Gold's rally: a topological contextualization

Assessing regime change via topological data analysis

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Is gold's recent price surge an anomaly?

A quantitative framework for distinguishing regime breaks from flow-driven repricing

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Executive Summary

Gold prices have surged dramatically in late 2025 and early 2026, with gold spot increasing 28

Key Finding: Despite extreme price momentum (100th percentile historically), the correlation structure of gold relative to currencies, bonds, and risk assets remains completely normal (43rd percentile deviation from historical average). This signature—extreme price movement with normal topology—is consistent with a *secular revaluation* of gold relative to fiat currencies rather than a market dislocation or panic.

Implication: The analysis supports Ray Dalio's framework of a long-term fiat-to-physical currency cycle. The topology indicates the market microstructure is functioning normally; this is a repricing, not a breakdown.

1 Background

1.1 Genesis of This Analysis

This analysis emerged from a broader research program applying topological data analysis to financial markets. The original objective was to develop early warning systems for market regime changes—specifically, to detect when correlation structures become unstable *before* price crashes occur.

The methodology was initially developed and validated on S&P 500 data, where we examined whether persistent homology of return time series could provide leading indicators of market stress. While the single-asset return topology proved to be a coincident (not leading) indicator, the pivot to *cross-asset correlation topology* showed more promise, with negative correlations between topological complexity and forward returns beginning to emerge.

When gold prices began their dramatic ascent in late 2025, surpassing \$5,500/oz within weeks, we redirected the framework to answer a specific question: **Is this move a regime break (fundamental change in how gold relates to other assets) or a level shift within an intact regime?**

1.2 Methodological Foundation

The core insight is that price returns are *outputs* of market dynamics, while correlation structures represent the underlying *inputs*. A regime change should manifest as a breakdown in the topological structure of inter-asset correlations before or during the price move. Conversely, a flow-driven repricing—where large buyers accumulate an asset—should occur with correlations intact.

We employ:

- **Rolling correlation matrices** (60-day windows) across 17 assets including gold, currencies, bonds, and equities
- **Persistent homology** to extract topological features (H_0, H_1, H_2) from correlation distance matrices
- **Wasserstein distance** to measure the rate of topological change between consecutive periods
- **Robust z-scores** (MAD-based) for anomaly detection

2 Methodology

2.1 Data Sources

The analysis integrates multiple data sources:

Category	Assets/Series	Source
Precious Metals	GLD, SLV, GDX	Yahoo Finance
Currencies	DXY, EUR/USD, JPY, GBP, CNY	Yahoo Finance
Fixed Income	TLT, TIP, SHY, 10Y/5Y Yields	Yahoo Finance
Equities	S&P 500, VIX	Yahoo Finance
Commodities	USO, DBA	Yahoo Finance
Macro	Real Rates, M2, Fed Balance Sheet	FRED API

Table 1: Data sources used in the analysis (2006–2026)

2.2 Topological Framework

For each rolling window, we:

1. Compute the 17×17 correlation matrix of log returns
2. Convert to distance matrix: $d_{ij} = \sqrt{2(1 - \rho_{ij})}$
3. Compute Vietoris-Rips persistent homology up to dimension 2
4. Extract persistence metrics: max persistence, feature count, total persistence
5. Compute Wasserstein distance between consecutive persistence diagrams

The key topological features are:

- H_0 **(Components):** Measures clustering—how assets group together
- H_1 **(Loops):** Measures cyclic relationships—triangular dependencies among assets
- H_2 **(Voids):** Measures hollow structures—fragile correlation configurations

3 Results

3.1 Current State Assessment

As of January 23, 2026:

Metric	Current	Z-Score	5Y Percentile
Gold Price (GLD)	\$451.79	—	—
20-Day Momentum	+38.8%	+2.38	100.0%
60-Day Momentum	+80.8%	—	—
H_1 Max Persistence	0.1563	+1.23	89.2%
H_2 Max Persistence	0.0338	+0.50	71.6%
Wasserstein Distance	0.1687	+1.76	81.8%
Composite Topology	—	+1.16	78.9%
Correlation Deviation	2.94	—	**43.0%**

Table 2: Current anomaly assessment. Price momentum is extreme; correlation structure is normal.

Critical observation: The correlation structure deviation from its 1-year average sits at the 43rd percentile—squarely in the normal range. This is the key finding.

3.2 Regime Classification

NORMAL REGIME

Correlation structure is within historical norms.
Current gold move is occurring within typical correlation patterns.

