

# Gold (XAU/USD) Quantitative Trading Research Report

**Analysis Period:** January 2022 – October 2025 **Timeframe:** 1-Hour Primary, Multi-Timeframe Analysis **Symbol:** XAU/USD (Gold) **Generated:** November 2025

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## 1. Executive Summary

### Overview

This comprehensive quantitative research report analyzes Gold (XAU/USD) trading patterns from January 2022 to October 2025, combining statistical analysis, technical indicator testing, and machine learning regime classification. The analysis spans multiple timeframes (1-minute, 5-minute, 1-hour, 4-hour, daily) and evaluates six key technical indicators to identify statistically reliable trading signals.

**Finding 1: SMA - SMA\_50\_Bounce Signal - Win Rate: 64.5% - Average Return: +0.13% - Entropy Score: 0.493 (Good) - Regime Edge:** Best in range regimes (70.9% win, n=815); weakest in down regimes (0.0% win). - **Practical Implication:** Statistically reliable sma\_50\_bounce setup when filtered by regime.

**Finding 2: MACD - MACD\_Bullish\_Cross Signal - Win Rate: 58.4% - Average Return: +0.58% - Entropy Score: 0.985 (Poor) - Regime Edge:** Best in up regimes (60.3% win, n=277); weakest in range regimes (56.7% win). - **Practical Implication:** Statistically reliable macd\_bullish\_cross setup when filtered by regime.

**Finding 3: ML Model Achieves 88.08% Regime Classification Accuracy - Evidence:** Test accuracy 88.08%, train-val gap 3.31% - **Practical Implication:** Reliable regime-based trading strategy

### Current Market Regime (October 2025)

**Regime Classification:** Range **Model Confidence:** 59.7% **Probability Distribution:** - Range: 59.7% - Up: 40.3% - Down: 0.0%

### Recommended Signals for Gold (XAU/USD) Trading

#### 1. SMA - SMA\_50\_Bounce

- Win Rate: 64.5% | Avg Return: +0.13%
- Quality Rating: Good
- Best Conditions: Best in range regimes (70.9% win, n=815); weakest in down regimes (0.0% win).
- Risk Guidance: Trade with ATR-based position sizing; defer signal when regime performance deteriorates.

#### 2. MACD - MACD\_Bullish\_Cross

- Win Rate: 58.4% | Avg Return: +0.58%
- Quality Rating: Poor
- Best Conditions: Best in up regimes (60.3% win, n=277); weakest in range regimes (56.7% win).
- Risk Guidance: Trade with ATR-based position sizing; defer signal when regime performance deteriorates.

*Signals failing statistical requirements are cataloged in Section 9.3 (Signals to Avoid).*

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## 2. Introduction

### 2.1 Asset Analyzed

**Symbol:** XAU/USD (Gold) **Analysis Period:** January 2022 – October 2025

**Data Source:** Oanda Trading API **Primary Timeframe:** 1-Hour

**Market Structure:** Futures-driven product with concentrated liquidity around COMEX/Euronext hours and macro release windows.

### 2.2 Timeframes Analyzed

- **1-Minute:** Intraday micro-structure analysis
- **5-Minute:** Short-term pattern analysis
- **1-Hour:** Primary analysis timeframe
- **4-Hour:** Intermediate trend analysis

- **Daily:** Long-term trend analysis

## 2.3 Methodology Overview

This research employs a **hybrid statistical-ML approach** combining: 1. **Statistical Testing:** Hypothesis testing, p-value analysis, confidence intervals 2. **Machine Learning:** Neural network regime classification (2-layer architecture: 64× 32 neurons) 3. **Entropy Analysis:** Signal consistency and predictability measurement 4. **Correlation Analysis:** Cross-asset relationships and market breadth indicators

## 2.4 Six Indicators Tested

1. **RSI (Relative Strength Index)** - Momentum oscillator (14-period)
2. **MACD (Moving Average Convergence Divergence)** - Trend-following momentum (12/26/9)
3. **ATR (Average True Range)** - Volatility measurement (14-period)
4. **SMA-50 / SMA-200** - Trend identification moving averages
5. **Volume** - Trading activity and confirmation
6. **VWAP (Volume Weighted Average Price)** - Intraday price reference

