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# Approximate Arbitrage-Free Option Pricing under the SABR Model

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## Abstract

The stochastic-alpha-beta-rho (SABR) model introduced by [Hagan et al. \(2002\)](#) provides a popular vehicle to model the implied volatilities in the interest rate and foreign exchange markets. To exclude arbitrage opportunities, we need to specify an absorbing boundary at zero for this model, which the existing analytical approaches to pricing derivatives under the SABR model typically ignore. This paper develops closed-form approximations to the prices of vanilla options to incorporate the effect of such a boundary condition. Different from the traditional normal distribution-based approximations, our method stems from an expansion around a one-dimensional Bessel process. Extensive numerical experiments demonstrate its accuracy and efficiency. Furthermore, the explicit expression yielded from our method is appealing from the practical perspective because it can lead to fast calibration, pricing, and hedging.

*Keywords:* SABR model; Approximate solution; Arbitrage-free option pricing; Perturbation method

*JEL classification:* C63 G13

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