post-COVID-19 period.

H_{1b}: There are speculative price movements in the silver market during the post-COVID-19 period.

H_{1c}: There are speculative price movements in the platinum market during the post-COVID-19 period.

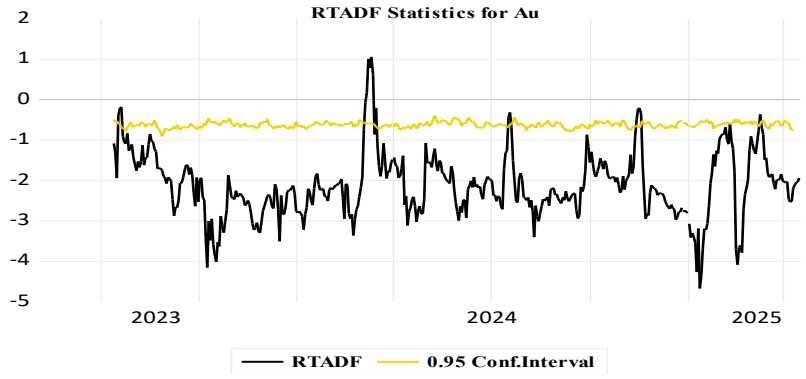
H_{1d}: There are speculative price movements in the palladium market during the post-COVID-19 period.

4. Findings

The RTADF, SADF, and GSADF test findings and visual analyses related to the prices of gold, silver, platinum, and palladium, which were examined in terms of balloon movements, are provided below.

Table 3: Gold Prices RTADF Results

Variable	Period	T-Statistic	Prob.
Gold	05.05.2023-15.04.2025	1.058	0.232

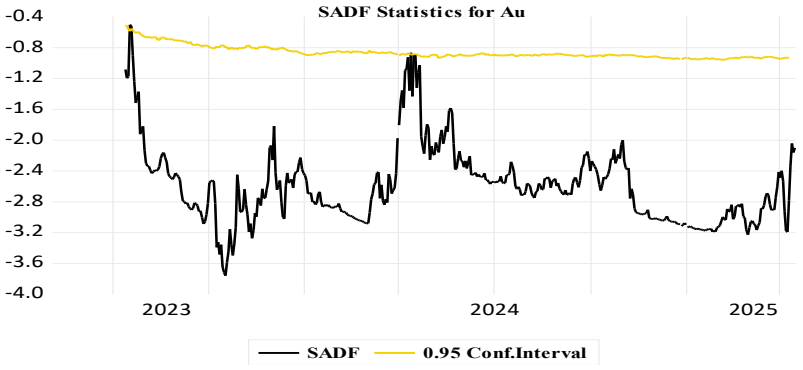


For gold, the RTADF test yielded a test statistic of (1.058) with a corresponding p-value of (0.232). These results do not indicate the presence of a bubble at the 5% significance level. The graphical analysis supports this finding, as the RTADF statistic did not exceed the 95% confidence interval threshold at any point in the sample. Nevertheless, the short-term increases observed in 2023 and

2024 suggest that gold may be more sensitive to speculative tendencies compared to other metals. However, this observation is not statistically significant.

Table 4: Gold Prices SADF Results

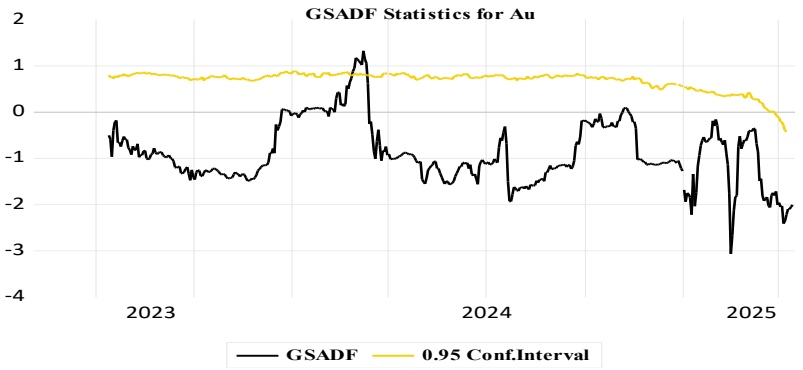
Variable	Period	T-Statistic	Prob.
Gold	05.05.2023-15.04.2025	-0.503	0.593



In Table 4, the SADF test applied to gold produced a test statistic of –0.503 with a corresponding p-value of 0.593. These results provide no statistical evidence of bubble formation at the 5% significance level. The graphical analysis confirms this finding, as the SADF statistic did not significantly exceed the 95% confidence interval threshold at any point during the examined period. Therefore, no statistically significant bubble was identified in the gold market during the post-COVID-19 period.

