



Beyond Monte Carlo: A quantum-inspired approach to financial risk analytics

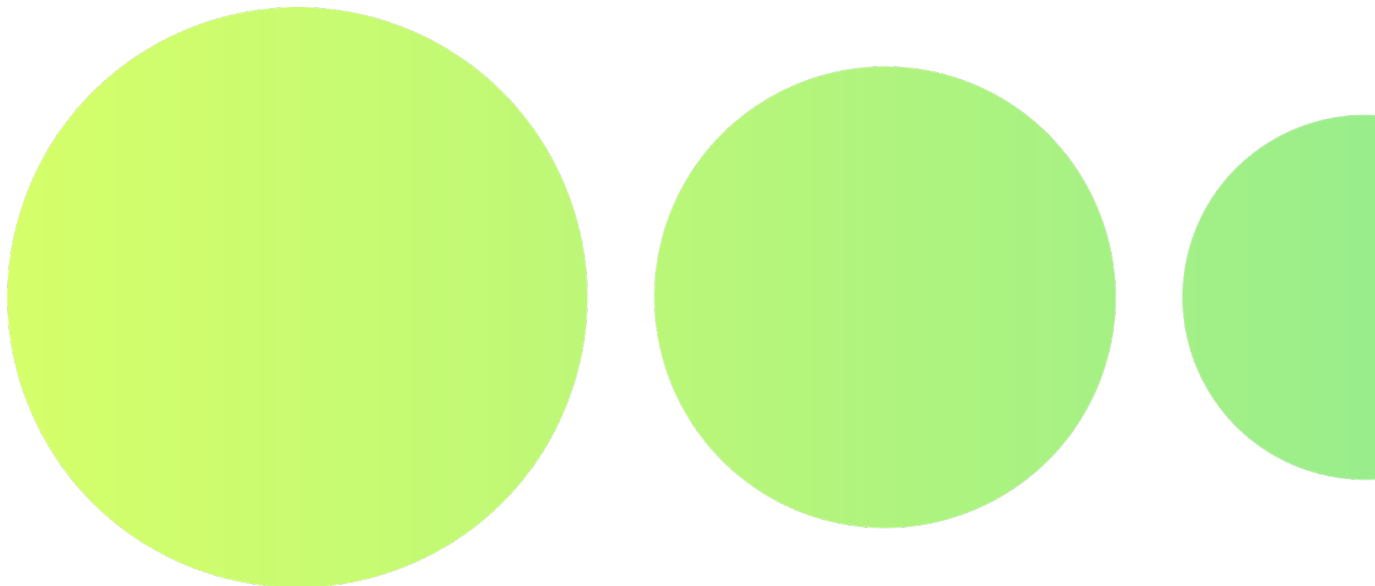
A faster, reproducible path to high-precision tail analytics for risk and capital decision-making.

Replacing Monte Carlo

Monte Carlo is a workhorse for financial analytics, yet new analytic frontiers are emerging in quantitative finance. Deloitte has developed an alternative—a quantum-inspired numerical solver that deterministically provides risk solutions with speed and precision. Quantum-inspired approaches leverage computational methods in quantum physics that run on standard, classical computers. Deloitte's patent-pending Multivariate Integration Engine (MIE) is designed to support faster, reproducible tail-risk analysis while improving the consistency and traceability of results. The solver efficiently and deterministically computes solutions for high-dimensional risk models with nonlinear loss, value, or price constraints.

Key benefits of the Multivariate Integration Engine

- 1. Improved tail precision:** Resolves rare, extreme-tail events with greater precision.
- 2. Faster computation:** Handles complex calculations quickly, speeding up slow, overnight calculations.
- 3. Reduced compute cost:** Lowers compute and infrastructure costs by doing more computation with less processing power.
- 4. Future-ready:** Serves as a bridge to financial analytics on quantum computers.



A quantum-inspired approach to market and credit risk analytics

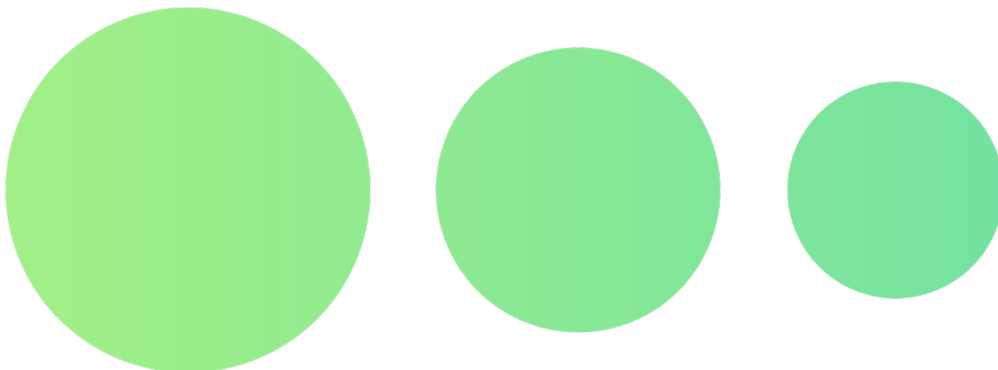
Financial institutions employ complex calculations to quantify potential losses across portfolios shaped by correlated risk factors and complex dependencies, including value at risk (VaR), derivative pricing, stress testing, derivative counterparty exposures (XVA), and more. Today, those institutions use Monte Carlo techniques to estimate tail risk by running millions of simulated scenarios that become especially demanding in the extreme tail, where rare but severe outcomes drive capital requirements. The MIE targets risk models where tail precision matters.