3.3 Historical Analog Analysis

We identified 11 historical episodes with similar signatures (elevated topology + high momentum):

Date	Comp Z	Mom Z	Price	20d	60d	120d
2008-03-17	+5.20	+1.62	\$99	−7.5%	−9.8%	−17.2%
2011-08-08	+6.49	+1.90	\$162	+13.3%	+4.9%	+0.2%
2020-08-10	+3.13	+3.70	\$191	−4.8%	−7.7%	−8.9%
2024-07-15	+2.20	+2.19	\$223	+0.6%	+9.8%	+8.2%
2025-10-08	+2.05	+1.71	\$366	−1.1%	+8.2%	—

Table 3: Selected historical analogs (5 of 11 shown)

Average forward returns after similar episodes:

- 20 days: −0.9%
- 40 days: −1.1%
- 60 days: +0.3%

- 120 days: -0.8%

The historical analogs suggest momentum exhaustion may slow the rate of appreciation, but do not predict a reversal.

4 Visualizations

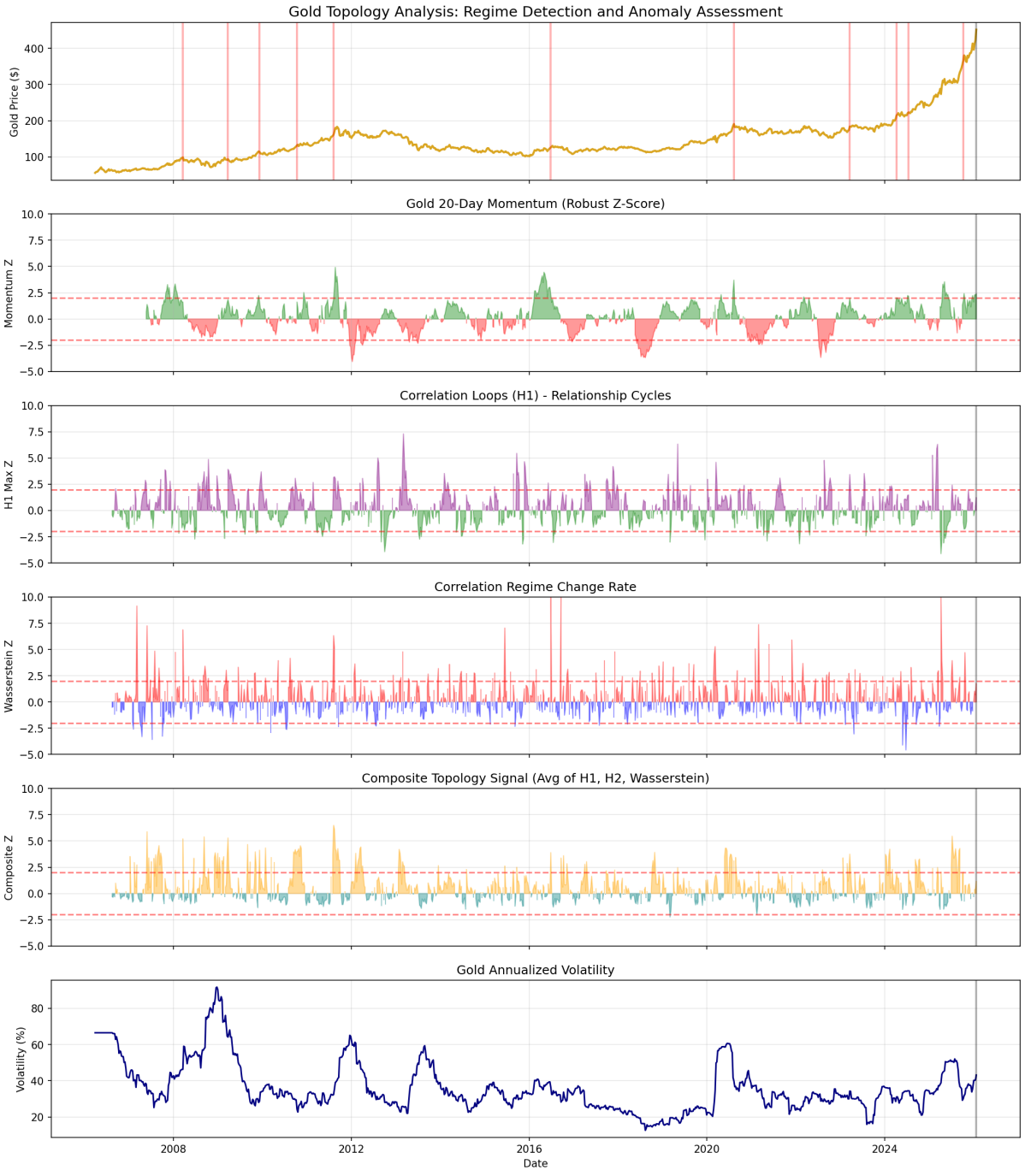

Figure 1: Gold topology analysis time series. Top panel shows price with historical analog markers (red lines). Subsequent panels show momentum z-score, H_1 correlation loops, Wasserstein regime change rate, composite topology signal, and annualized volatility.

