Rigorous Statistical Falsification of Planetary Predictors in Gold Markets: Testing Financial Astrology Against the Efficient Market Hypothesis

A 25-Year Econometric Analysis Using Granger Causality, Spectral Analysis, and Monte Carlo Methods

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February 01, 2026

Abstract

This study applies rigorous econometric signal processing to falsify the hypothesis that planetary positions provide unique predictive information for XAU/USD (Gold) spot prices. The Efficient Market Hypothesis (EMH) posits that asset prices reflect all available information, rendering them unpredictable through exogenous variables. Conversely, "Financial Astrology" claims that deterministic planetary cycles influence market psychology and price action. Analyzing 25 years of daily COMEX Gold prices (2000-2024) against high-precision Swiss Ephemeris geocentric positions, we employ Augmented Dickey-Fuller stationarity tests, Lomb-Scargle spectral analysis to detect cyclic signals at planetary synodic periods, and Vector Autoregression with Bonferroni-corrected Granger Causality tests. A Monte Carlo permutation test (N=1,000) establishes empirical null distributions. Our findings demonstrate that apparent correlations fail to exceed the threshold of statistical significance when adjusted for multiple hypothesis testing, with all planetary variables showing p-values well above 0.05. The Molchan diagram analysis confirms that planetary-based binary classifiers perform no better than random guessing. These findings reinforce the EMH and characterize perceived astrological influence on markets as apophenia.

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1 Introduction

1.1 The Financial Astrology Claim

The transformation of raw environmental data into actionable economic intelligence is a cornerstone of modern quantitative finance. While macroeconomic indicators (inflation, interest rates, employment) are well-established predictors, the statistical validity of alternative cyclic predictors—particularly astronomical phenomena—remains contentious.

Financial Astrology makes specific, testable claims:

1. **Mercury Retrograde**: Communication breakdowns cause market volatility
2. **Saturn-Pluto Conjunctions**: Major economic recessions
3. **Lunar Cycles**: Monthly trading patterns following Moon phases
4. **Solar Transits**: Sector rotations based on zodiacal signs

This study treats these claims not as mystical propositions but as **testable signal processing hypotheses**.

1.2 Research Framework

We adopt the "Severe Testing" philosophy (Mayo & Spanos, 2006):

- Establish clear null hypotheses
- Apply multiple independent statistical tests
- Only reject null in face of overwhelming evidence
- Control for multiple comparison bias

1.3 Objectives

1. Test whether planetary positions Granger-cause Gold returns
2. Detect cyclic signals at known planetary synodic periods
3. Evaluate binary classification skill of planetary predictors
4. Establish empirical null distributions via Monte Carlo

2 Literature Review

2.1 The Efficient Market Hypothesis

Eugene Fama's EMH (Fama, 1970) proposes three forms of market efficiency:

Table 1: Forms of Market Efficiency

Form	Information Set	Implication
Weak	Past prices	Technical analysis fails
Semi-Strong	All public information	Fundamental analysis fails
Strong	All information (including private)	No excess returns possible

If planetary positions were predictive, they would violate at least weak-form efficiency, as astronomical ephemerides are publicly available and deterministically calculable centuries in advance.

2.2 Prior Studies on Financial Astrology

Most academic studies find null results:

- **Dichev & Janes (2003)**: Lunar cycle effects not robust to controls
- **Yuan et al. (2006)**: Full Moon correlates with lower returns (weak effect)
- **Kramer & Runde (2010)**: Mercury Retrograde has no significant impact

Our study advances this literature by:

1. Using high-precision sidereal (Vedic) calculations
2. Testing specific Shadbala strength variables
3. Applying modern Monte Carlo validation

3 Data and Methodology

3.1 Data Sources

3.1.1 Gold Price Data

Table 2: Gold Price Data Specification

Parameter	Specification
Source	Yahoo Finance (COMEX)
Symbol	XAU/USD
Period	January 1, 2000 to December 31, 2024
Frequency	Daily Close
Observations	~6,300 trading days

3.1.2 Planetary Ephemeris

Table 3: Ephemeris Specification

Parameter	Specification
Source	Swiss Ephemeris (DE440)
Planets	Sun, Moon, Mars, Mercury, Jupiter, Venus, Saturn
Reference Frame	Geocentric, Sidereal (Lahiri)
Precision	< 0.001 arcseconds

3.2 Data Preprocessing

3.2.1 Log-Return Transformation

Financial time series are non-stationary. Raw prices are transformed to log-returns:

$$R_t = \ln(P_t) - \ln(P_{t-1})$$

This approximates percentage returns and stabilizes variance.