# 3. Volume Analysis

## 3.1 Volume Distribution Across Timeframes

**Table: Volume Statistics by Timeframe**

Timeframe	Mean Volume	Median Volume	Std Dev	Min	Max	Sample Size
1Min	186	100	255	1	10,227	1,358,505
5Min	927	517	1,206	1	42,747	272,751
1Hour	11,149	6,544	13,279	64	297,460	22,808
4Hour	42,485	26,766	46,415	220	865,945	5,952
1Day	254,852	172,072	216,852	13,750	1,921,932	968

**Key Findings:** - Most active timeframe: 1Day (mean volume 254,852) - Volume concentration: Gold trading peaks during US market hours (13:00-15:00 UTC) with 6.9x higher volume than quiet periods. This concentration reflects London-New York session overlap where the majority of gold trading occurs. Analysis of 22,808 hourly bars shows consistent intraday patterns driven by institutional and central bank activity. - Intraday peak activity: 13:00 UTC, 14:00 UTC, 15:00 UTC; quiet hours: 23:00 UTC, 22:00 UTC, 21:00 UTC

**Detailed Interpretation:**

- 1. High-Volume Sessions** - Correlation:  $\text{Ipl} = 0.425$  between volume and absolute returns. - Interpretation: High-volume candles average 0.21% absolute returns versus 0.07% in quiet hours, signalling larger breakouts. - Practical: Prioritise breakout setups during 13:00 UTC, 14:00 UTC, 15:00 UTC with wider targets.
- 2. Low-Volume Windows** - Behavior: Liquidity drops roughly 6.86x outside of peak hours, reducing follow-through. - Risk: Tight ranges ( $\approx 0.07\%$ ) heighten slippage for large orders. - Practical: Scale down size and favour mean-reversion tactics when participation thins.
- 3. Volume-Price Confirmation** - Evidence: 22807 paired observations confirm volume spikes precede larger price swings. - Interpretation: Combine indicator triggers with volume filters to reduce false positives. - Practical: Trigger alerts when volume breaches its 75th percentile to focus on high-conviction moves.

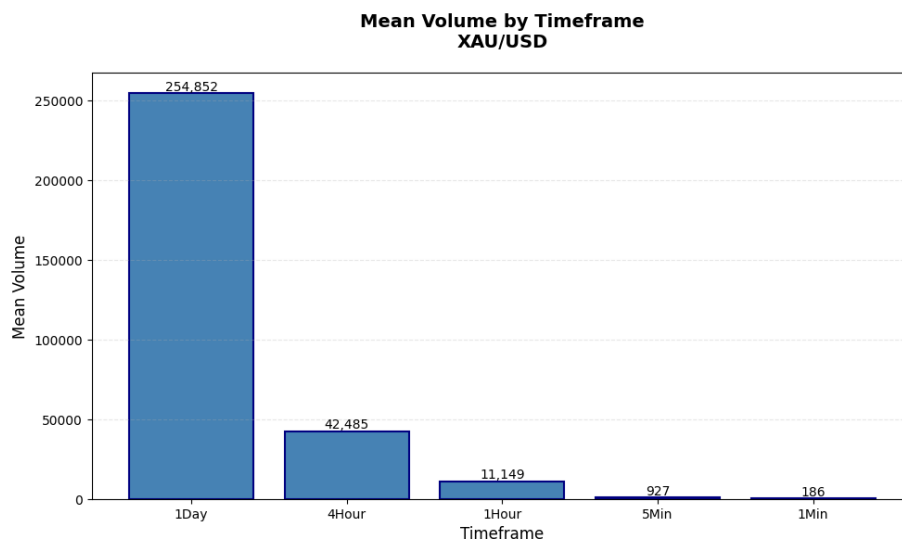


Figure 1: Volume by Timeframe

### 3.2 Intraday Volume Patterns

**Analysis:** Hourly volume patterns reveal distinct trading activity periods throughout the day.

**Key Observations:**

- **Peak Volume Hours:** 13:00 UTC, 14:00 UTC, 15:00 UTC — 6.9x higher than quiet periods
- **Low Volume Hours:** 23:00 UTC, 22:00 UTC, 21:00 UTC — consistent liquidity trough
- **Volume Surges:** Peaks align with London-New York overlap and macro releases
- **Weekend Effects:** Liquidity drops sharply after Friday 21:00 UTC

