The Financial Viscosity Indicator: A Physics Inspired Stability Metric

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Abstract

Financial markets frequently experience regime shifts, characterized by varying degrees of stability and volatility. This report introduces a novel, physics-inspired viscosity indicator designed to proactively measure market instability and regime fragility. Unlike conventional volatility measures, this viscosity indicator integrates both the displacement of prices from a moving equilibrium and their velocity, inspired by physical spring systems. Empirical analysis demonstrates that this model effectively identifies periods of instability in time with when significant market corrections occur. Despite these strengths, the indicator has clear limitations, such as a lack of directional sensitivity and potential misclassification of stable trending markets. This report concludes by suggesting practical applications and future improvements.

1 Introduction

Author's Note: This idea is, for the most part, unfinished. You can read more about various factors that I do not explore in the limitations and future improvements section. This paper is primarily focused on proof of concept and its potential in financial markets.

Financial markets are characterized by complexity and rapid regime changes, leading investors to constantly search for reliable early-warning indicators of market instability. Traditional volatility metrics (such as VIX) reflect existing market risk but often fail to predict potential regime shifts proactively. Inspired by physics—specifically, spring and viscosity dynamics—this report introduces an innovative approach to measuring financial market stability, termed the *Financial Viscosity Indicator* (FVI).

2 Theoretical Foundation

Drawing analogies from physics, financial markets can be modeled similarly to spring systems. Prices tend to revert toward long-term equilibrium values, represented mathematically by moving averages. The displacement (d_t) represents how far prices deviate from "equilibrium", while velocity (v_t) captures the speed of price movements.

In physics, viscosity measures a fluid's resistance to deformation under stress. Analogously, our viscosity indicator captures market "resistance" or stability:

$$\text{Viscosity}_t = \frac{1}{(\exp\left[(\beta \cdot v_t) + (\gamma \cdot d_t) + (\alpha \cdot v_t \cdot d_t) - \delta\right])^2}. \tag{1}$$

Where $\alpha, \beta, \gamma, \delta$ represent shared sensitivity between both factors, velocity sensitivity, displacement sensitivity, and bias/centre respectively. These require some form of callibration in order to be used with the model effectively. Fine tuning of this model for different assets can be done depending on how each of the two factors influence stability of the market. From trial and error (which is a terrible way to derive parameters, I am aware), I derived the following values for these variables:

- $\alpha = 1.2$
- $\beta = 0.8$
- $\gamma = 0.2$
- $\delta = 1$

This combination gave a higher sensitivity to velocity changes, which is more useful for measuring potential breakouts. Lowering the overall impact of displacement was to address the potential issue of bullish and bearish markets being labeled as extremely low viscosity regimes.

High viscosity values indicate stable, equilibrium-oriented markets, while low values signal instability and potential rapid momentum or regime changes.

3 Methodology

To implement the indicator, daily price data for the SPY ETF from January 2015 to April 2025 was obtained. A 50-day Simple Moving Average (SMA) was used as the equilibrium measure. Displacement and velocity were computed as follows:

$$d_t = |P_t - \text{SMA}_{50}| \tag{2}$$

$$v_t = |\Delta P_t|, \quad \text{smoothed using an Exponential Moving Average (EMA)} \tag{3}$$

Normalization using log transformations was applied to manage scale variability and improve interpretability.

4 Empirical Results

Empirical tests demonstrated the indicator's responsiveness during known historical volatility events. Notably, the indicator showed clear drops in time with the COVID-19 market crash (March 2020), the bear market of 2022 (note the lower average viscosity and the high amount of fluctuations from early-mid 2022), and the volatility spike of early 2025. Also note that in bull/bear markets, viscosity temporarily plummets by around 0.2 points, which signals potential trend instability (and subsequently, potential short/long entry points). These findings underscore the indicator's capability as an early-warning signal.

