Theta Proxy

Accelerated Risk Management

The Challenge in Risk Management

Bank-wide risk management applications require a large number of derivatives to be priced in the context of potential future scenarios.

The Basel II directive allows for a significant reduction in capital requirements if the potential future exposure is measured accurately. This involves each product in the Bank's portfolio being priced under a large number of future scenarios, each sampled at many time steps. With daily evaluation, only fractions of a second are available for pricing each product in each specific scenario and time. To meet such requirements, product prices are often approximated and – to be safe – risk figures are systematically overestimated.

Despite the advent of high performance computing the effective risk control of exotic derivatives remains out of reach.

Our Solution

Theta Proxy is an advanced technology which allows evaluations of pricing functions with extreme speed-ups compared to traditional methods.

This new technology presents a significant breakthrough for Monte Carlo pricing in time sensitive applications such as risk management. Monte Carlo methods are known for their wide applicability to pricing problems extending to even the most exotic derivatives. However, this advantage could not yet be successfully exploited due to tight performance constraints in bank-wide risk measurements. Theta Proxy is the first Monte Carlo based evaluation strategy that overcomes this issue.

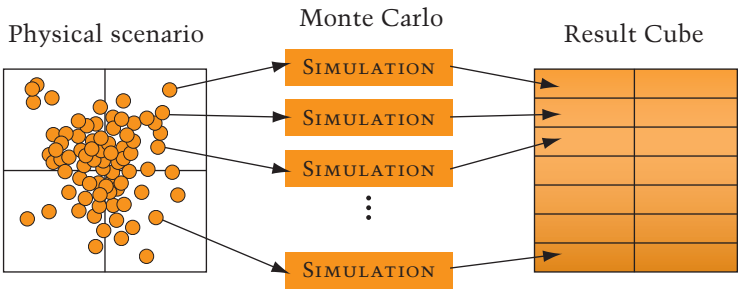
Complex financial products can now be priced with unprecedented speed and accuracy, making their risk manageable.

THETARIS
Engineering in Finance

Theta Proxy Technology

The Setting

Theta Proxy is a new technology for accelerated Monte Carlo evaluation. It is applicable whenever a range of similar evaluations are performed with nearby, but different start parameters. In typical risk management settings a scenario engine generates potential future market parameters according to physically observed statistics. Standard Monte Carlo pricing is characterized by a massive number of simulations with no results being reused. The Theta Proxy has been developed to remove this redundancy.



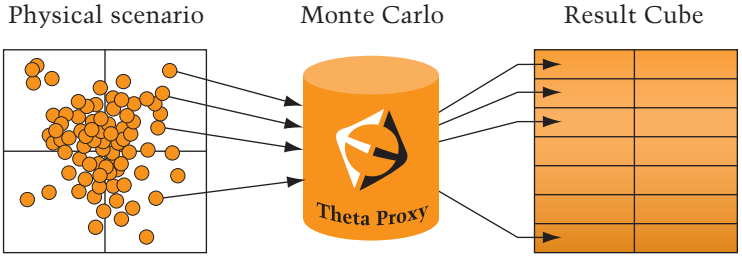
Standard Monte Carlo pricing on physical scenarios without reusing results from previous similar simulations.

The Innovation

The new technology facilitates an incremental Monte Carlo simulation approach. Theta Proxy integrates seamlessly with the Theta Suite, Thetaris' financial development toolkit, but its generic nature also allows application to any existing pricing solution.

Theta Proxy achieves its speed-ups by leveraging knowledge of the product structures and the closely related structure of incoming physical pricing scenarios.

The method determines results from few representative scenarios and propagates simulation results to the consecutive pricing scenarios, utilizing the fact that functions are smooth in most regions and that exercise boundaries are equal within each time step.
Theta Proxy can be used to increase the speed and accuracy of product pricing.



Optimized scenario placement using Theta Proxy technology.

The following two examples – namely "European Put option" and "Asian-American option" – demonstrate the accuracy and speed of the Theta Proxy by benchmarking it against conventional methods. In this case study, we compute the Black-Scholes prices of the option in 5000 physical simulations with 250 time steps, i.e. 1,250,000 valuations are performed. The benchmarking methods are:

1. **Analytical Solution:** For an European Put option, an analytic solution is available. However, for the Asian-American option no solution exists.

2. **Pure Simulation:** Each option valuation is conducted using few risk-neutral paths. Even though this is error prone, the errors in the evaluation cancel each other out such that the risk estimate is still valid. However, this method is not feasible for pricing options with early exercise. Consider that at least 10,000 risk-neutral paths would be required for each of the 1.25 mn valuations. With 10 seconds per evaluation, this would take 145 days.

3. **Numerical Solution by PDE:** The PDE delivers fast and accurate results for all prices at a specific time step at once and thus serves as a benchmark for the Asian-American option.

