# A Quantitative Framework for Trading Post-Shock Volatility Relaxation in Financial Markets

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March 2026

Financial markets often experience large shocks caused by macroeconomic events, geopolitical conflicts, liquidity crises, or sudden changes in supply chains. Such shocks generate abrupt price movements and elevated volatility across multiple asset classes. Recent global developments such as geopolitical conflicts, disruptions in commodity supply chains, and rapid shifts in energy markets have produced significant price fluctuations in metals, commodities, and equity markets. Events such as war-related supply shocks or sudden policy announcements frequently generate large and persistent price movements that propagate through financial markets.

Empirical research has shown that market activity after such shocks follows statistical regularities. In particular, Lillo and Mantegna [1] demonstrated that the frequency of extreme price movements following large market crashes decays according to a power law similar to the Omori law observed in earthquake aftershock sequences.

This project aims to analyze these post-shock market dynamics and explore whether the predictable relaxation of volatility can be used to construct systematic trading strategies. The objective is to combine statistical modeling, high-frequency market data, and quantitative trading methods to identify exploitable volatility patterns following large market disturbances.

## 1 Methods

The study focuses on liquid financial markets including U.S. equities, commodities, and major indices. The dataset will consist of historical price series, return distributions, and volatility measures spanning multiple recent market shocks.

Our framework consists of the following stages:

1. **Shock Detection**

   Large shocks are identified by detecting extreme price movements relative to the typical volatility level of an asset. Events where returns exceed a multiple of the standard deviation are classified as market shocks.

2. **Post-Shock Activity Analysis**

Following a shock event, we measure the frequency of extreme returns in the subsequent time window. Empirical evidence suggests that the rate of these events follows a power-law decay of the form

$$n(t) \sim t^{-p}$$

where $n(t)$ represents the rate of extreme price movements after the shock and $p$ is the decay exponent.

3. **Volatility Relaxation Modeling**

   Using the observed decay dynamics, we model the expected volatility trajectory following a shock:

$$\sigma(t) = A(t - t_0 + c)^{-\alpha}$$

   where $\sigma(t)$ represents expected volatility, $t_0$ denotes the time of the shock, and $\alpha$ describes the speed of volatility relaxation.

# 2 Trading Strategy Implementation

After estimating the expected volatility decay following a shock using the Omori-type relation,

$$\sigma(t) = A(t - t_0 + c)^{-b}$$

we compare the observed volatility with the predicted volatility.

## Signal Generation

We define a deviation factor

$$D(t) = \frac{\sigma_{\text{observed}}(t)}{\sigma_{\text{expected}}(t)}$$

which measures how far the realized market volatility deviates from the theoretical relaxation path.

## Case 1: Slow Relaxation (Trend Continuation)

If volatility remains significantly higher than predicted,

$$D(t) > 1.3$$

for a sustained time window $X$, the market has not fully absorbed the initial shock.

**Interpretation:**

Information from the shock is still propagating through the market and volatility remains elevated.

**Trade Implementation**

- Trade direction: Same direction as the original shock
- Entry: Confirmation window (5–10 minutes after the shock)

- Position size: Inversely proportional to deviation magnitude
- Stop: When $D(t)$ falls back below 1
- Exit: Fixed time horizon $T$

### Case 2: Fast Relaxation (Mean Reversion)

If volatility decays faster than predicted,

$$D(t) < 0.7$$

for a sustained time window $X$, the shock may have been primarily liquidity-driven rather than information-driven.

**Interpretation:**

The market has overreacted temporarily and volatility has collapsed faster than expected.

**Trade Implementation**

- Trade direction: Opposite to the shock direction
- Entry: After volatility undershoot confirmation
- Position size: Smaller than in trend continuation trades
- Stop: When new volatility expansion begins
- Exit: Return toward pre-shock volume-weighted average price

This framework allows systematic identification of trading opportunities by monitoring deviations from the expected Omori-law volatility relaxation dynamics.

## 3 Research Objectives

The goal of this project is to develop a reproducible quantitative framework for analyzing post-shock volatility dynamics and evaluating its potential as a systematic trading strategy. The research will focus on empirical validation, parameter estimation, and preliminary backtesting across multiple market regimes.

By combining insights from statistical physics, market microstructure, and quantitative finance, this project aims to explore whether the predictable structure of volatility relaxation can be used to generate robust trading signals in modern financial markets.

## References

[1] F. Lillo and R. N. Mantegna. Power-law relaxation in a complex system: Omori law after a financial market crash. *Physical Review E*, 68, 016119, 2003.