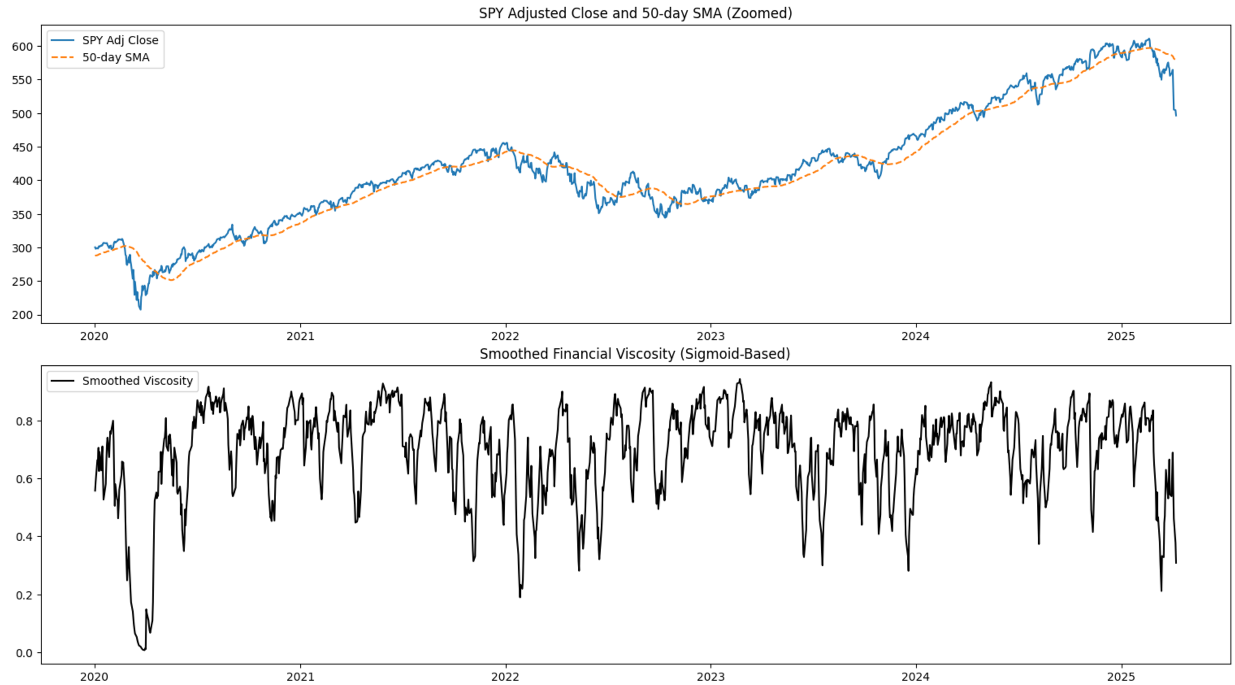

Figure 1: SPY price over time vs SPY viscosity indicator

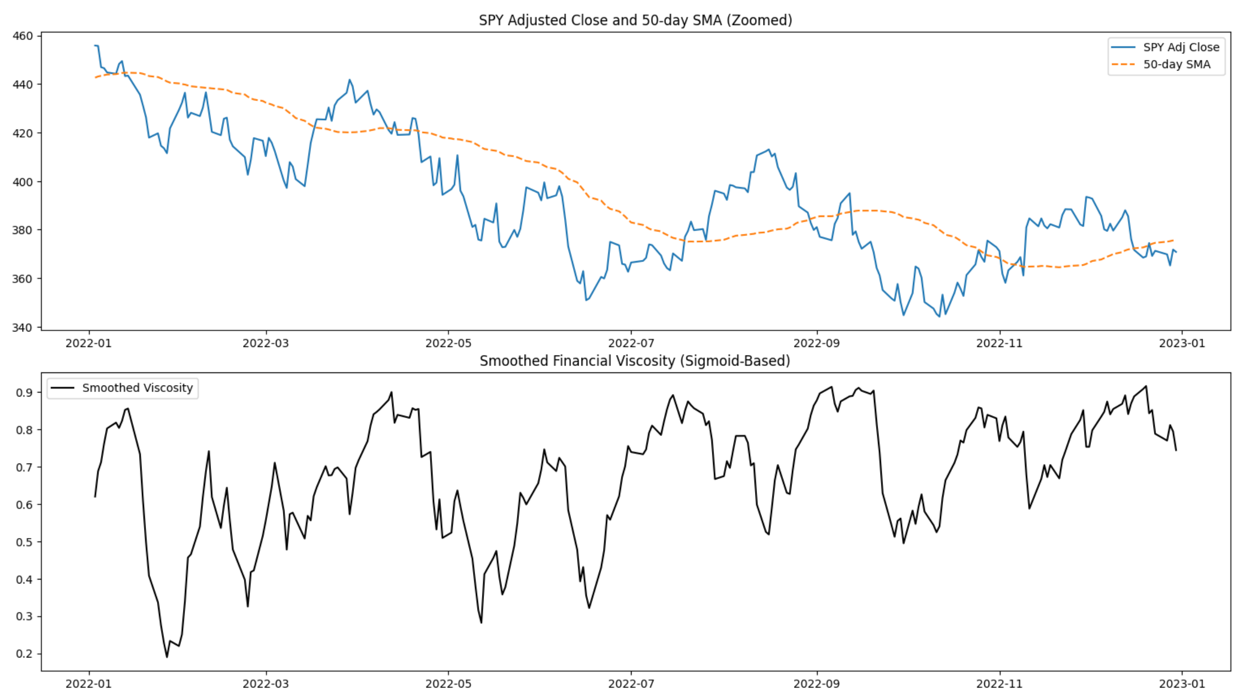

Figure 2: SPY price and viscosity for 2022

Another noteworthy feature of this indicator is that tracking the average rate of change of viscosity can indicate potential trends in momentum or stability. Periods with high average ROC of viscosity signal a high level of momentum away from the moving average, signaling a high chance of a bear/bull period.

Since most of the context of these results is in working with long-term periods, using average viscosity in conjunction with current viscosity is more reasonable when tracking regimes or predicting risk. However, there is a potential for this to be used in shorter time frames, and viscosity is used to extract alpha from fluctuations in viscosity.

Overall, this measure is effective at signaling potential shifts in stability, momentum, or volatility. However, it is most effectively used with other factors in order to determine risk adjustment, trading strategy, etc.

5 Practical Applications

The Financial Viscosity Indicator has several practical applications in financial risk management:

- **Regime Classification:** Clearly differentiates stable regimes from potentially unstable ones, aiding in strategic allocation decisions.
- **Risk Management:** Early-warning capabilities allow for proactive risk mitigation and hedging.
- **Portfolio Adjustment:** Investors can adjust leverage or position size dynamically, depending on viscosity levels.

6 Limitations

While effective, the FVI has notable limitations:

- **Lack of Directional Information:** The indicator is direction-agnostic, making it difficult to distinguish between bullish and bearish instability. Signals can be hard to interpret depending on the time frame you look at.