Table 5: Gold Prices GSADF Results

Variable	Period	T-Statistic	Prob.
Gold	05.05.2023-15.04.2025	1.325	0.288

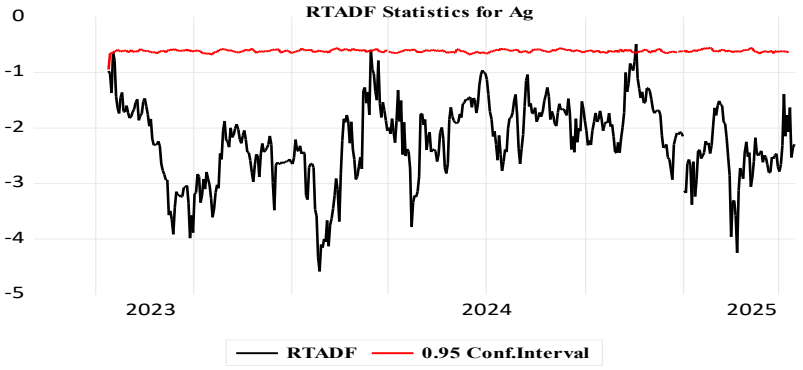


The GSADF test applied to gold yielded a test statistic of (1.325) with a corresponding p-value of (0.288). These results do not indicate bubble formation at the 5% significance level. Moreover, the GSADF statistic did not exceed the 95% confidence interval threshold at any point during the examined period. Nonetheless, the increases observed between 2023 and 2024 suggest that gold may be more susceptible to speculative fluctuations compared to other metals. When examining the tables above,

the results of all three tests related to gold prices show that the test statistics obtained are below the critical values recommended in the literature. Furthermore, all p-values are above the 10% significance level, indicating that no statistically significant bubble movement was detected in gold prices during this period. However, the higher statistic obtained in the GSADF test (1.325) compared to other metals suggests a tendency toward bubble behavior, though not at a statistically significant level.

Table 6: Silver Prices RTADF Results

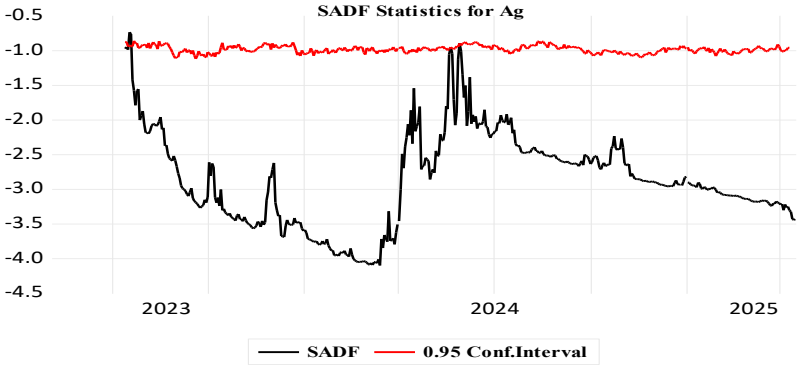
Variable	Period	T-Statistic	Prob.
Silver	05.05.2023-15.04.2025	-0.485	0.991



According to the RTADF test results for silver, the test statistic was (–0.485) with a corresponding p-value of (0.991). Since the probability value is well above the 5% significance level, the null hypothesis cannot be rejected. Therefore, no statistically significant evidence of a speculative bubble was found in the silver market during the period 05.05.2023–15.04.2025.