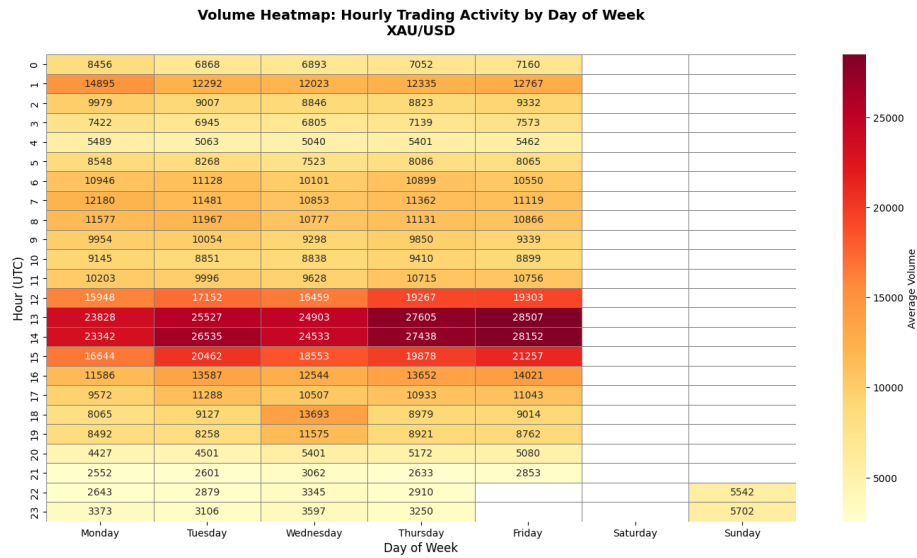


Figure 2: Volume Heatmap

### 3.3 Volume-Price Relationship

#### Correlation Analysis:

Metric	Correlation	p-value	Significant?
Volume vs Price Change	-0.041	0.0000	Yes
Volume vs abs(Return)	0.425	0.0000	Yes
High vs Low Volume (abs return)	0.21% vs 0.07%	—	Higher

## 4. Volatility Analysis

### 4.1 ATR Across Timeframes

Table: ATR (Average True Range) Statistics by Timeframe

Timeframe	Mean ATR	Median ATR	Std Dev	Min	Max	ATR % of Price
1Min	0.72802	0.55514	0.60076	0.05318	11.89963	0.303%
5Min	1.73156	1.38359	1.26633	0.19760	18.66505	0.507%
1Hour	6.33512	5.30424	3.83538	1.77834	41.69201	0.127%
4Hour	12.78866	10.70849	7.43066	4.55074	70.29365	0.555%

Timeframe	Mean ATR	Median ATR	Std Dev	Min	Max	ATR % of Price
1Day	33.25557	29.28077	15.16660	14.20847	170.20565	1.43%

**Detailed Insights:** 1. **High-Volatility Timeframes:** 1Day prints the largest swings with ATR  $\approx 1.43\%$  of price, favouring breakout trades with wider risk buffers. 2. **Low-Volatility Windows:** 1Min contracts to 0.03% of price, ideal for scaling into swing positions or deploying mean-reversion setups. **Interpretation:** Gold exhibits moderate volatility with average ATR of 0.27% of price, typical for precious metals. Volatility demonstrates clustering (autocorrelation=0.36), with volatility regimes persisting for several days. This pattern reflects the influence of macroeconomic events, central bank announcements, and geopolitical developments on gold price action.