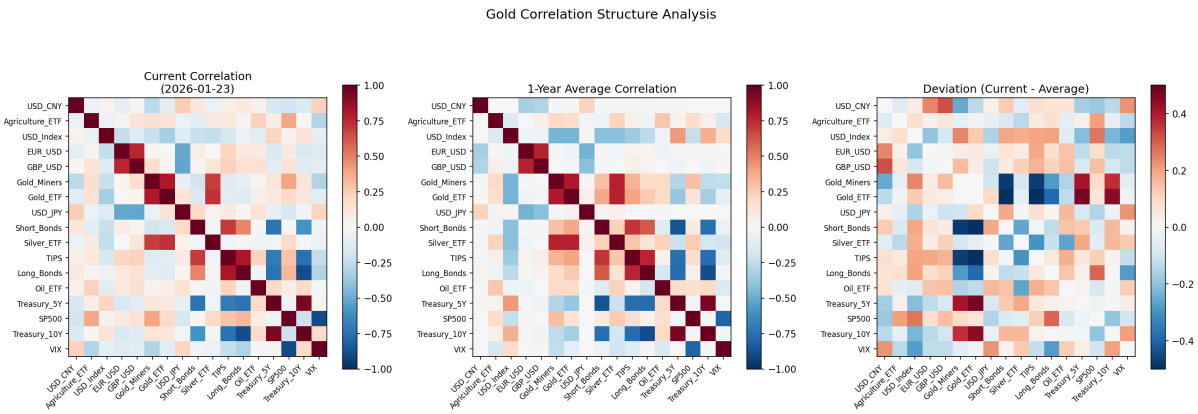

Figure 2: Correlation structure analysis. Left: current correlation matrix. Center: 1-year average. Right: deviation (current minus average). Note that gold's correlations with other assets remain close to historical norms.