Table 7: Silver Prices SADF Results

Variable	Period	T-Statistic	Prob.
Silver	05.05.2023-15.04.2025	-0.733	0.606

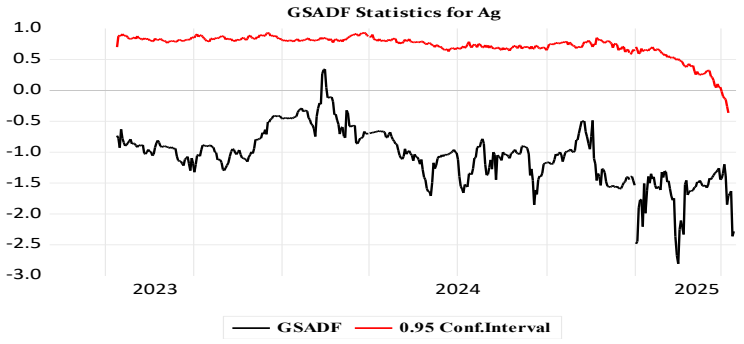


In Table 7, the SADF test was employed to examine speculative bubble formations in the silver market for the period 05.05.2023–15.04.2025. The obtained test statistic (–0.733) and p-value (0.606) were not

statistically significant at the 5% level. Furthermore, the SADF statistic did not exceed the critical value corresponding to the 95% confidence interval at any point in the time series. This finding indicates that there is no evidence of speculative price bubbles in the silver market during the analyzed period.

Table 8: Silver Prices GSADF Results

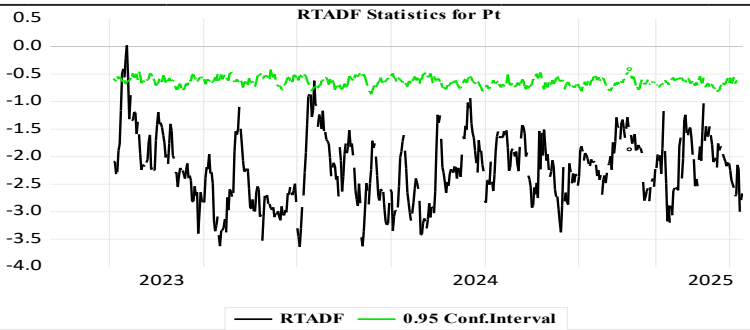
Variable	Period	T-Statistic	Prob.
Silver	05.05.2023-15.04.2025	0.344	0.904



The GSADF test results, consistent with the SADF test, provide no evidence of speculative bubble formations in the silver market during the examined period. The obtained test statistic (0.344) and p-value (0.904) are not statistically significant at the 5% level. The graphical findings also support this result, as the GSADF statistic did not exceed the critical value band at any point in the time series. In all three tests conducted for silver, the test statistics remained negative or very low, resulting in very high p-values. These results clearly show that silver prices did not undergo any explosive processes during this period. The negative result of the RTADF test statistic indicates that the series is close to a stationary structure, while the low value of the GSADF indicates that there are no signals of multiple bubble formations.

Table 9: Platinum Prices RTADF Results

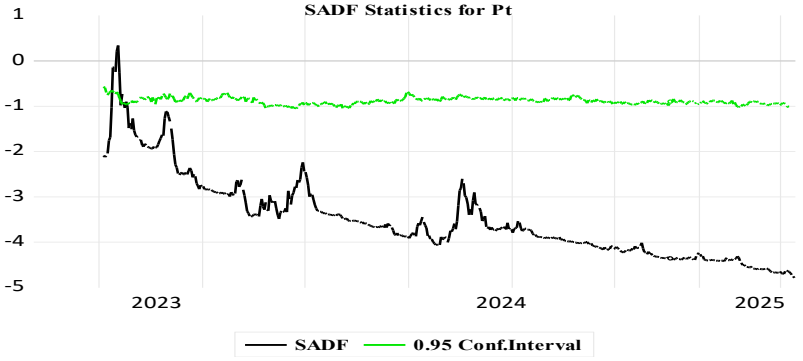
Variable	Period	T-Statistic	Prob.
Platinum	05.05.2023-15.04.2025	0.021	0.877



The RTADF test results also indicate that there is no evidence of speculative bubbles in the platinum market during the examined period. The obtained test statistic (0.021) and p-value (0.877) were not found to be significant at the 5% level.