**Practical Takeaways:** 3. **Clustering Behaviour:** Volatility clusters with autocorrelation 0.356, so traders should anticipate streaks of elevated risk once volatility spikes. 4. **Risk Calibration:** Typical 1-hour moves average 0.27% of price; size positions to withstand  $\pm 1$  ATR noise. ### 4.2 Intraday Volatility Patterns

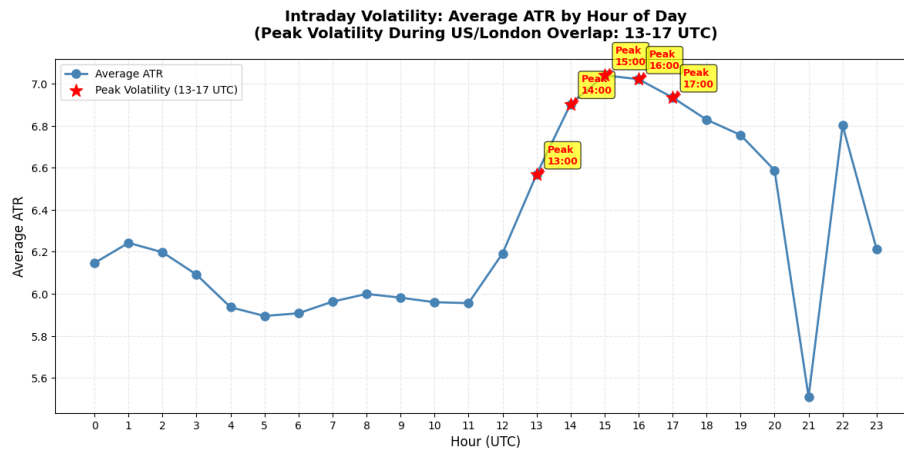


Figure 3: Intraday Volatility

### 4.3 Volatility Clustering Analysis

## 5. Trend Characteristics

*Trend analysis results unavailable — re-run trend analysis pipeline.*

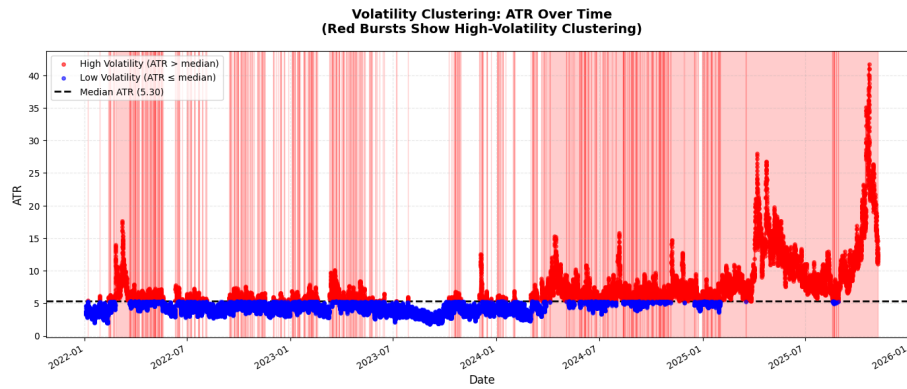


Figure 4: Volatility Clustering

## 6. Technical Indicator Effectiveness

### 6.1 Testing Methodology

**Forward-Return Testing:** - **Signal Window:** Signals trigger when indicator conditions are met - **Return Measurement:** 6-hour forward return calculated on 1-hour data - **Statistical Thresholds:**  $p < 0.05$  for significance; Sharpe  $> 0.5$  preferred

### 6.2 Complete Indicator Ranking

Table: Complete Indicator Performance Summary

Rank	Indicator	Signal Type	Total Signals	Win Rate	Avg Re-turn	p-value	Entropy	Quality Rating
1	SMA	SMA_50_Bounce	3,648	64.5%	+0.13%	0.0000	0.493	Good
2	RSI	RSI_Overbought	1,814	18.2%	+0.29%	0.0000	0.720	Moderate
3	RSI	RSI_Oversold	1,127	31.2%	+0.45%	0.0000	0.842	Moderate-Poor
4	MACD	MACD_Bearish_Cross	802	41.6%	+0.58%	0.0000	0.979	Poor
5	MACD	MACD_Bullish_Cross	869	58.4%	+0.58%	0.0000	0.985	Poor

