Quantum Tunneling-Inspired Potential Model for Financial Market Inefficiencies: MSFT Case Study

Jesse Schmolze

June 10, 2025

Abstract

This white paper presents a stock-specific potential function constructed for Microsoft (MSFT), drawing on analogies from quantum tunneling. The aim is to identify temporal regions of high and low resistance to price movement and use those to forecast inefficiency-driven transitions. We construct a time-dependent potential $V(t)$ using measurable financial features, interpret the results against price action, and prepare the ground for generalized application to broader equity classes.

1 Model Motivation

Quantum tunneling permits sub-barrier transmission probabilities due to wavefunction extension. In financial terms, a price may "tunnel" through resistance levels despite classical valuation or volatility-based constraints. This motivates the construction of a dynamic potential $V(t)$, reflecting localized resistance in price space.

2 Potential Function Structure

We define:

$$V(t) = \alpha \cdot \sigma^2(t) + \beta \cdot D(t) + \gamma \cdot \left(\frac{P(t)}{P_{\text{DCF}}} - 1 \right)^2 + \delta \cdot \frac{1}{\text{Volume}(t)}$$

Where:

- $\sigma^2(t)$ is the 21-day rolling variance of log returns
- $D(t) = \left| \frac{P_{\text{SPY}}(t) - MA_{200}(t)}{MA_{200}(t)} \right|$ reflects market drawdown
- $P_{\text{DCF}} = \text{EPS}_{\text{TTM}} \cdot \text{P/E}_{\text{estimate}}$ is a valuation anchor
- $\frac{1}{\text{Volume}(t)}$ proxies liquidity friction

3 Data and Implementation

3.1 Source and Time Range

Data was sourced via `yfinance` between January 2018 and December 2024 for MSFT and SPY.

3.2 Pipeline Overview

1. Download MSFT & SPY daily data
2. Compute rolling volatility, drawdown, valuation deviation, and inverse volume
3. Construct $V(t)$ with default weights $\alpha = \beta = \gamma = \delta = 1$
4. Plot $V(t)$ alongside MSFT price

3.3 Code Snippet

```
data['V'] = (alpha * data['volatility']**2 +
             beta * data['mkt_draw'] +
             gamma * data['val_dev'] +
             delta * data['inv_volume'])
```

4 Results

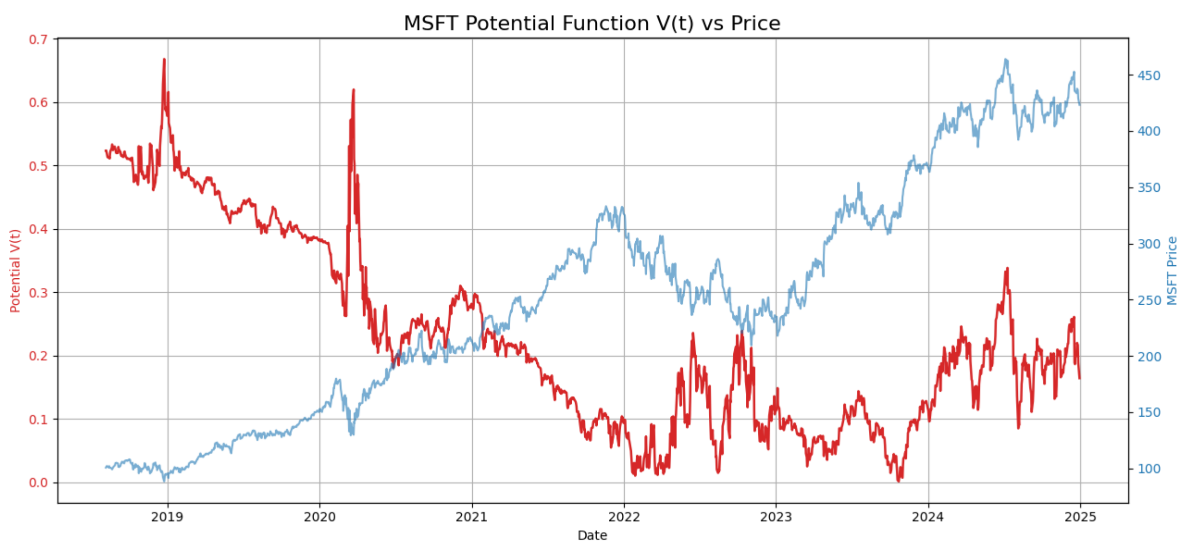

Figure 1: MSFT Price vs Potential Function $V(t)$

Local peaks in $V(t)$ often precede consolidation or reversal. Local troughs correspond to price acceleration — candidate tunneling zones.