Table 10: Platinum Prices SADF Results

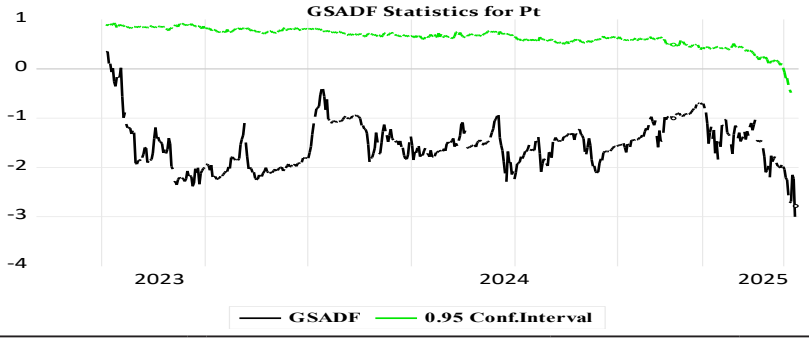
Variable	Period	T-Statistic	Prob.
Platinum	05.05.2023-15.04.2025	0.342	0.154



The SADF test results for the platinum market provide no evidence of speculative bubble formations during the examined period. The test statistic (0.342) and p-value (0.154) are not statistically significant at the 5% level.

Table 11: Platinum Prices GSADF Results

Variable	Period	T-Statistic	Prob.
Platinum	05.05.2023-15.04.2025	0.351	0.883

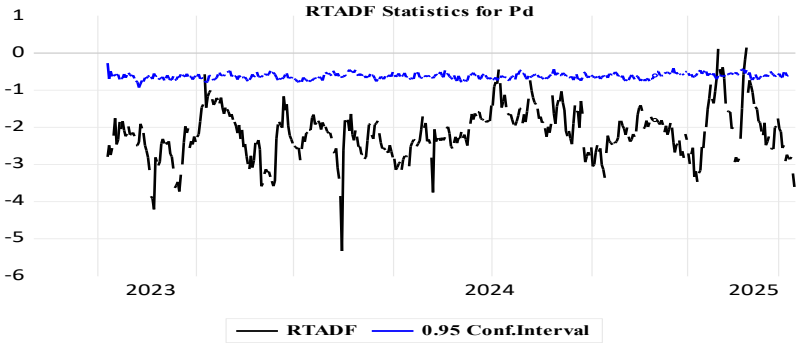


The GSADF test results for platinum, consistent with the SADF and RTADF findings, provide no evidence of speculative bubble formations during the examined period. The test statistic (0.351) and p-value (0.883) are not statistically significant at the 5% level. The graphical findings also support this result, as the GSADF statistics did not exceed the critical value corresponding to the 95% confidence interval at any point in the time series. In the analysis conducted for platinum, it was observed that the RTADF and GSADF test statistics were relatively low and did not approach the significance level.

Although the 0.342 statistic obtained in the SADF test appears relatively high, it remains below the 10% significance level and, therefore, does not indicate the formation of a statistically significant bubble. These findings suggest that no speculative bubble process occurred in the platinum market during the period.

Table 12: Palladium Prices RTADF Results

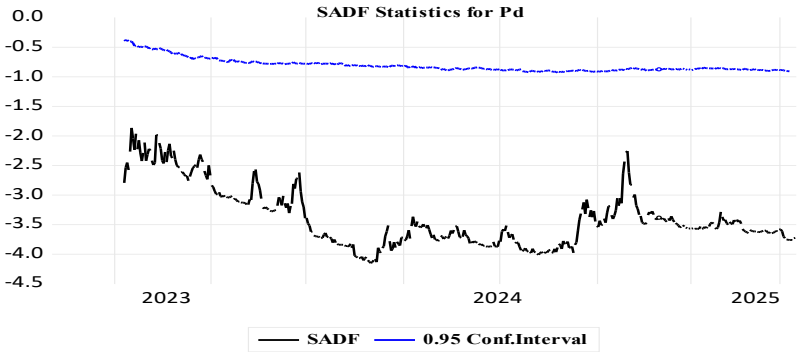
Variable	Period	T-Statistic	Prob.
Palladium	05.05.2023-15.04.2025	0.147	0.808



The RTADF test results for the palladium market reveal no evidence of speculative bubbles during the period 05.05.2023–15.04.2025. The obtained test statistic (0.147) and p-value (0.808) are not statistically significant at the 5% level.