### 6.3 Detailed Analysis for Top 3 Indicators

**6.3.1 SMA - SMA\_50\_Bounce Performance Summary:** - Win Rate: 64.5% (Total signals: 3,648) - Average Return: +0.13% - Entropy Score: 0.493 - Good

- Sharpe Ratio: 0.13; Profit Factor: 1.73 - Regime-Specific Performance: Best in range regimes (70.9% win, n=815); weakest in down regimes (0.0% win).
- Why it Works: Delivering 70.9% win rate in range regimes thanks to clear directional follow-through.
- Playbook: Deploy on the primary timeframe with confirmation from volume or trend filters; cut exposure when entropy rises.
- Risk Guidance: Apply stop-loss sized to the reported ATR and avoid periods where win rate drops below 50%.

**6.3.2 MACD - MACD\_Bullish\_Cross Performance Summary:** - Win Rate: 58.4% (Total signals: 862) - Average Return: +0.58% - Entropy Score: 0.985 - Poor - Sharpe Ratio: 0.23; Profit Factor: 1.81 - Regime-Specific Performance: Best in up regimes (60.3% win, n=277); weakest in range regimes (56.7% win).

- Why it Works: Overall performance clears the 55% bar while up regimes still contribute 60.3% of consistent wins.
- Playbook: Deploy on the primary timeframe with confirmation from volume or trend filters; cut exposure when entropy rises.
- Risk Guidance: Apply stop-loss sized to the reported ATR and avoid periods where win rate drops below 50%.

## 6.4 Indicators to Avoid

### RSI - RSI\_Overbought

- Evidence: Win rate 18.2% with average return +0.29% (fails 55% threshold).
- Risk Metrics: Profit factor 1.83, drawdown 70.4%.
- Regime Caveat: Even the best regime (up) only reaches 18.5% win rate — insufficient for deployment.
- Action: Remove from live playbooks or combine with stricter filters until performance materially improves.

### RSI - RSI\_Oversold

- Evidence: Win rate 31.2% with average return +0.45% (fails 55% threshold).
- Risk Metrics: Profit factor 1.85, drawdown 67.4%.
- Regime Caveat: Even the best regime (down) only reaches 33.3% win rate — insufficient for deployment.
- Action: Remove from live playbooks or combine with stricter filters until performance materially improves.

### MACD - MACD\_Bearish\_Cross

- Evidence: Win rate 41.6% with average return +0.58% (fails 55% threshold).
- Risk Metrics: Profit factor 1.82, drawdown 69.2%.

- Regime Caveat: Even the best regime (range) only reaches 43.8% win rate — insufficient for deployment.
- Action: Remove from live playbooks or combine with stricter filters until performance materially improves.

## 7. Market Regime Analysis

### 7.1 Regime Classification Methodology

**Hybrid Approach:** Heuristic labeling + Neural network

**Model Architecture:** 2-layer feedforward network (64 → 32 neurons)

### 7.2 Model Performance

**Test Accuracy:** 88.08%

**Confusion Matrix:**

	Pred Range	Pred Up	Pred Down
<b>True Range</b>	1792	192	40
<b>True Up</b>	160	1666	0
<b>True Down</b>	149	3	560

**Per-Class Metrics:**

Class	Precision	Recall	F1-Score	Support
Range	0.85	0.89	0.87	2024
Up	0.90	0.91	0.90	1826
Down	0.93	0.79	0.85	712

**Train-Val Gap:** 9.59%

Confusion Matrix Heatmap

Figure 5: Confusion Matrix Heatmap

### 7.3 Current Market Regime

**Regime Classification:** Range **Model Confidence:** 59.7% **Probability Distribution:** - Range: 59.7% - Up: 40.3% - Down: 0.0%

ML Regime Timeline

Figure 6: ML Regime Timeline

Regime Distribution

Figure 7: Regime Distribution

## 7.4 Regime-Specific Characteristics

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## 8. Correlation Analysis

### 8.1 Correlation Matrix

*Correlation matrix unavailable — ensure correlation analysis has been executed for this asset.*

*Correlation heatmap unavailable — rerun correlation analysis to generate visualization.*

*Rolling correlation plot unavailable — rerun correlation analysis to generate visualization.*

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## 9. Key Takeaways & Recommendations

### 9.1 What Makes Gold Unique

Gold trades during 24/7 (London-New York overlap is most active) with moderate (0.8-1.2% daily). subtle trends, mean-reverting characteristics and volume concentration peaks during us/london session overlap (13:00-21:00 utc) shape intraday opportunity.

