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 Mathematical Formulation

2.1 Modeling Viscosity

Let P_t denote the asset price at time t, and let $\mu_t = \text{SMA}_{50}(P_t)$ represent its 50-day simple moving average (SMA), which we treat as a dynamic equilibrium anchor.

We define two primary components:

- **Displacement:** $d_t = |P_t - \mu_t|$, representing how far the price deviates from its equilibrium.

- **Velocity:** $v_t = |\Delta P_t|_{\text{EMA}}$, the absolute value of recent price change, smoothed using an exponential moving average.

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

These components are combined into a latent instability score:

$$\theta_t = \alpha v_t + \beta d_t + \gamma v_t d_t - \delta$$

We then define the **Financial Viscosity Indicator (FVI)** as:

$$\text{Viscosity}_t = \frac{1}{(\exp(\theta_t))^2}$$

This structure models market stability as being **inversely proportional** to the exponential square of latent stress:

$$\text{Viscosity}_t \propto \frac{1}{\exp(2\theta_t)}$$

The exponential decay reflects the intuition that once both displacement and velocity rise (particularly together), small increases in either result in large reductions in stability — analogous to energy barrier dynamics in physics. Squaring the exponential further sharpens this penalty, ensuring that extreme conditions collapse viscosity rapidly.

The FVI is bounded in the open interval $(0, 1]$, where:

- Values close to 1 indicate high stability (low latent stress).
- Values near 0 indicate a fragile or stretched regime, with elevated risk of instability.

Although the model is not derived from first principles, its structure loosely resembles that of a damped spring system, where market displacement and velocity play roles analogous to restoring and damping forces in a differential equation of the form $F = -kx - \lambda F'$.

2.2 Parameter Selection

The Financial Viscosity Indicator (FVI) relies on four tunable parameters: α, β, γ, and δ, which control the sensitivity of the model to different market forces. Their roles are as follows:

- α: controls the weight of smoothed price velocity (rate of change)
- β: controls the weight of displacement from the moving average
- γ: controls the interaction term $v_t d_t$, capturing compounded instability
- δ: an optional bias or centering term to shift the sigmoid or energy threshold

For the results in this paper, we use the following parameter values:

$$\alpha = 0.8, \quad \beta = 0.2, \quad \gamma = 1.2, \quad \delta = 1$$

These values were chosen through trial and error (which is terrible but was good enough) based on desired behavior and interpretability, with the goal of:

- Penalizing rapid price movement more heavily than static deviation from the mean
- Ensuring that high velocity and high displacement jointly collapse viscosity
- Calibrating the output to remain mostly within a practical range (0.2–0.95) to reflect useful market states

Further research could explore automatic optimization of these parameters using machine learning or optimization techniques, or adapting them dynamically to different asset classes or market conditions.

3 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.

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.

