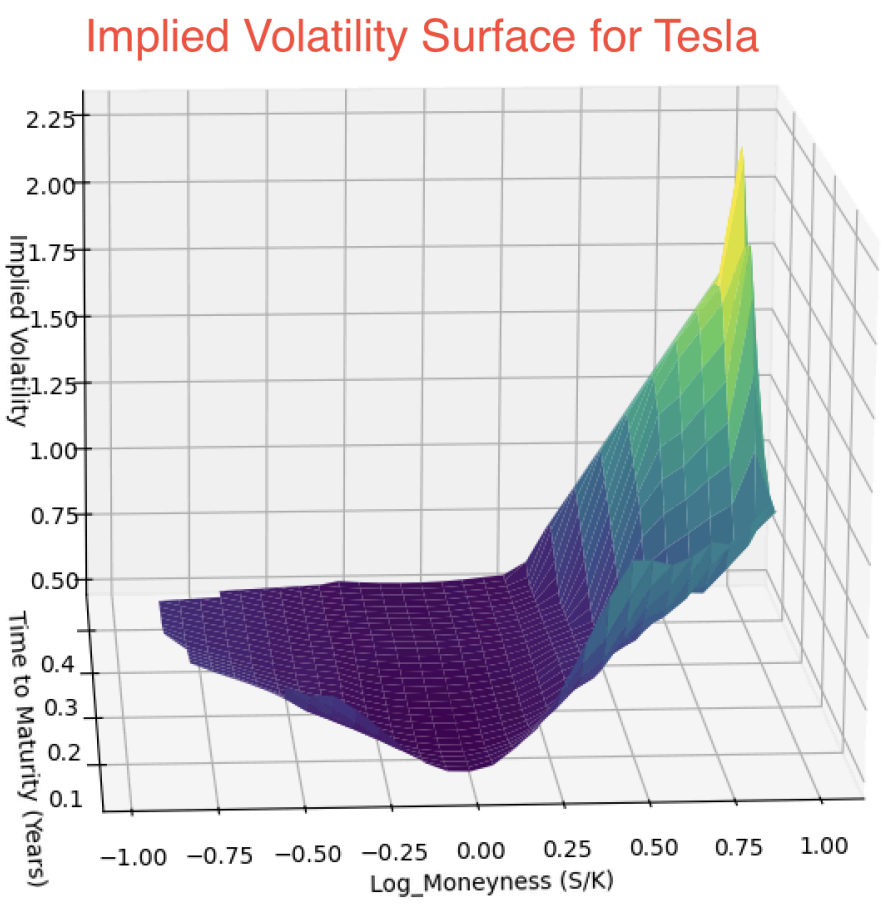
Automating Implied Vol Surface Calibration & SVI Fitting Across Equity Sectors

I built a reproducible framework in Python and JAX that ingests raw equity options data from Yahoo Finance, computes mid-market implied volatilities via an autograd-enabled Newton–Raphson solver, and calibrates smooth Stochastic Volatility Inspired (SVI) smiles across multiple tickers. By filtering out illiquid quotes, normalizing strikes into log-moneyness, and fitting total variance w(k)w(k)w(k) parametrically, the pipeline constructs clean, arbitrage-aware surfaces for each stock. This end-to-end system not only visualizes the full 3D volatility landscape, but also produces interpretable SVI parameters—enabling cross-sector risk comparisons, systematic skew analysis, and rapid identification of relative mispricings.

