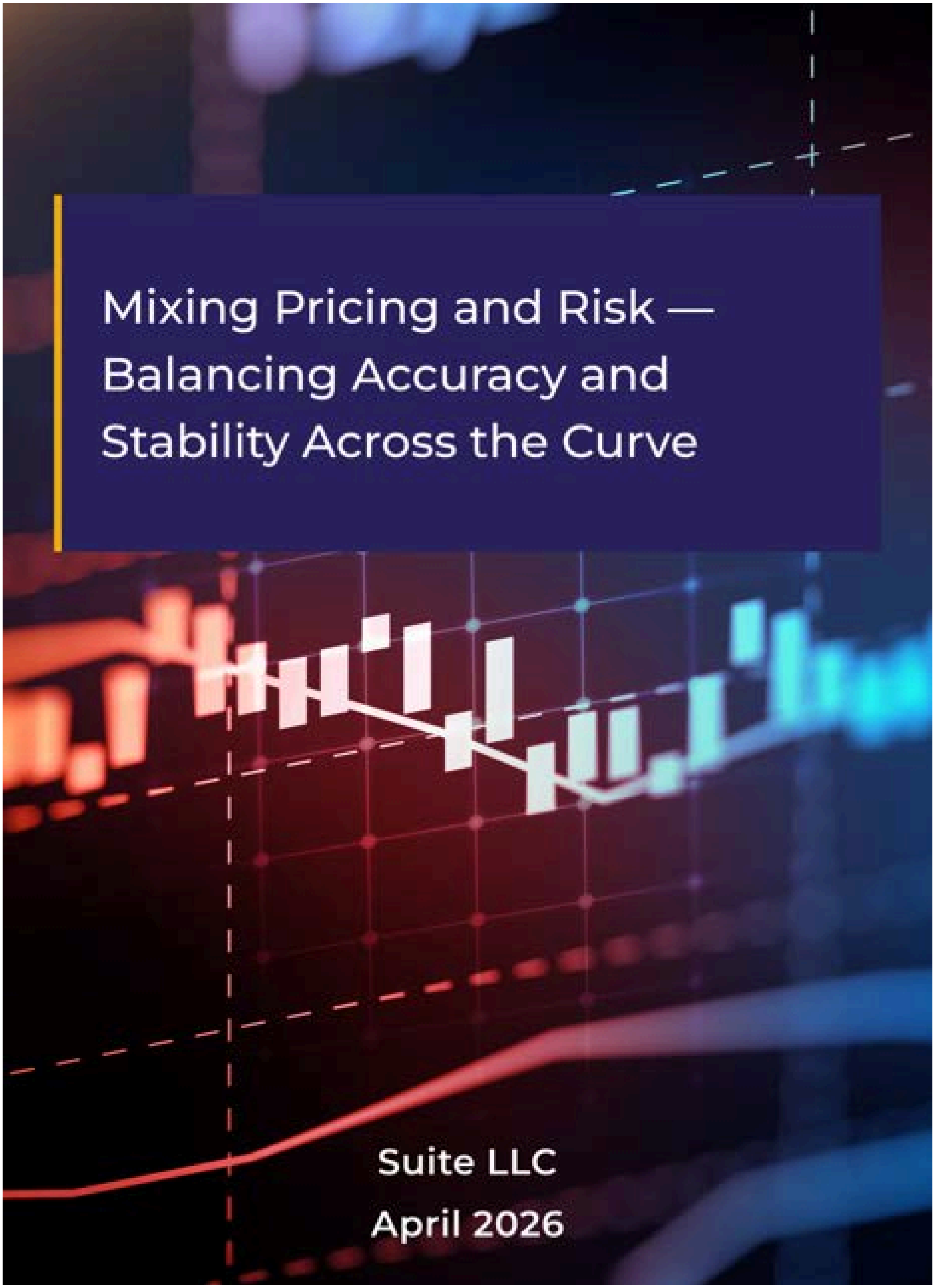

Mixing Pricing and Risk — Balancing Accuracy and Stability Across the Curve

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Executive Summary

Modern financial institutions rely on yield curve construction techniques to accurately price instruments and assess risk. However, methodologies that optimize pricing accuracy—such as spline interpolation—often introduce inefficiencies and instability in risk calculations.

This paper presents a hybrid framework that separates pricing and risk methodologies while maintaining consistency between them. By combining spline-based pricing curves with risk approximations through a Jacobian transformation, firms can achieve faster, more stable, and coherent risk metrics without sacrificing pricing fidelity.