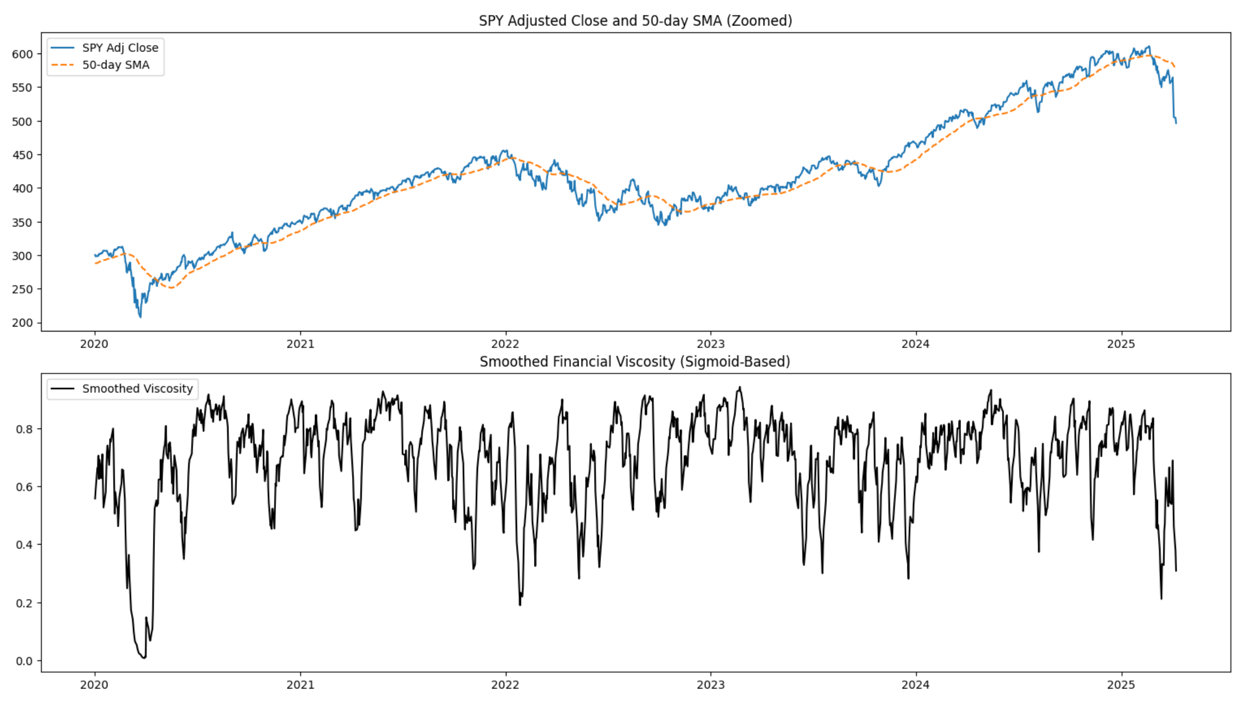

Figure 1: SPY price over time vs SPY viscosity indicator

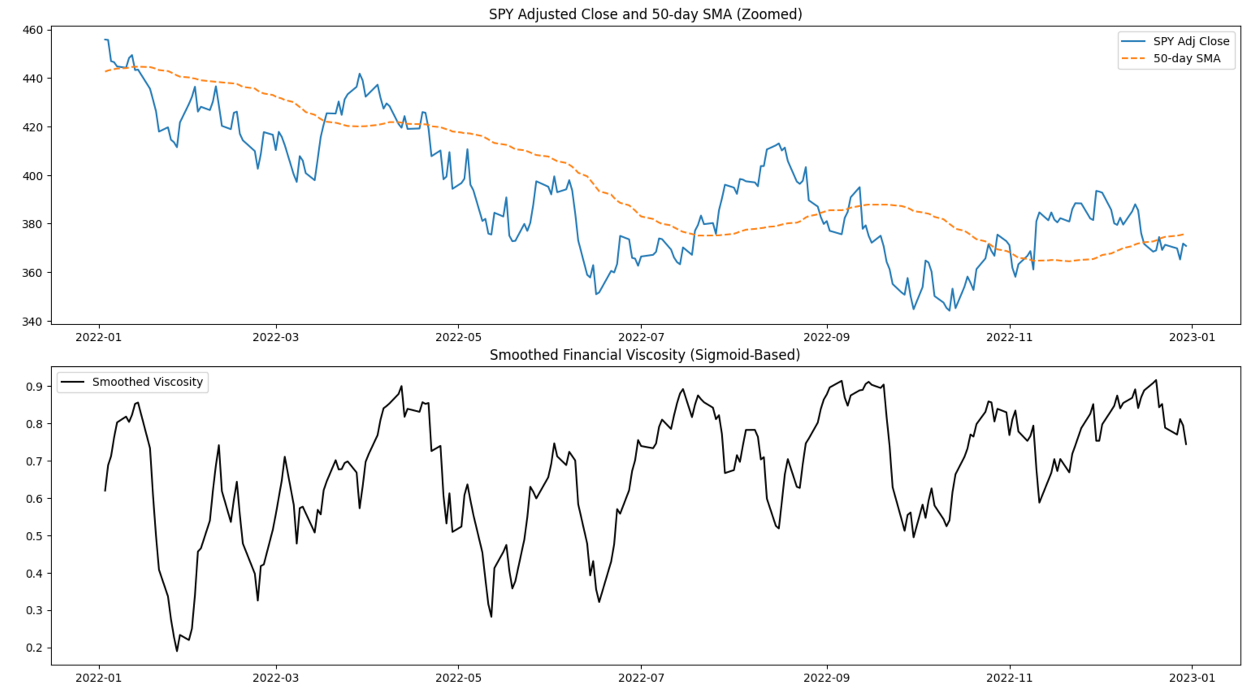

Figure 2: SPY price and viscosity for 2022

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.

4 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.

5 Applications and Vision

The Financial Viscosity Indicator (FVI) has some really interesting potential uses in finance—especially for spotting when markets are becoming fragile before traditional volatility measures catch up.

Since it tries to measure how *stretched* or unstable the market is based on how far prices are from the moving average and how fast they're changing, it naturally fits into areas like:

- **Risk management:** If viscosity drops quickly, it could signal that the market is entering a fragile or unstable state, which might be a good time to hedge or de-risk.
- **Regime detection:** Because viscosity is bounded and responsive to both trend deviation and movement speed, it could be used to label regimes—high viscosity values might reflect calm, stable markets, while low values could mark chaotic or transitional periods.
- **Portfolio adjustments:** The signal could be used to dial risk up or down. For example, if viscosity drops below a certain threshold, a strategy might scale back exposure or avoid risk-on trades. When viscosity rises again, the strategy could re-engage.

Even a basic threshold rule—like reducing risk when viscosity drops below 0.3 and re-risking when it rises above 0.6 could help limit drawdowns during stressful periods without needing to predict direction. (these are obviously arbitrary numbers, but you get the idea)

There's also potential to use the FVI in more advanced ways. One idea worth exploring is using it as a feature in a classification model to help predict market regimes, or feeding it into reinforcement learning agents to guide strategy switching based on how stable the environment seems. Since it's bounded and interpretable, it could pair nicely with machine learning models that don't usually handle market structure very well.

While the indicator still needs refinement (and definitely better math), I think it fills an interesting gap. Most volatility models are reactive—they tell you how volatile something has been. FVI is meant to be more proactive: it tries to measure how unstable the system already feels, based on how stretched and fast-moving prices are. That could be valuable in building strategies that adapt early, rather than reacting too late.

6 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.