A Proposed Framework for the Kinetic Stress Index (KSI)

Will Cook

7th July 2025

Version: 1.0 (Rough Methodological Draft)

1. Introduction and Rationale

This paper puts forward an initial framework for a metric we have termed the Kinetic Stress Index (KSI), which is designed to function outside the reflexive feedback loops of conventional, traded market indicators. The intention is to develop a tool that provides an objective, macroscopic perspective on systemic integrity, moving beyond the quantification of simple price volatility to measure the stability of the market's internal architecture itself. The core proposition rests on modelling the system of asset relationships through a kinetic analogy, whereby the system is described not merely by its static state, or **position**, but also by its instantaneous rate of change, its **velocity**, and its rate of acceleration. Within this conceptual model, a high KSI reading would signify a statistically significant deviation of the system's current kinetic state from its historical norms, suggesting that the underlying dynamics of the market's correlation regime are undergoing a tangible structural change not necessarily captured by standard metrics.

The first stage of this proposed methodology involves a sequence of data transformations designed to convert raw asset prices into a set of normalised, statistically tractable time series. We begin with daily closing prices, P_t, for a chosen universe of assets, converting them into logarithmic returns, r_t, to benefit from their time-additive properties, calculated as follows:

$$r_t = \ln\left(\frac{P_t}{P_{t-1}}\right)$$

From these returns, we then capture the evolving nature of inter-market relationships by computing the Pearson correlation coefficient, ρ_t, for every unique asset pair over a rolling window. As these correlation values are inherently bounded between -1 and 1, a characteristic which presents statistical challenges, we subsequently apply the Fisher Z-transformation. This critical step maps the bounded correlation series into an unbounded, more normally distributed space, creating a set of position variables, z_t, via the expression:

$$z_t = \operatorname{arctanh}(\rho_t) = \frac{1}{2}\ln\left(\frac{1+\rho_t}{1-\rho_t}\right)$$

2. The State Vector and a Proposed Measure of Systemic Distance

With these transformed correlation series representing the system's position, we then construct a more comprehensive, high-dimensional vector intended to capture the system's full kinetic state for any given day. To the position vector (X_t), we add a velocity component (V_t), derived from the first-order difference of the position vector to approximate its momentum, and an acceleration component (A_t), derived from the second-order difference to approximate the net forces acting upon the system. These three distinct vectors are then concatenated into a single, complete state vector, S_t, which for our current four-asset model is an 18-dimensional object structured as:

$$S_t = \begin{bmatrix} X_t \\ V_t \\ A_t \end{bmatrix}$$

To quantify the degree of systemic anomaly, we propose the use of the Mahalanobis distance. This statistical measure was chosen specifically for its capacity to assess the distance of a single day's state vector from the centre of all historical observations, while accounting not only for the variance of each individual component but, critically, for the entire covariance structure between them. This prevents more volatile components from disproportionately influencing the index and considers the interrelationships between position, velocity, and acceleration across all asset pairs. To ensure the stability and robustness of this calculation, we have currently opted to employ the Ledoit-Wolf shrinkage estimator for the historical covariance matrix, $\hat{\Sigma}_{t-1}$. The final KSI value is the square root of this calculation, defined as:

$$\text{KSI}_t = \sqrt{(S_t - \mu_{t-1})^T \hat{\Sigma}_{t-1}^{-1} (S_t - \mu_{t-1})}$$

where μ_{t-1} is the historical mean vector. This collapses the complex system state into a single scalar representing the statistical strangeness of the market's behaviour on a given day.

3. Decomposition, Preliminary Observations, and Avenues for Further Research

A potentially valuable feature of this framework is its capacity for decomposition, which may allow us to investigate the primary drivers behind any given reading by isolating which of the 18 state-vector components are contributing most significantly to the anomaly. This can be approached by calculating the Z-Score for each component, $S_{i,t}$, which standardises its deviation from its own historical mean, $\mu_{i,t-1}$, and variance, $\hat{\Sigma}_{ii,t-1}$, as follows:

$$Z_{i,t} = \frac{S_{i,t} - \mu_{i,t-1}}{\sqrt{\hat{\Sigma}_{ii,t-1}}}$$

A preliminary backtest of this framework from 2007 to the present shows an encouraging, albeit tentative, alignment between spikes in the KSI and major historical market crises.

While this historical alignment is interesting, it is the behaviour of the index at the present time that has prompted this report; notably, the latest data point from the close of trade on the 4th of July 2025 shows the index reaching a value of 29.01, a level that is substantively higher than any previously observed peak in our backtest, including those seen during the Global Financial Crisis. A decomposition of this recent spike suggests its primary drivers are not necessarily unprecedented price volatility, but rather what appear to be extreme values in the velocity and acceleration of shifts within core cross-asset correlations, indicating a change in market behaviour that may be without recent historical precedent.

In conclusion, this paper has outlined an initial and provisional framework for the Kinetic Stress Index. For now, we have a model that appears to capture historical dislocations and is currently indicating a state of potentially unprecedented structural change. We must stress, however, that this is an early-stage approach that requires significant refinement and validation. Further investigation is needed to explore the model's sensitivity to different lookback windows, the impact of asset selection on its behaviour, and its robustness across different historical regimes before any definitive conclusions can be drawn. We present these findings not as a finished product, but as a compelling starting point for what we believe is a necessary and urgent line of further research.

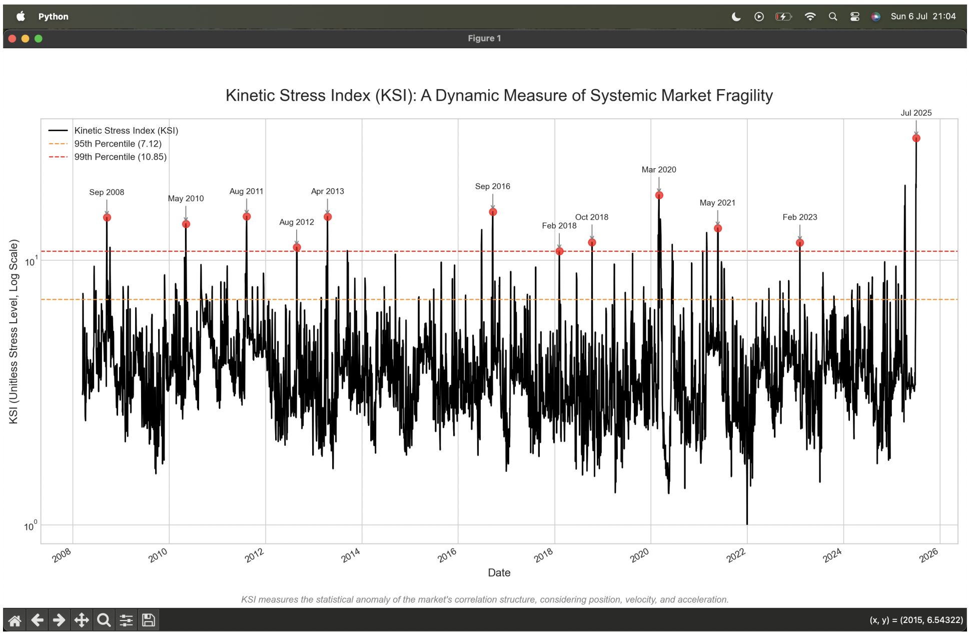

Figure 1: A preliminary backtest of the proposed Kinetic Stress Index from 2008 to 2025, where spikes appear to coincide with known periods of market dislocation.