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Improving the Willow Tree Method: An Enhanced Variant and an Empirical Comparison with the Binomial Tree Method

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Abstract

Originally proposed by M. Curran for pricing path dependent interest rate derivatives and equity options, the Willow Tree (WT) method is revisited here in the context of European options. We incorporate the sampling schemes of Wei Xu, Zhiwu Hong, and Chenxiang Qin — namely the first partial moment (FPM) and kurtosis matching (KM) approaches — to evaluate the trade-off between numerical accuracy and computational cost.

In the low volatility regime, a moderately refined WT grid (? 180 nodes) already achieves sub-basis-point signed errors at microsecond runtime, whereas a comparable binomial lattice requires substantially larger step counts. The main weakness of the baseline WT appears under long maturities (T) and high volatilities (?), where its bounded support discretization breaks the exponential martingale identity and yields a tree resolution dependent underpricing bias. Applying an Esscher (exponential tilting) reweighting restores the martingale identity to machine precision and reduces pricing errors to the sub-percent range even in demanding settings. Across experiments, the first-partial-moment sampler exhibited the most stable behavior and smallest residuals; hence, nodes?180 with FPM provides a practical default configuration for European calls.

Keywords: Option pricing; Willow Tree approximation; Esscher transform (exponential tilting); Binomial lattice approximation