- **Misclassification of Long Term Trends:** Viscosity can often flip between high and low values between days due to a high amount of dependency on velocity. This can be seen particularly well when displacement is already high and velocity is moderate/high.
- **Requires Tuning on Parameters:** Viscosity requires tuning of various sensitivities (α, β, etc...). This can result in viscosity centering itself around one particular factor or range of values. Due to my limited understanding in optimization and machine learning, I don't know how to do this effectively.
- **Mathematical limitations:** The model might be flawed, or does not properly account for certain macro factors. Furthermore, this model was not derived from any first principles.

7 Future Improvements

Future research should focus on addressing these limitations by:

- Deriving the formula from financial or physical principles (e.g., energy dissipation in a viscous market). Linking displacement/velocity to established concepts like momentum or mean-reversion strength.
- Incorporating signed directional metrics to differentiate bullish versus bearish instability.
- Integrating the indicator within machine-learning models to enhance predictive accuracy.
- Optimizing parameters dynamically based on prevailing market regimes. (parameters were set to constant values, I would love to explore optimization more in the future!)
- Formally testing regime detection and validation in order to strengthen conclusions

8 Conclusion

This report introduced a novel, physics-inspired Financial Viscosity Indicator capable of proactively measuring market instability and fragility. Empirical validation has shown its practical utility in detecting regime shifts before significant market disruptions. Despite current limitations, the indicator represents a meaningful contribution toward proactive risk management and systematic financial modeling, warranting further development and application in both academic and industry settings.