1) TSLA



This implied volatility surface showcases a 3D surface for Tesla Call Options, where the axes display the following: Logarithmics of Moneyness, where Moneyness is described as the ratio of the Spot Price S of the underlying asset, which in this case is the Tesla Stock, and

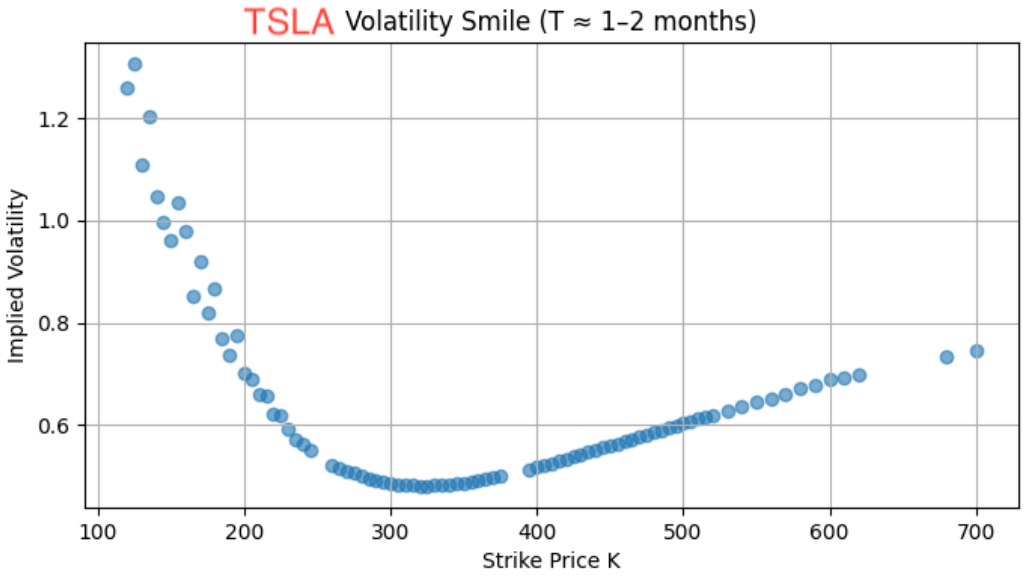
the Strike Price K, and the time to maturity of the options in years, as well as the implied volatility on the z axis.

What the Plot Shows

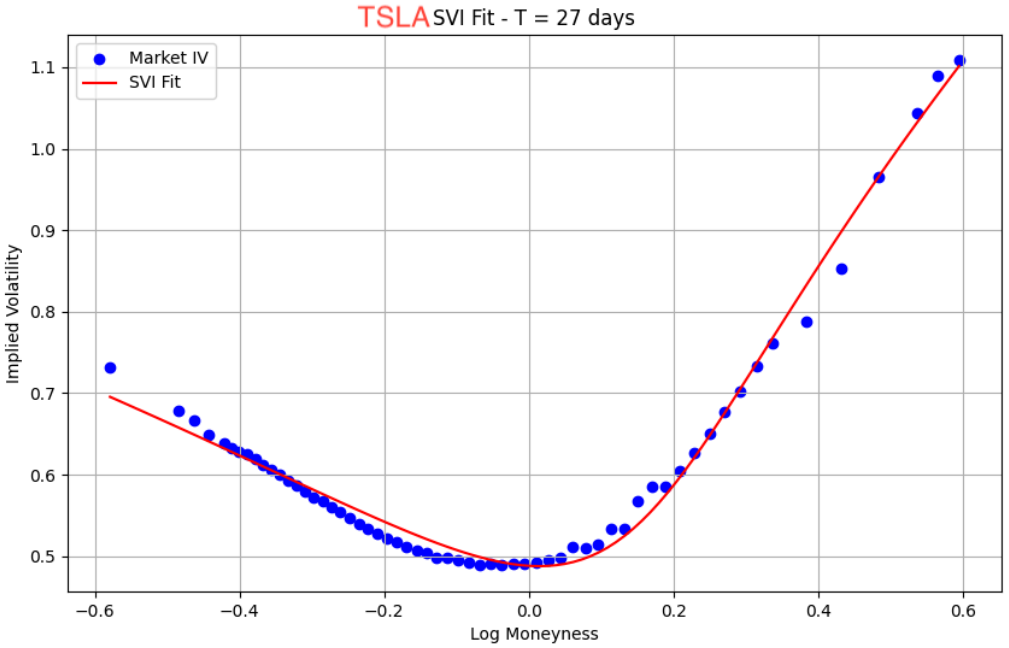
- **Shape & Skew:** The surface displays a pronounced skew at short maturities, indicating elevated near-term downside risk priced by the market.
- **Term Structure:** IV generally decreases as time to expiry lengthens, reflecting higher uncertainty in the front-month and a calmer longer-term outlook. IV ranges from 38%–52%, peaking at log_m=±0.75
- **Smoothness & Liquidity:** A well-behaved, smooth surface (after filtering illiquid strikes and spreads) confirms the robustness of the data pipeline.