Physical Scenario Setting

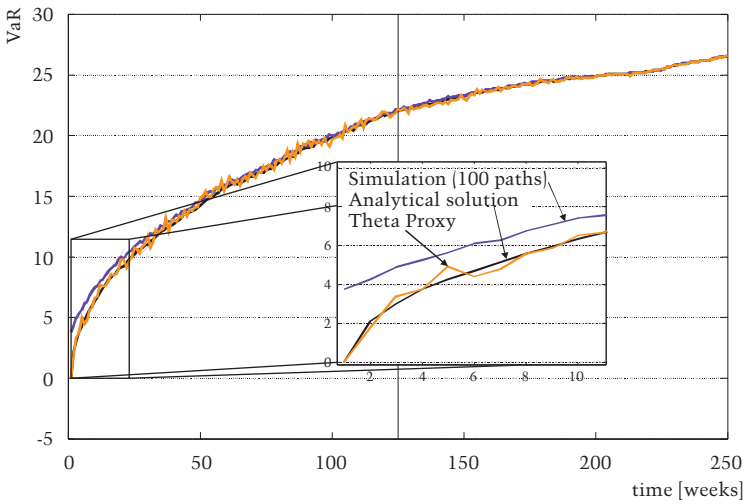
- 5000 physical scenarios with 250 time steps each
- 5 years with weekly samples
- Geometric Brownian Motion (drift = 10% p.a., volatility = 20%)
- 5% risk-free interest rate

European Put option

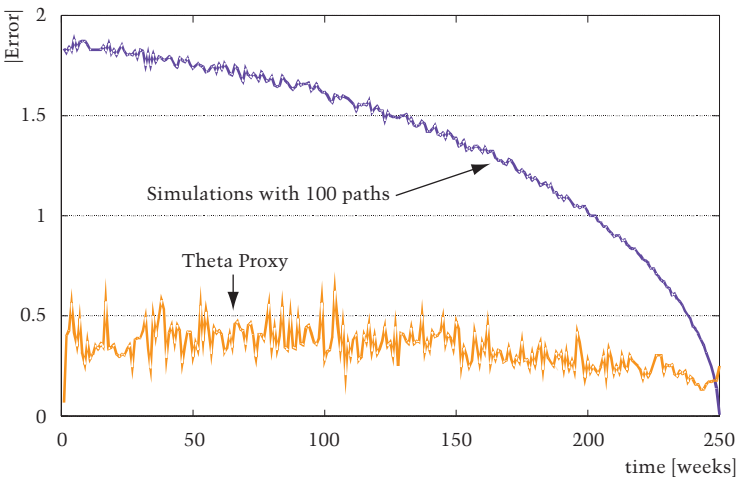
Strike 100 €
Maturity 5 years

Benchmarking Value at Risk (VaR) computations of the Theta Proxy with an analytical solution shows that the Theta Proxy is very precise. A Monte Carlo method with 100 paths in each physical scenario results in larger errors then the ones of Theta Proxy.

Benchmark European Option (Value at Risk)



Average absolute error in option value per scenario



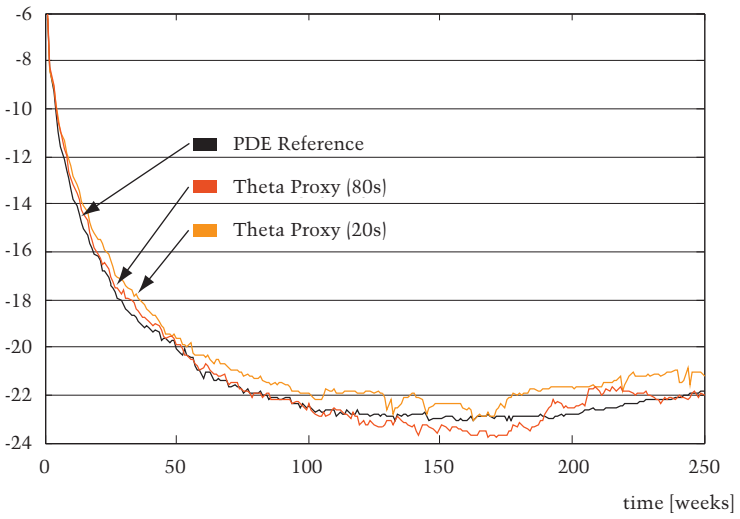
Also, with Theta Proxy the average error for the option price estimate in each scenario is a lot smaller compared to using 100 Monte Carlo paths in each scenario.

American Asian Option

Strike K	100 €
Maturity	5 years
Average A	arithmetic average of stock price
Exercise	K – A

A benchmarking of Theta Proxy with an accurate PDE reference method demonstrates that the Theta Proxy still holds its ground and the error of the risk measure Value at risk (VaR) is small. In the above figure, VaR is presented for the reference method as well as Theta Proxy with 20 and 80 seconds total CPU time.

Benchmark American Asian Option (Value at Risk)



Theta Proxy. The fastest Monte Carlo pricing solution.

A path-dependent option with continuous early exercise can be priced at highspeed with Theta Proxy

- 1,250,000 option prices computed in 20 seconds.
- 0.000016 seconds per evaluation.
- **Up to 100.000 x faster Monte Carlo evaluations**

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