Table 13: Palladium Prices SADF Results

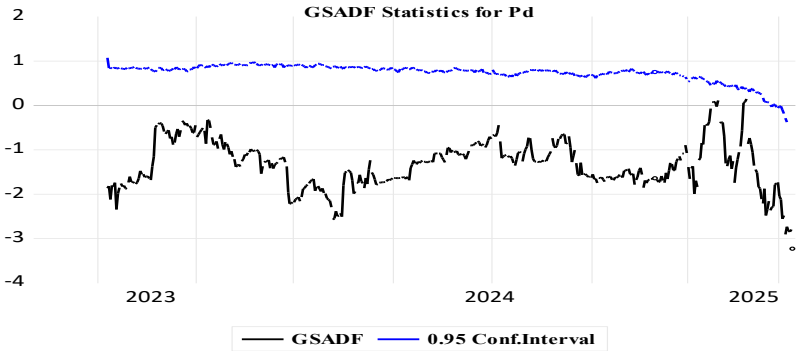
Variable	Period	T-Statistic	Prob.
Palladium	05.05.2023-15.04.2025	-1.866	0.991



The SADF test results for the palladium market provide no evidence of speculative bubbles during the analyzed period. The test statistic (–1.866) and p-value (0.991) are not statistically significant at the 5% level. The graphical findings further support this result, as the SADF statistics did not exceed the critical value band at any point in the time series.

Table 14: Palladium Prices GSADF Results

Variable	Period	T-Statistic	Prob.
Palladium	05.05.2023-15.04.2025	0.147	0.957



The GSADF test results for the palladium market provide no evidence of speculative bubble formations during the examined period. The test statistic (0.147) and p-value (0.957) are not statistically significant at the 5% level. The graphical findings also support this conclusion, as the GSADF statistics did not exceed the critical value corresponding to the 95% confidence interval at any point in the time series. These results indicate that palladium prices followed a pattern consistent with market fundamentals between 05.05.2023 and 15.04.2025, remaining free from excessive speculative pressures. Across all tests, the results clearly show no evidence of bubble formation in the palladium market. The very low SADF statistic (–1.866) reflects a highly stationary structure, while the GSADF test, despite considering different combinations of r_1 and r_2, identified no significant explosive processes. Thus, no economically meaningful speculative price movements were observed in the palladium market during the analyzed period, confirming that prices remained aligned with market fundamentals.

When the RTADF, SADF, and GSADF test results are collectively evaluated, no statistically significant speculative movements were found in the gold, silver, platinum, or palladium markets during the post-COVID-19 period (05.05.2023–15.04.2025). The short-term fluctuations observed in 2023, 2024, and 2025 are better explained by global economic developments, monetary policy dynamics, and geopolitical risks rather than speculative behavior. In 2023, expectations that the Federal Reserve would end its interest rate hikes, combined with high inflation, recession concerns, and a weakening dollar, may have increased demand for precious metals. In 2024, expectations of interest rate cuts, global recession risks, and ongoing geopolitical tensions further strengthened the role of precious metals. In 2025, the U.S.-China trade conflicts appear to have contributed to price fluctuations. However, as shown by the RTADF, SADF, and GSADF tests, the price increases during this period do not point to statistically significant bubbles; rather, they represent rational responses to market fundamentals and global uncertainties. Moreover, the simultaneous rise in gold, silver, platinum, and palladium prices highlights the continued safe-haven demand from investors.