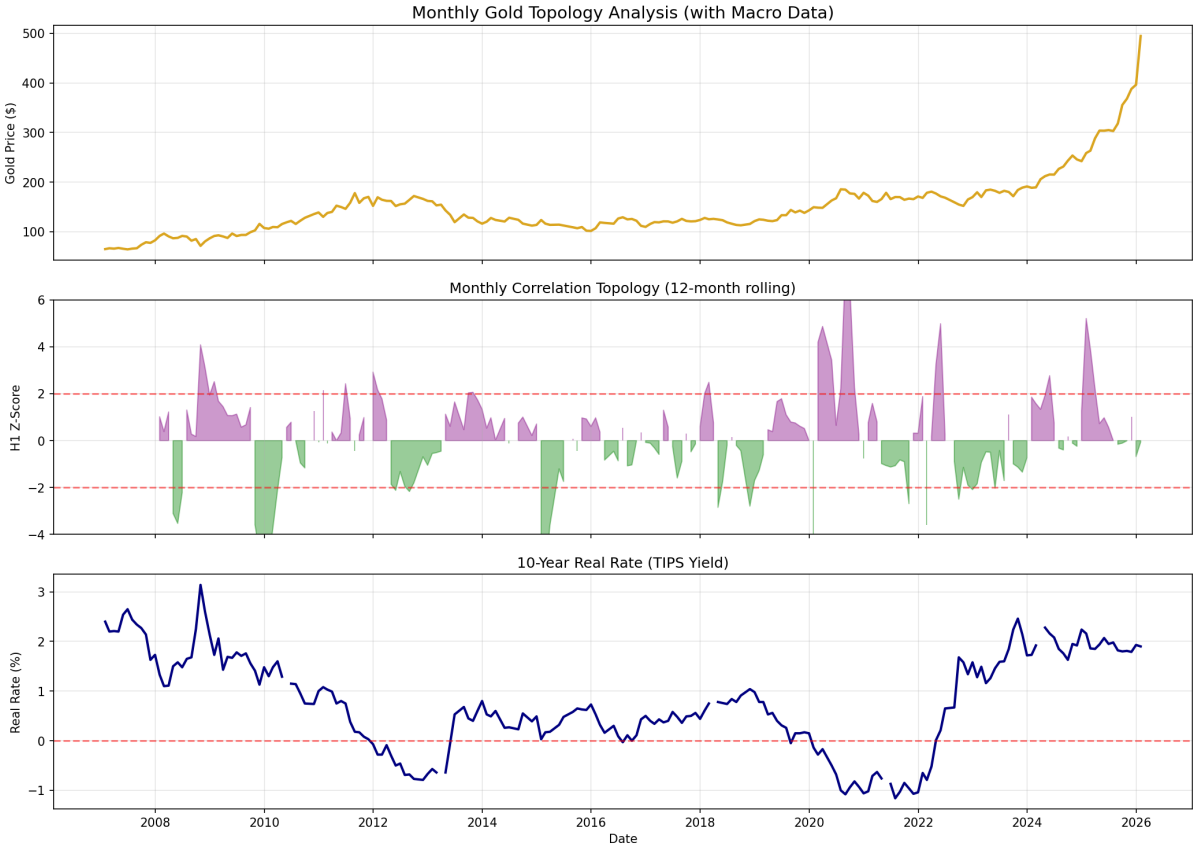

Figure 3: Monthly topology analysis including FRED macro data. Bottom panel shows 10-year real rates (TIPS yield), currently at +1.90%—historically elevated, which would normally be bearish for gold.

5 Macro Signal Analysis

5.1 Real Rates

The 10-year real rate (TIPS yield) stands at +1.90%, in the 81st percentile historically. Under normal circumstances, positive real rates are bearish for gold, as the opportunity cost of holding a non-yielding asset increases. Yet gold is rallying.

5.2 Foreign Treasury Holdings

Foreign official holdings of US Treasuries increased 25.9% year-over-year—contrary to the "de-dollarization" narrative often cited to explain gold strength. This signal is bearish for gold in traditional frameworks.

5.3 Integrated Signal Summary

Signal	Reading	Direction
Daily Topology	+1.16	Bullish
Momentum Z	+2.38	Bullish
Real Rate Signal	−1.90	Bearish
De-dollarization	−2.59	Bearish
Weighted Composite	**+0.14**	**Neutral**

Table 4: Integrated signal summary. Mixed conditions yield neutral composite.

6 Interpretation

6.1 The Disconnect

The central finding is a *disconnect* between price behavior and structural behavior:

- **Price momentum:** Extreme (100th percentile)
- **Correlation structure:** Normal (43rd percentile)

This pattern is the signature of a **flow-driven move within an intact regime**—not a regime break. The correlation heatmap confirms that Gold_ETF and Gold_Miners behave exactly as they "should" relative to USD_Index, TIPS, bonds, etc. The *relationships* haven't changed; the *level* has.

6.2 Dalio's Framework

This analysis is consistent with Ray Dalio's description of a secular, long-term cycle of fiat currency devaluation relative to physical stores of value. The forces driving gold higher are likely:

1. **Central bank accumulation:** Structural bid from sovereign buyers (China, Russia, Turkey, India, Poland have been active)
2. **Sovereign balance sheet concerns:** Debt/GDP trajectories in major economies
3. **Geopolitical hedging:** Sanctions risk and reserve diversification post-2022

These are *slow* forces that manifest as persistent price drift with normal volatility and intact cross-asset relationships. The topology confirms: the market microstructure is functioning normally. This is a repricing, not a panic.

6.3 Forward Outlook

Based on historical analogs, the *rate* of appreciation may slow over the next 20–60 days (average forward returns near zero). However, nothing in the topology suggests an imminent reversal. The structural bid from central banks and the secular forces Dalio describes may continue to support prices at elevated levels.

7 Conclusion

Gold's dramatic price surge in late 2025 and early 2026 occurs within a **normal correlation regime**. Despite extreme momentum, the topological structure of gold's relationships with currencies, bonds, and risk assets remains intact. This finding supports the interpretation of a *secular repricing* of gold relative to fiat currencies—consistent with long-term forces such as central bank accumulation, sovereign debt concerns, and geopolitical hedging—rather than a market dislocation or speculative bubble.

The topology does not predict the future direction of gold prices, but it characterizes the *nature* of the current move: orderly, flow-driven, and structurally sound.

Analysis conducted January 2026 using topological data analysis methods. Data sources: Yahoo Finance, FRED. Computational tools: Python (giotto-tda, scipy, pandas, numpy).