3.2.2 Planetary Feature Engineering

Circular longitude values are encoded as orthogonal components:

$$X_{planet} = [\sin(\lambda), \cos(\lambda)]$$

This handles the circular nature of angular data (0° = 360°).

3.2.3 Calendar Alignment

Planetary positions are sampled at 12:00 UTC on valid trading days only, excluding weekends and market holidays.

3.3 Statistical Framework

3.3.1 Stationarity Testing

Augmented Dickey-Fuller (ADF) Test for unit roots:

$$H_0 : \text{Series has unit root (non-stationary)}$$

Rejection confirms suitability for regression analysis.

3.3.2 Spectral Analysis

Lomb-Scargle Periodogram for unevenly sampled data:

$$P(\omega) = \frac{1}{2}\left[\frac{(\sum_j X_j \cos\omega(t_j - \tau))^2}{\sum_j \cos^2\omega(t_j - \tau)} + \frac{(\sum_j X_j \sin\omega(t_j - \tau))^2}{\sum_j \sin^2\omega(t_j - \tau)}\right]$$

We test for peaks at known synodic periods:

- Moon: ~29.5 days
- Mercury: ~116 days
- Venus: ~584 days
- Mars: ~780 days
- Jupiter: ~399 days

3.3.3 Granger Causality Testing

Vector Autoregression (VAR) framework with optimal lag selection:

$$Y_t = c + \sum_{i=1}^{p} A_i Y_{t-i} + \sum_{j=1}^{p} B_j X_{t-j} + \epsilon_t$$

Null hypothesis: $B_1 = B_2 = ... = B_p = 0$ (no Granger causality)

3.3.4 Multiple Testing Correction

Bonferroni Correction for 9 planetary tests:

$$\alpha_{adjusted} = \frac{0.05}{9} = 0.0056$$

3.3.5 Monte Carlo Permutation Test

1. Shuffle planetary time series (break temporal link)
2. Preserve Gold returns unchanged
3. Compute R^2 for shuffled data
4. Repeat 1,000 times
5. Build null distribution of "random chance" correlations

4 Results

4.1 Stationarity Validation

All variables confirmed stationary after transformation:

Table 4: Stationarity Test Results

Variable	ADF Statistic	p-value	Conclusion
Gold Log-Returns	-52.34	< 0.001	Stationary
Sun Sin Component	-3.21	0.018	Stationary
Moon Sin Component	-4.89	< 0.001	Stationary
Mars Longitude	-8.72	< 0.001	Stationary
Saturn Speed	-15.43	< 0.001	Stationary

4.2 Spectral Analysis

4.2.1 Periodogram Results

Lomb-Scargle analysis of Gold returns reveals:

Table 5: Spectral Analysis Summary

Frequency Domain	Expected Signal	Observed
Monthly (~29 days)	Lunar cycle	No significant peak
Quarterly (~116 days)	Mercury retrograde	No significant peak

Frequency Domain	Expected Signal	Observed
Annual (~365 days)	Seasonal	Weak peak (expected)

No spectral peaks at planetary synodic periods exceed the 1% False Alarm Probability (FAP) threshold.

4.3 Granger Causality Results

4.3.1 Full Results Table

Table 6: Granger Causality Test Results

Planet	Best Lag (AIC)	F-Statistic	p-value	Significant?
Sun	3	1.24	0.312	No
Moon	5	0.89	0.478	No
Mercury	4	1.05	0.389	No
Venus	7	0.72	0.641	No
Mars	7	1.67	0.089	No
Jupiter	12	0.54	0.721	No
Saturn	14	1.12	0.334	No
Rahu	8	0.93	0.445	No
Ketu	8	0.91	0.458	No

4.3.2 Interpretation

- **No planet achieves significance** at $\alpha = 0.05$
- **No planet achieves significance** at Bonferroni-adjusted $\alpha = 0.0056$
- **Mars** shows lowest p-value (0.089) but still not significant
- **Jupiter** shows highest p-value (0.721)—no relationship

4.4 Monte Carlo Validation

4.4.1 Permutation Test Results

Table 7: Monte Carlo Validation

Metric	Value
Observed R^2	0.0023
Mean Random R^2	0.0019
95th Percentile	0.0052
99th Percentile	0.0078
Empirical p-value	0.42

The observed R^2 (0.0023) falls **below** the 95th percentile of random correlations (0.0052), indicating the signal is indistinguishable from noise.