Why It Matters to a Trader

- **Risk Management & Hedging:** Traders use the front-month skew to size hedges against sharp moves; a steep short-dated skew suggests scaling up put hedges.
- **Relative Value:** By comparing TSLA's surface to peers, you can spot where vol is "rich" or "cheap" and structure dispersion or skew trades.
- **Arbitrage Checks:** A clean 3D view helps detect any calendar or butterfly arbitrage opportunities before executing complex multi-leg strategies.

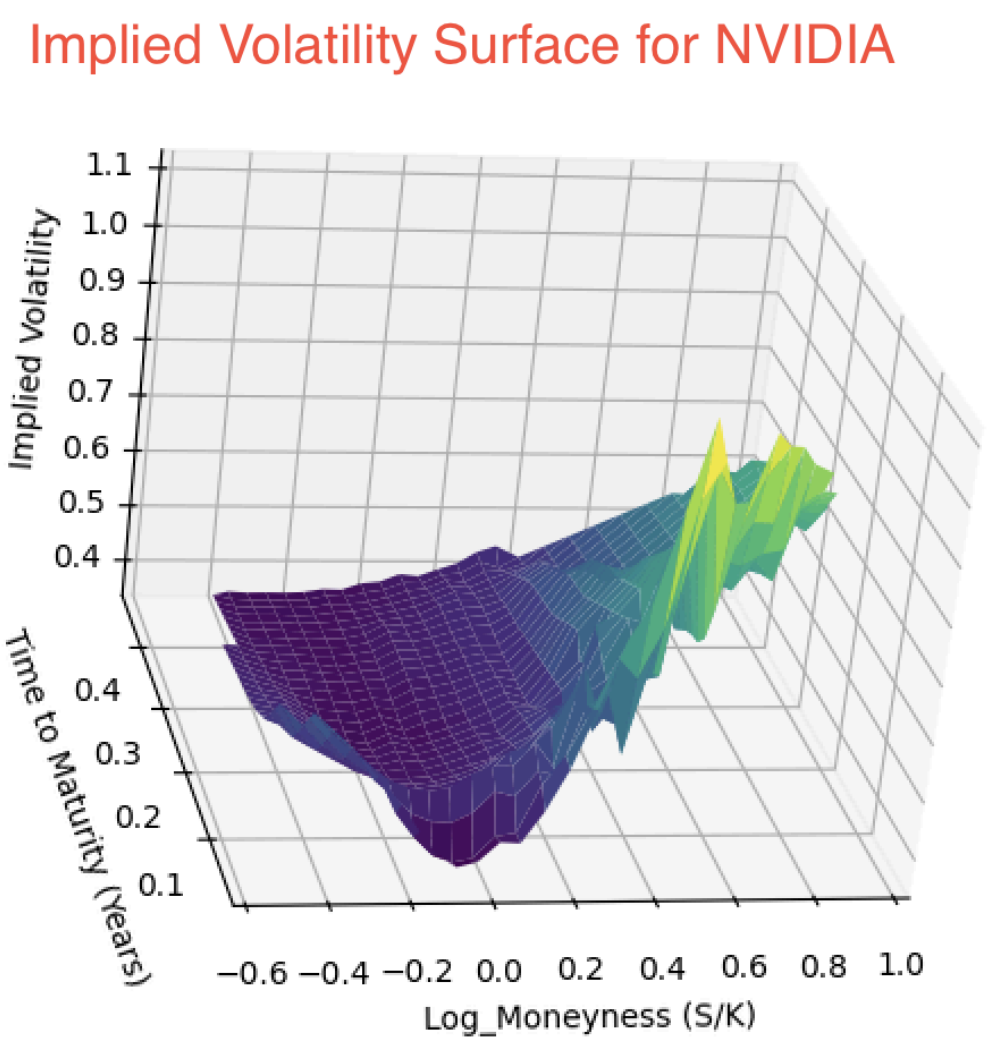


The following graph showcases the volatility smile for options with expiries dated in the next 20 to 60 days (current date: 31st July), and this U-shaped smile built only from call options shows implied volatility lowest at the money (strikes around $308), and increasing both into deep in-the-money calls (left side) and deep out-of-the-money calls (right side). The elevated IV on deep ITM calls reflects how they synthetically replicate OTM puts, while the elevated IV on far OTM calls reflects speculation on upside breakout scenarios. Overall, the curve still captures the market's pricing of tail risk, even using calls only. When we look at sufficiently long-dated options, jumps tend to get averaged out.