Default Risk Charge (DRC) is a regulatory capital measure under the Fundamental Review of the Trading Book (FRTB) framework of market risk that captures the jump-to-default on trading-book positions. It estimates potential losses over a defined horizon by modeling correlated defaults across issuers and sets the charge at the 99.9% tail of the resulting loss distribution to support capital requirements. DRC is a demanding test of extreme tail precision.

Deloitte's MIE reformulates the portfolio loss calculation. It captures the relationships between those factors and individual issuers in a structured mathematical representation that can be evaluated deterministically to recover the portfolio loss distribution.

The results of an industrially relevant benchmark on DRC involving 200 issuers with sector, region, and global economic risk factors demonstrated both performance and accuracy:

- **Approximately 70% faster** than a 2-million-path Monte Carlo calculation at 200 issuers.
- **Relative error within 0.3%** of a 100-million-path Monte Carlo reference.
- **Further accelerated 35x on GPUs** compared to the CPU implementation.
- **Generates identical results every time** while Monte Carlo results vary from one run to the next.



Performance and accuracy benchmarks

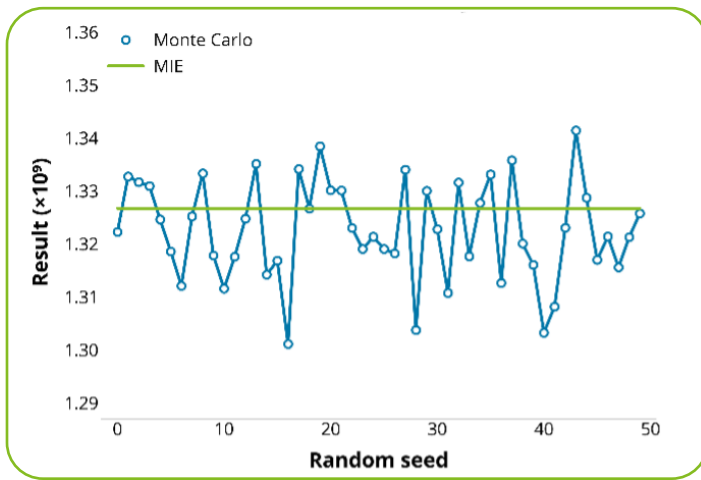


Figure 2: Stability comparison of MIE results to the variability of Monte Carlo results over 50 different random seeds. MIE provides a consistent result, while Monte Carlo outputs fluctuate significantly.

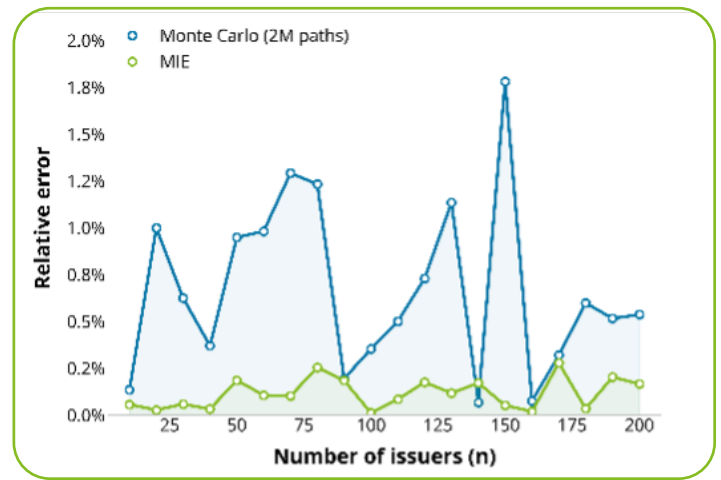


Figure 3: Relative error of MIE vs. a 2-million-path Monte Carlo simulation against a 100-million-path reference. MIE's error remains consistently low and stable as portfolio size increases.