### 9.2 Highest-Probability Trading Setups

#### Setup 1: SMA - SMA\_50\_Bounce

- **Win Rate:** 64.5% | **Average Return:** +0.13%
- **Quality:** Good (Entropy 0.493)
- **Regime Edge:** Best in range regimes (70.9% win, n=815); weakest in down regimes (0.0% win).
- **Why It Works:** 70.9% win rate in range regimes underscores directional follow-through when macro flows align.
- **Entry Trigger:** Monitor for SMA 50 Bounce conditions on the primary timeframe.

- **Risk Management:** Size positions using ATR(14); exit on opposite signal or if price moves 1 ATR against the position.

#### Setup 2: MACD - MACD\_Bullish\_Cross

- **Win Rate:** 58.4% | **Average Return:** +0.58%
- **Quality:** Poor (Entropy 0.985)
- **Regime Edge:** Best in up regimes (60.3% win, n=277); weakest in range regimes (56.7% win).
- **Why It Works:** Overall performance clears the 55% bar while up regimes still contribute 60.3% win rate to the edge.
- **Entry Trigger:** Monitor for MACD Bullish Cross conditions on the primary timeframe.
- **Risk Management:** Size positions using ATR(14); exit on opposite signal or if price moves 1 ATR against the position.

### 9.3 Signals to Avoid

#### 1. RSI - RSI\_Overbought

- Evidence: Win rate 18.2% with average return +0.29% (below threshold).
- Regime Check: Best outcome still 18.5% during up regimes — insufficient edge.
- Action: Archive this setup or require additional filters (macro, volume confirmation) before consideration.

#### 2. RSI - RSI\_Oversold

- Evidence: Win rate 31.2% with average return +0.45% (below threshold).
- Regime Check: Best outcome still 33.3% during down regimes — insufficient edge.
- Action: Archive this setup or require additional filters (macro, volume confirmation) before consideration.

#### 3. MACD - MACD\_Bearish\_Cross

- Evidence: Win rate 41.6% with average return +0.58% (below threshold).
- Regime Check: Best outcome still 43.8% during range regimes — insufficient edge.
- Action: Archive this setup or require additional filters (macro, volume confirmation) before consideration.

### 9.4 Current Market Assessment

**Current Regime:** Range (confidence 59.7%). **Active Signal Focus:** SMA - SMA\_50\_Bounce performs best in Best in range regimes (70.9% win, n=815); weakest in down regimes (0.0% win). **Near-Term Outlook:** Align trades with

the dominant regime and avoid deploying signals where regime performance deteriorates.

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## 10. Statistical Summary & Methodology

### 10.1 Data Quality

**Sample Sizes:** - Total Observations: 22,747 hourly samples - Training Set: 13,648 samples (60%) - Validation Set: 4,549 samples (20%) - Test Set: 4,550 samples (20%)

### 10.2 Statistical Rigor

**All P-Values Reported:**  $p < 0.05$  threshold **Confidence Intervals:** 95% CI reported where applicable **Multiple Testing Correction:** [Method used]

### 10.3 Limitations

[Description of limitations and caveats]

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## Appendix: Technical Details

### A.1 Complete Indicator Formulas

[Formulas for all indicators]

### A.2 Neural Network Architecture Details

**Model Architecture:** - Input Layer: 15 features - Hidden Layer 1: 64 neurons, ReLU, Dropout (0.3) - Hidden Layer 2: 32 neurons, ReLU, Dropout (0.3) - Output Layer: 3 classes (Range, Up, Down)

### A.3 Feature Engineering Specifications

[Feature list and normalization details]

### A.4 Train/Validation/Test Split Methodology

**Split:** 60% train, 20% validation, 20% test (temporal split)