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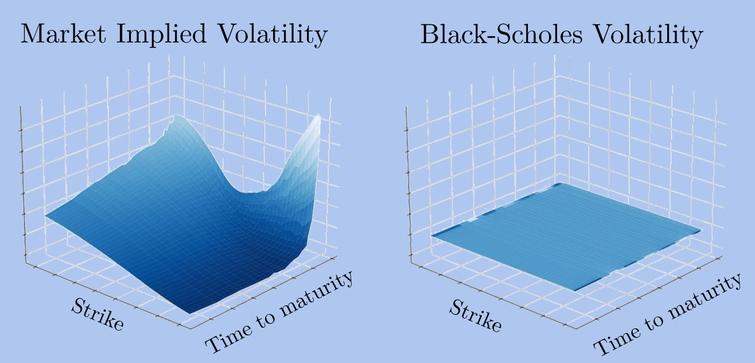
Parametric and Semiparametric Option Pricing Using the GARCH Framework

How does option pricing work in industry practice?

- The most-widely used tool for pricing options and other derivatives is the Black-Scholes model which assumes normally distributed returns of the underlying asset.
- The Black-Scholes model underestimates the tail risk of the underlying asset, thus mispricing away-from-the-money options. This can be seen by inspecting the implied volatility surface of real options on the market (left) and the flat volatility surface of the Black-Scholes model (right).
- Normally distributed asset returns assumed by the Black-Scholes model lack common stylised facts of market returns like, e.g., volatility clustering effects.



Main problems underlying the Black-Scholes model:

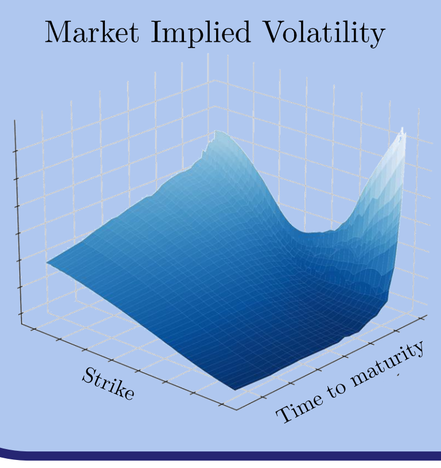
Derivative pricing inaccuracies and **Undesirable path properties**

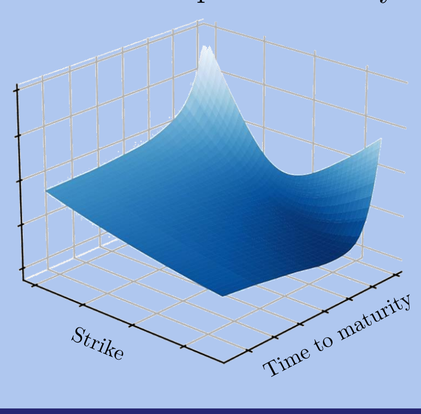
Can we fix both problems with one stochastic model?

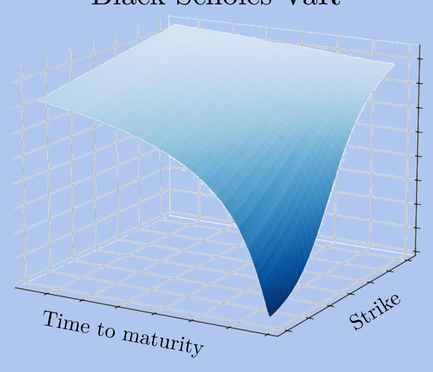
- Since options are a popular tool for financial hedging, these static and dynamic problems have led to large losses in the past financial crises. From a risk management point of view, both problems need to be tackled simultaneously.
- Modelling asset returns by GARCH processes is a common tool to mimic the most prominent features of market-observed returns time series. Here, conditional volatility is modelled using an autoregressive moving average process.
- Pricing options using GARCH processes is not straightforward. We analyse a parametric valuation approach named *Locally Risk-Neutral Valuation Relationship* by Duan (1995) and come up with a semiparametric valuation approach which is more flexible in the choice of GARCH specifications.

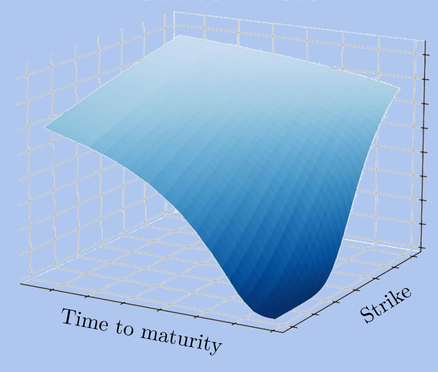
How do GARCH models perform on real option data?

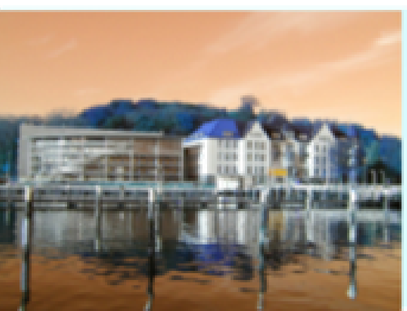
- Market-observed volatility smiles can be recovered by GARCH option pricing models (see left tile). Across all maturities and strikes, the models achieve a pricing error of about 2%. Using the novel semiparametric approach, Value-at-Risk measures of option portfolios are lowered by about 50% (see right tile), leading to a more conservative risk management of options.











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