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1. Introduction

Pricing and risk models are fundamentally approximations of observed market prices and potential future movements. While both aim to reflect the same underlying financial reality, combining them into a single framework often leads to trade-offs.

A persistent challenge in financial analytics is balancing:

- Accuracy in pricing (fit to market instruments)
- Stability and speed in risk calculations

Traditional approaches attempt to unify both objectives within a single curve construction methodology, which can lead to inefficiencies and numerical instability.

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2. The Problem with Spline Interpolation in Risk

Spline interpolators are widely used in some markets for swap curve construction because they:

- Provide smooth curves
- Fit benchmark instruments precisely
- Enable realistic pricing across non-standard maturities

However, in a risk context, spline methods introduce challenges:

- Computational inefficiency: Rebuilding curves for each market shock is slow
- Instability in forward rates: Small input changes can produce erratic forward movements

- Non-local sensitivity effects: Changes in one tenor can propagate unpredictably

As a result, spline-based approaches are well-suited for pricing but problematic for large-scale risk calculations.

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3. A Hybrid Approach to Pricing and Risk

To address these challenges, it's possible to take advantage of several of the tools provided by ALib to build a three-step framework that combines pricing accuracy with stable and fast risk. We refer to that as a Jacobian Spline Mapping.

Step 1: Pricing Curve Construction (Spline-Based)

- Build a yield curve using a spline interpolator, such as a quadratic or cubic polynomial spline applied to the forward rates.
- Ensure accurate fit to market instruments

Step 2: Risk Curve Construction (Linear/Flat Interpolation)

- Construct a second curve using linear or flat forward interpolation with identical market pillars
- Compute sensitivities of the zero rates to underlying market instruments (e.g., swap rates)
- Use ALib's curve functions to extract the zero curves associated with a scenario and "subtract" the base zero curve. This provides the Jacobian matrix, capturing precisely how each market rate shock in the risk calculation will propagate across the implied zero rates, potentially along the entire curve. This will be used in the next step to define scenarios to apply to the splined curve.

Example insight:

- The 5Y swap rate primarily impacts the 5Y zero rate
- It also affects neighboring tenors (e.g., 2Y and 10Y, with minor differences in zero rates running out to the far end of the curve)

Step 3: Build a scenario set for application to the splined curve

- Using ALib's Risk Framework, define a scenario set from the Jacobian created earlier.
- Recall that each scenario contains a series of simultaneous perturbations of various magnitudes to points across the zero curve.
- Run ALib's scenario analysis to apply this set of scenarios to the splined curve.

This produces:

- Smooth, spline-consistent risk outputs – i.e. the levels of all forward rates across the base curve are consistent with the spline.
- Risk bucketing looks well localized and predictable.
- Fast results – cubic splines are inherently computationally expensive. Using this approach, we need only build the splined curve one time, rather than once for each scenario. Since there are as many scenarios as there are market prices on the curve, then the alternative approach will be significantly more computationally efficient.

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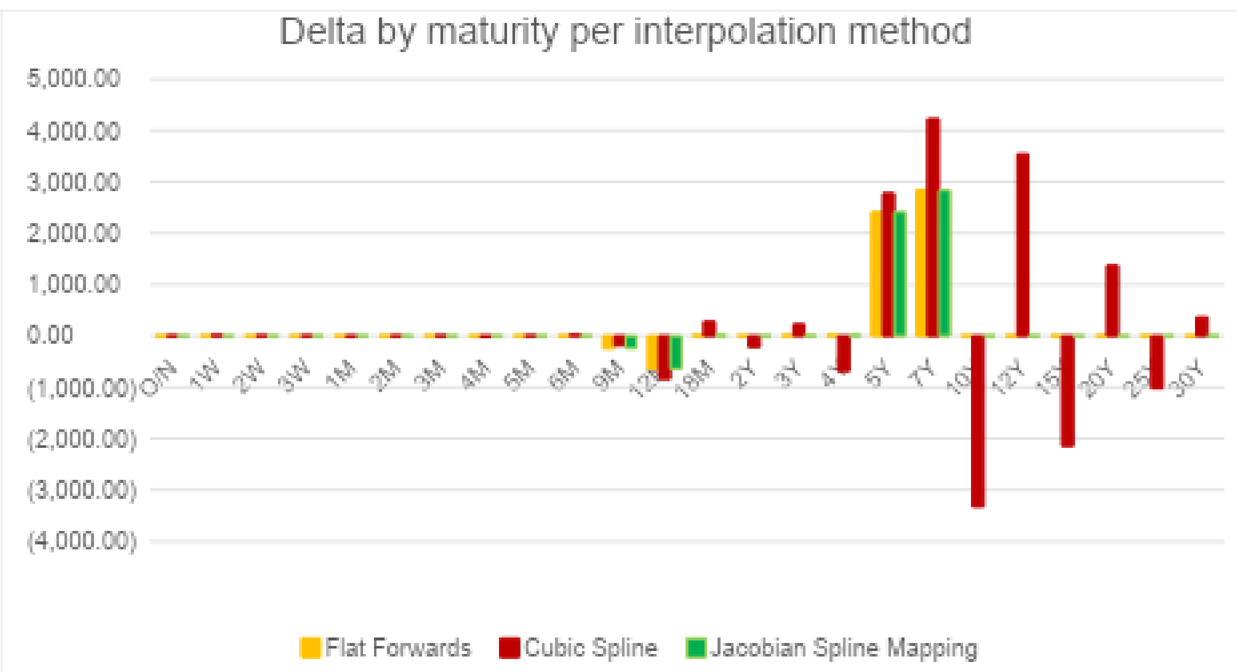
4. Example 1 – risk on forward starting swap