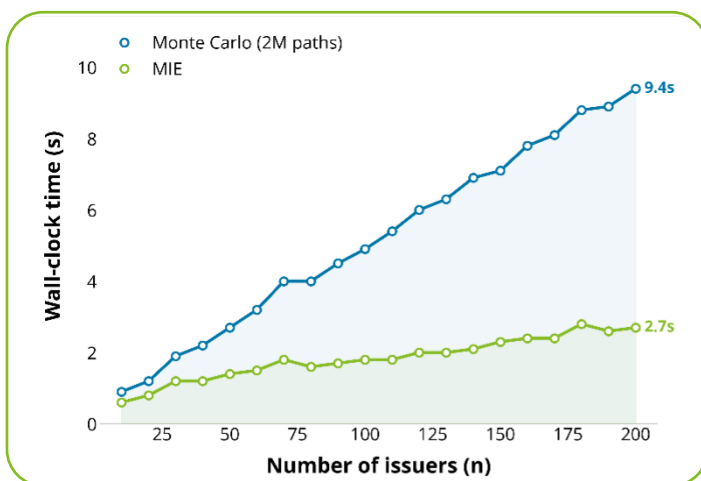


Figure 4: CPU runtime comparison of MIE and a 2-million-path Monte Carlo simulation. MIE is consistently faster, finishing in 2.7 seconds vs. 9.4 seconds for Monte Carlo with 200 issuers.

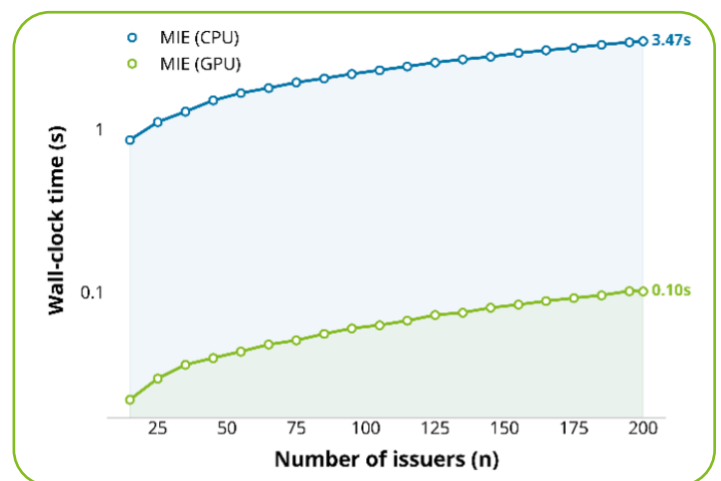


Figure 5: MIE performance on a CPU vs. a GPU. The GPU-accelerated MIE is 35 times faster, completing the calculation in 0.10 seconds.

Looking ahead: The future of risk calculations

MIE has now been demonstrated across multiple financial risk models, including VaR, expected shortfall, idiosyncratic dividend yield, and enterprise-scale DRC. Together, these results provide an initial proof point that deterministic, quantum-inspired methods can deliver value where tail precision, reproducibility, reusable distributional outputs, and hardware acceleration matter most.

The next step is to identify high-value workflows across market, credit, counterparty, and capital risk where these capabilities can materially improve how risk is calculated and understood. As financial institutions look beyond traditional sampling-based approaches, MIE provides a foundation for faster, more reproducible, and more decision-useful risk analytics.

Deloitte has extensive experience applying frontier analytics to solve complex risk-modeling problems for global financial institutions.

Explore faster, *more reproducible risk*

Organizations looking to move beyond traditional sampling-based approaches can engage Deloitte to help them assess priority MIE applications based on their portfolio characteristics, data availability, and existing risk processes.

Contact us to learn more:

Scott Buchholz

Managing Director
Global Quantum Lead
sbuchholz@deloitte.com

Mekena McGrew PhD

Senior Manager
Quantum Information Science Lead
mmcgrew@deloitte.com

Clifford Goss PhD

Partner
Risk and Forensics
cgoss@deloitte.com

Kiza Mahajan

Senior Manager
Risk and Forensics
kimahajan@deloitte.com

Michael Monaco

Senior Manager
Risk and Forensics
mimonaco@deloitte.com

Endnote

1. The benchmark is based on synthetic data. Actual performance and accuracy may vary depending on portfolio composition, model design, data characteristics, and implementation environment.



This document contains general information only and Deloitte is not, by means of this document, rendering accounting, business, financial, investment, legal, tax, or other professional advice or services. This document is not a substitute for such professional advice or services, nor should it be used as a basis for any decision or action that may affect your business. Before making any decision or taking any action that may affect your business, you should consult a qualified professional advisor. Deloitte shall not be responsible for any loss sustained by any person who relies on this document.

As used in this document, "Deloitte" means Deloitte Consulting LLP, a subsidiary of Deloitte LLP. Please see www.deloitte.com/us/about for a detailed description of our legal structure. Certain services may not be available to attest clients under the rules and regulations of public accounting.

Copyright © 2026 Deloitte Development LLC. All rights reserved.