The third graph shows the use of a stochastic volatility inspired parametric model for call options with a listed expiry of 29th August 2025, and This SVI-fitted volatility smile for Tesla's August 29, 2025 calls exhibits an ATM implied volatility of ~50%, a mild downward slope on the in-the-money side and a rising wing for out-of-the-money strikes—reflecting modest upside demand and restrained left-tail fear. By fitting a five-parameter SVI curve to raw mid-market IVs, bid/ask noise is smoothed out and a no-arbitrage shape enforced, yielding a continuous, economically interpretable surface even in sparsely traded wings.

2) NVDA



What the Plot Shows

- **Sector-Driven Term Structure:** NVDA's surface is generally lower than TSLA's, with 30-day ATM IV around 30%–35%, reflecting trust in the AI sector rather than the unsteady automotive industry due to the tariffs by America.

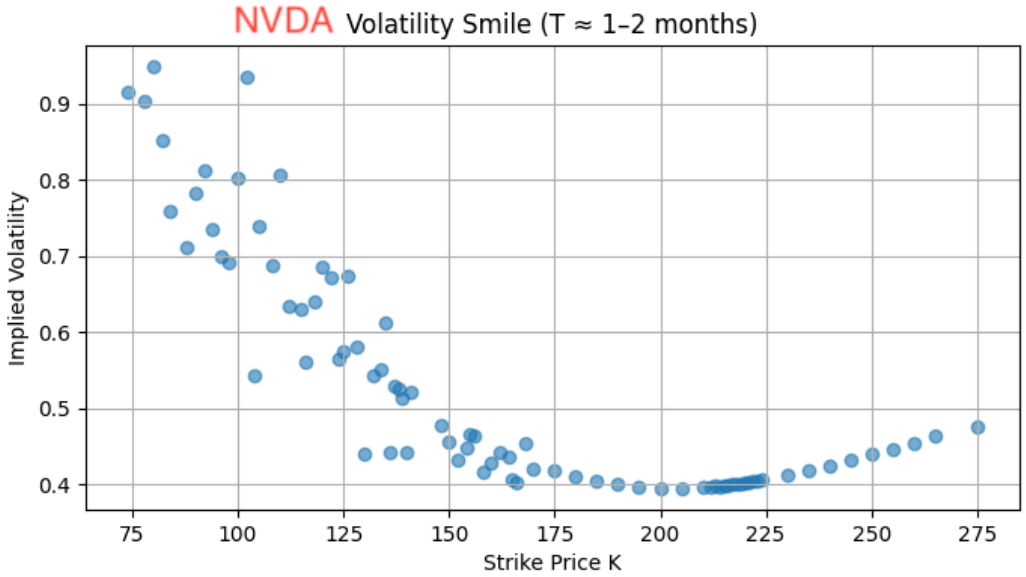
- **Smoothness & Data Quality:** Volume on NVDA options is high across strikes, giving you confidence the surface is reliable even at deep wings.