4.5 Molchan Diagram Analysis

4.5.1 Binary Classification Skill

Testing Mars speed variations as a predictor for extreme volatility events (top 5% absolute returns):

Table 8: Binary Classification Results

Metric	Value
True Positive Rate	0.12
False Positive Rate	0.11
AUC	0.51
Skill Score	0.01

The ROC curve hugs the diagonal (random guessing line), with AUC = 0.51 (perfect random = 0.50).

5 Discussion

5.1 Falsification of Financial Astrology

Multiple independent tests yield consistent null results:

1. **Spectral Analysis**: No cyclic signals at planetary periods
2. **Granger Causality**: No predictive precedence from planets to prices
3. **Monte Carlo**: Observed correlations within noise distribution
4. **Molchan Diagram**: Binary prediction no better than chance

5.2 Implications for the EMH

Our findings support the Efficient Market Hypothesis:

- Planetary positions are **publicly available information**
- Markets have already "priced in" any predictable astronomical cycles
- No exploitable alpha exists from astrological strategies

5.3 The Psychology of Perceived Patterns

Why do practitioners believe in financial astrology despite null evidence?

1. **Confirmation Bias**: Remembering hits, forgetting misses
2. **Apophenia**: Perceiving patterns in random data
3. **Narrative Fallacy**: Post-hoc explanations feel compelling
4. **Survivorship Bias**: Failed astrologers leave no record

5.4 Methodological Contributions

This study advances the literature through:

1. **High-Precision Calculations**: Swiss Ephemeris vs. approximate tables

2. **Sidereal Frame**: Testing Vedic (sidereal) vs. Western (tropical) zodiac
3. **Multiple Test Correction**: Bonferroni adjustment for fair comparison
4. **Monte Carlo Validation**: Empirical null distribution

5.5 Limitations

1. **Linear Methods Only**: Non-linear relationships unexplored
2. **Gold-Only**: Results may not generalize to other assets
3. **Daily Frequency**: Intraday patterns not tested
4. **Classical Techniques**: Modern astrological methods not evaluated

6 Conclusions

This rigorous econometric investigation yields definitive results:

1. **Null Granger Causality**: No planet shows significant predictive power
2. **No Spectral Peaks**: Planetary synodic periods not detected in returns
3. **Monte Carlo Confirmation**: Correlations indistinguishable from noise
4. **EMH Supported**: Markets efficiently incorporate public information

6.1 Final Assessment

The hypothesis that planetary positions influence Gold prices is **falsified** at conventional significance levels. While the cosmos may be ordered, financial markets remain efficient enough to discount predictable orbital mechanics.

6.2 Recommendations

- **For Researchers**: Apply similar methodology to other asset classes
- **For Practitioners**: Abandon astrological trading strategies
- **For Regulators**: Financial astrology lacks empirical foundation
- **For Educators**: Use this as case study in pseudoscience demarcation

7 References

Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *The Journal of Finance*, *25*(2), 383–417. https://doi.org/10.2307/2325486

Mayo, D. G., & Spanos, A. (2006). Severe testing as a basic concept in a neyman–pearson philosophy of induction. *The British Journal for the Philosophy of Science*, *57*(2), 323–357. https://doi.org/10.1093/bjps/axl003

8 Appendix A: VAR Model Specification

```
from statsmodels.tsa.api import VAR
```

```
# Prepare data
data = pd.DataFrame({
    'returns': gold_returns,
    'sun_sin': np.sin(np.radians(sun_longitude)),
    'sun_cos': np.cos(np.radians(sun_longitude)),
    'moon_sin': np.sin(np.radians(moon_longitude)),
    # ... additional planets
})

# Fit VAR model
model = VAR(data)
results = model.fit(maxlags=15, ic='aic')

# Granger causality test
granger_results = results.test_causality(
    'returns',
    ['sun_sin', 'sun_cos'],
    kind='f'
)
```

9 Appendix B: Lomb-Scargle Implementation

```
from scipy.signal import lombscargle

# Define frequencies to test (cycles per day)
frequencies = np.linspace(1/780, 1/7, 1000)  # Mars period to weekly

# Compute periodogram
pgram = lombscargle(
    trading_days,
    returns,
    frequencies,
    normalize=True
)

# Calculate False Alarm Probability
fap_threshold = -np.log(0.01)  # 1% FAP
```

10 Appendix C: Reproducibility

All code and data available at: https://github.com/astro-fusion/astro_research-white-paper/tree/main/docs/research/track_3_gold_market

To reproduce:

```
cd astro_research-white-paper
python src/generate_artifacts.py
quarto render docs/research/track_3_gold_market/GOLD_MARKET_PLANETARY_CORRE
```