The graph above shows the sensitivities of a simple $10mn swap starting nearly 1Y forward and maturing 5Y later.

Note the following:

- The risk profile using the flat forward interpolation is extremely intuitive and useful.
- The risk profile using the cubic spline interpolation on the forwards is highly unstable and difficult to use directly.
- The risk profile using our Jacobian Spline Mapping onto the cubic spline curve looks almost identical to the profile when using flat forward interpolation – and hence is equally intuitive and useful.

5. Example 2 – risk on non-linear trades

In the previous example we saw that the risk for Jacobian Spline Mapping onto the spline was basically identical to the risk for the flat forwards curve. This brings us to the question of: why not simply use the flat forwards curve?

If a trader believes their market requires the use of a splined interpolation in order to match dealer pricing at off-benchmark maturities, then that trader will want to see different forward rates along their curve when compared to the flat forward curve.

If the portfolio being analyzed is very linear, then the different forward rates will not impact the results greatly.

But if the portfolio contains options, then the delta will very much be a function of the level of the forward rate – and will consequently change depending on the interpolation choice.

	Caplet Delta	
Bucket	Flat Interpolator	Jacobian Spline Mapping
9M	(291.90)	(381.07)
12M	405.56	523.20

In this example, we see that the deltas in the key risk buckets when using the flat forward curve versus the Jacobean Spline Mapping are quite different. The position being analyzed is a single caplet, struck close to the money under the splined curve, but out of the money on the equivalent flat forward curve. As a result, the delta when using the Jacobian Spline Mapping is significantly larger than when using the flat forward curve. To the extent that the cubic spline is preferred for its forward rates, the risk from the Jacobian Spline Mapping will also be preferred.

6, Key Advantages

6.1 Computational Efficiency

- Avoids repeated spline recalibration
- Enables faster risk calculations for large portfolios

6.2 Stability

- Jacobian Spline Mapping ensures sensitivity behaves as predictably as under linear/flat interpolators
- Reduces noise in forward rate movements

6.3 Consistency with Pricing

- Maintains alignment with spline-based pricing outputs
- Produces risk measures that reflect the same economic assumptions

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7. Practical Implications

As portfolios become more complex and markets exhibit non-linear behaviors such as:

- Contango
- Backwardation

…it becomes increasingly important to maintain consistency between pricing and hedging.

This hybrid approach ensures:

- More reliable hedge ratios
- Balanced portfolios under market stress
- Reduced model risk from interpolation artifacts

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8. Implementation Considerations

The framework has been implemented within the ALib ecosystem, enhanced by a dedicated risk engine developed by Suite LLC.

Key design goals include:

- High performance - with minimal necessary recomputation ensured by the underlying dependency graph.

- Numerical robustness
- Flexibility across asset classes

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9. Conclusion

Separating pricing and risk methodologies—while reconnecting them through the Jacobian Spline Mapping—offers a practical solution to a long-standing problem in financial analytics.

This approach delivers:

- Fast computation
- Stable sensitivities
- Pricing-consistent risk outputs

As financial markets evolve, such hybrid frameworks will become essential for firms seeking both precision and scalability in their analytics infrastructure.