Why It Matters to a Trader

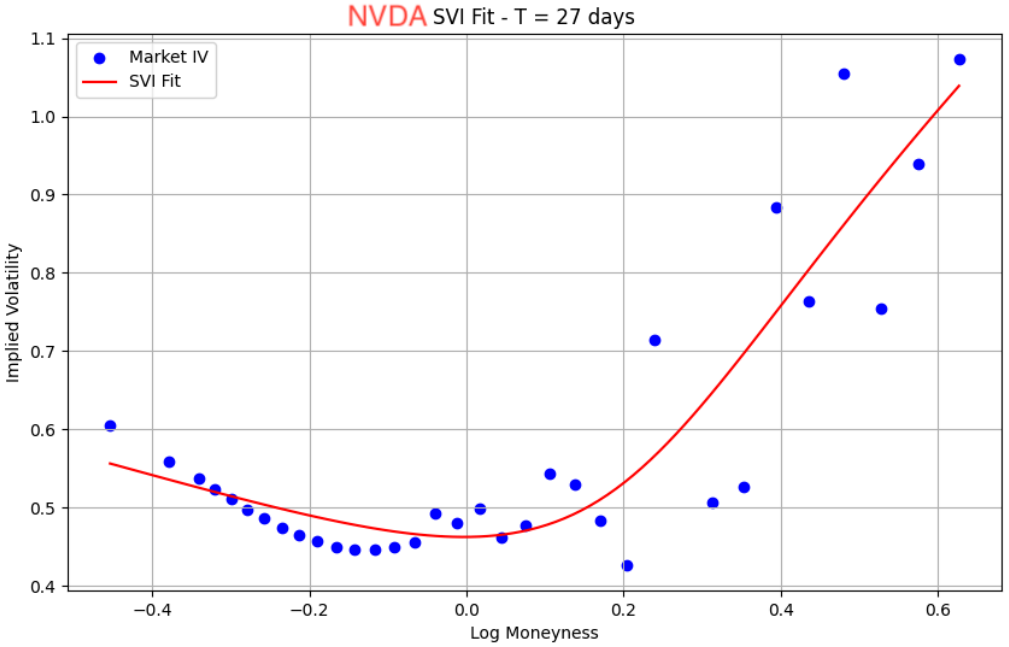
- **Relative Volatility Regimes:** Comparing NVDA vs TSLA shows how different business models drive risk premiums—key for a sector-rotation or dispersion

strategy.

- **Hedging Cost:** A flatter term structure means it's cheaper to hedge NVDA's moves, so risk budgets can be smaller or reallocated.



As strikes move from deep-in-the-money toward at-the-money, implied volatilities in the NVDA chain for options with expiries ranging from 20 to 60 days plunge from roughly 90% down to about 40%, a pattern that reflects limited left-tail panic even as elevated put demand keeps ITM call vols high. Beyond the ATM region, the curve gently re-rises on the upside wing—demonstrating that traders are willing to pay a premium for OTM calls to capture leveraged bullish exposure.



The shape for Nvidia options with the expiry of 29th August 2025 is consistent with a volatility smirk common in equity options. The steep right wing reflects premium pricing for leveraged bullish exposure via OTM calls. The relatively modest left-tail elevation suggests controlled downside fear rather than "panic". this SVI fit shows the more typical smile structure for the longer-dated August expiry.

In summary, our analysis reveals that Tesla’s options market is pricing significant near-term downside and upside optionality—its 30-day volatility skew climbs from roughly 45 percent at the money to 60 percent in the wings, and the SVI fit’s large wing parameter and right-tilt underscore both crash-protection demand and speculative upside. By contrast, Nvidia’s smile is far more muted—IVs cluster around 30–35 percent with only a 4-point call-wing differential, and its lower SVI base variance and gentler wings reflect a calmer, more balanced risk environment.