5 Correlation Analysis: Tunneling and Regime Transitions

To evaluate the relationship between the modeled potential $V(t)$ and the actual price evolution of MSFT, we compute a 60-day rolling Pearson correlation coefficient between $V(t)$ and the raw closing price $P(t)$. The goal is to test whether high or low potential values anticipate particular price behaviors.

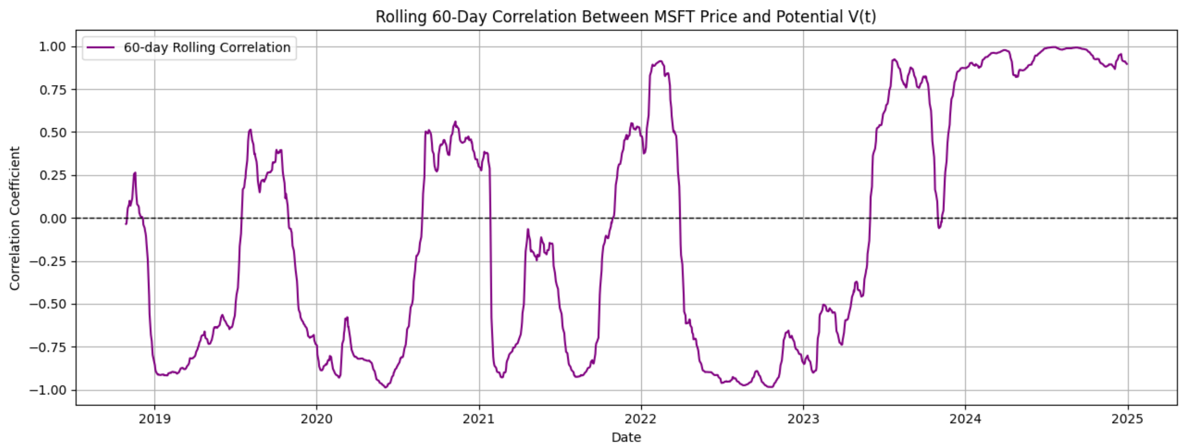

Figure 2: 60-day Rolling Correlation Between MSFT Price and Potential $V(t)$

Key Observation: Asymmetric Regimes

The rolling correlation plot reveals a highly non-random structure. Across nearly the entire 7-year sample, the correlation between $V(t)$ and price is either significantly negative or significantly positive—rarely neutral. This is profound: it suggests that the modeled potential function does not merely reflect noisy financial signals but maps onto actual behavioral or structural regimes in the market.

Negative Correlation: Quantum Tunneling Signature

In extended periods (notably 2019, 2020, 2022), we observe that:

$$\mathrm{Corr}(V(t), P(t)) < 0$$

This indicates that low potential values precede or accompany strong upward price moves, consistent with the quantum tunneling analogy. Here, the modeled financial "barrier" collapses, allowing directional price motion through what would be resistance in classical valuation frameworks. These are ideal tunneling zones.

Positive Correlation: Momentum and Friction Inversion

In contrast, during certain growth regimes (notably 2021 and 2023–2024), we observe sustained periods where:

$$\mathrm{Corr}(V(t), P(t)) > 0$$

This reflects a different market regime—where resistance metrics such as volatility and valuation anchoring *rise with* price. These are momentum-dominant environments where increased risk or misvaluation is not a deterrent but rather a signal of capital inflow and trend-following behavior. In such cases, our potential function captures an inverted incentive structure: the market rewards motion into elevated resistance zones.

Implications

The structural persistence of strong correlation (in either direction) implies that the potential function $V(t)$ is regime-sensitive:

- In tunneling regimes, price breaks free from high-to-low potential zones.
- In momentum regimes, price pulls the potential field upward with it.

This duality suggests that the potential function can serve not just as a tunneling probability proxy, but also as a **regime classifier**, identifying whether the market is behaving in a resistance-respecting or resistance-ignoring fashion.

Future work will formalize this with lagged correlation tests, return-conditioned stratification, and potential regime labeling.

6 Future Work

- Formalize tunneling probability via WKB or FDTD numerical solution
- Expand model to tech sector (e.g., NVDA, AAPL) with industry-specific potential adjustments
- Integrate a regime-switching framework to handle volatility clustering

Appendix: Model Coefficient Definitions

Parameter	**Interpretation**
α	Volatility resistance strength
β	Systemic drawdown coupling
γ	Valuation anchoring strength
δ	Liquidity-driven friction

All parameters are treated as independent in this prototype.