5. Conclusion

It is known that prices in financial markets are shaped not only by basic economic indicators but also by investor behavior, expectations, risks, perception of uncertainty and global developments. This situation, especially in commodity markets, can sometimes cause asset prices to deviate from their rational values and exhibit speculative price movements. These speculative tendencies occur as a result of investors directing the market with emotional reactions such as enthusiasm, herd behavior, excessive optimism or panic, and can often have temporary but significant effects in terms of financial stability. In this context, the study empirically tested whether the prices of gold, silver, platinum and palladium, which are considered as precious metals, exhibited speculative price movements between the period of 05.05.2023-15.04.2025 after COVID-19. For this purpose, RTADF, SADF and GSADF tests were applied and the presence of speculative behavior in the price series was investigated. These tests were developed to detect temporary but severe price deviations within time series, and the GSADF test stands out with its ability to detect multiple bubble periods.

Unlike bubble analyses in the literature, which typically focus on stock, foreign exchange, and cryptocurrency markets, the study's focus on safe-haven precious metals represents a key strength. Furthermore, its focus on the post-COVID-19 period provides a unique contribution by revealing the impact of investor behavior on the post-pandemic normalization process. Methodologically, the combined application of RTADF, SADF, and GSADF tests increases the reliability of the findings and enables a more robust analysis of speculative price movements. The study is not only based on econometric results but also contributes theoretically to the literature by discussing the role of investor psychology in price movements within the theoretical framework of behavioral finance.

When the findings obtained from the RTADF, SADF and GSADF tests applied within the scope of the study are evaluated together, no statistically significant bubble formation was detected in any of the four precious metals examined. Although the test results for gold suggest relatively closer values to bubble formation compared to other metals, this finding is not statistically significant. Therefore, no definitive conclusion can be drawn regarding the existence of a bubble in gold prices. In contrast, silver is considered the least likely asset to exhibit bubble behavior, as it recorded the lowest test statistics and the highest p-values across all tests. Moreover, the GSADF test, with its ability to capture multiple bubble periods, provides a more comprehensive analysis compared to the SADF and RTADF tests. Nevertheless, the GSADF results also confirm the absence of explosive price behavior for all metals examined.

The findings show that there was no statistically significant speculative price movement in the prices of precious metals gold, silver, platinum and palladium during the period examined. However, rapid changes in financial markets, trade wars, geopolitical risks and uncertainties reveal that these markets may be open to potential speculative price fluctuations in the future. In investment decisions to be taken specifically for precious metals, instead of only considering short-term price movements, macroeconomic indicators and global risk factors should definitely be taken into consideration. Although no statistically significant price movement was detected in the study, it should not be overlooked that precious metal markets are inherently highly volatile and may occasionally exhibit

excessive buy–sell reactions depending on shifts in investor sentiment. The results support the safe-haven role of precious metals; however, rather than limiting their portfolios solely to gold, investors may benefit from diversifying with other precious metals such as silver, platinum, and palladium, which can contribute to a more effective balance of risks, particularly during periods of crisis and uncertainty. Furthermore, in the case of assets such as gold, which tend to display relatively closer behavior to speculative price movements, it is important for investors to consider not only technical analyses but also behavioral finance factors when making decisions and diversifying their portfolios.

The findings of this study share both similarities and differences with several studies in the literature. First, similar to the results of Bialkowski et al. (2011) and Samırkaş & Samırkaş Komşu (2022), who found no evidence of bubbles in gold prices, this study also reports no statistically significant bubbles in precious metals, including gold. In addition, the findings of Çelik et al. (2019), which indicate the absence of bubbles in palladium, are consistent with the results of this study. On the other hand, studies such as Bertus & Stanhouse (2001), Baur & Glover (2012), Pan (2017), Öncü (2021), Işıldak (2022), and Ural (2022) document the presence of speculative bubbles in gold and silver during different periods, which distinguishes this research from theirs. Moreover, while Maghyereh & Abdoh (2022) identified bubble formations in gold and palladium during the COVID-19 period, the absence of such evidence in this study marks another point of divergence.

This study is based on daily price data covering only a specific period. However, since the formation and evolution of speculative bubbles may exhibit different dynamics over time, future research could benefit from employing datasets that span longer time horizons to enable a more accurate and comprehensive assessment of bubble behavior. In addition, incorporating not only price series but also other financial and behavioral variables—such as trading volume, volatility indices, and investor sentiment—into the models would allow speculative tendencies to be analyzed in a more multidimensional manner.

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Resume

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