# The Structural Dynamics of Option-Implied Probability Distributions for Major Events

The main aim of this thesis is to look at an event study through the lenses of the Implied volatility probability distributions (IVPD) are a way of understanding what the market is expecting regarding the future price of an asset (both stocks, indexes and ETFs) based on the price of options available. showing the whole distribution of probabilities and the associated strike prices, essentially what is the most probable price for the future.

The study of implied volatility distribution functions (IVDFs) forms a crucial bridge between derivatives pricing theory and the empirical analysis of market expectations and risk preferences. Formally, the IVDF is based on the Risk-Neutral Density (RND), representing the market’s expected distribution of the underlying asset price at a future expiration date, calculated under the risk-neutral measure .

The core concept is based on Breeden and Litzenberger (1978) paper, in which they showed that the second derivative of a European call price with respect to strike gives the risk-neutral PDF of the underlying asset price at maturity

So, the math ends up being quite simple

## Research questions

This to tackle both descriptive analysis and create a framework with practical forecasting applications.

1. Do pre-event distributions contain predictive information about post-event realized outcomes?
2. Can post-event distributional shifts forecast subsequent market behavior?
3. Do different event types (macro disruption vs. firm-specific news) generate systematically different distributional signatures?

# Proof of concept

## Data sources

**Option Data:**

* Bloomberg
* A yfinance

**News data:**

Seeing when the news hit is crucial for understanding where the actual market came to a consensus on the impact of the event.

* Factiva
* Bloomberg: DS document search analysis tool NSE News Item Search

## Initial graphs as a proof of concept

3d chart with the surface of the probability density across maturities

A screen shot of a graph

AI-generated content may be incorrect.

Flattened chart to better see if the probability charts are symmetrical. Centered on the same strike or bimodal.

A diagram of a distribution function

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Flattened chart to better see where the most likely strike is compared to the current price and also confidence bands to see how much the distribution flattens the timeframe increases and as uncertainty increases with it.

A graph showing the number of data

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## Possible developments

### Skew and kurtosis event studies

Skewness quantifies the asymmetry of the expected return distribution. The common observation of negative RND skewness confirms a market consensus on crash risk—investors are willing to pay a premium for protection against large negative returns. A dynamic decrease (more negative) in skewness around an event window is the primary indicator that the event has sharply intensified downside expectations.

Hypothesis 1a (Directional Prediction):

* H₀: has no predictive power for subsequent returns
* H₁: Negative (increased left-tail risk) predicts negative abnormal returns over the next 5-10 trading days

Kurtosis measures the thickness of the distribution’s tails and the height of its peak; High kurtosis signifies a belief in greater probability of "fat tail" events.

Hypothesis 1b (Volatility Prediction):

* H₀: Change in implied kurtosis does not predict realized volatility
* H₁: Increased predicts higher realized volatility in the subsequent period

Using Factiva to see when the market caught up and came to a new consensus on the implications established after the news comes out, especially with bigger events (like ChatGPT, tariffs, global events)

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| **Volatility Surface Feature** | **RND Shape Implication** | **RND Moment Change** | **Market Risk Interpretation** |
| Smirk (Negative Skew) | Left-Skewed and Leptokurtic (Fat Left Tail) | Skewness decreases (more negative); Kurtosis increases. | High perceived downside (crash) risk; investors pay a premium for OTM puts. |
| Forward Skew (Positive Skew) | Right-Skewed and potentially Leptokurtic | Skewness increases (more positive); Kurtosis increases. | High perceived upside potential (e.g., takeover speculation or positive news). |
| Volatility Smile (Symmetric) | High Kurtosis (Fat Both Tails, Symmetric) | Skewness remains near zero; Kurtosis significantly increases. | High probability of large price moves in either direction, reflecting general uncertainty. |

Check also with a volatility index like the VIX for the baseline volatility of the model in the event study.