Applications of Quantum Computers in Banking

Q-Con Conference: Quantum, Applied. Value, Delivered

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prepared for: Q-Con Quantum Conference

September 8, 2026

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Academic and Professional Profile Dr. Philippe De Brouwer holds a background in theoretical physics and earned a second Master's degree in Business Engineering while working full time. His academic distinction includes solving the "fallacy of large numbers" puzzle, originally posed by P.A. Samuelson and unresolved for 38 years. In his Ph.D., he challenged the foundational assumptions of Harry Markowitz's Nobel Prize-winning Mean Variance Theory, developing the "Maslowian Portfolio Theory" and fundamentally advancing the field of investment advice.

Career Highlights Early in his career, De Brouwer transitioned from insurance to banking and from IT to asset management. At Fortis (now BNP Paribas), he played a key role in launching one of Belgium's first capital-guaranteed funds and was promoted to director in 2000. In 2002, he joined KBC, where he orchestrated the merger of four companies and became CEO of the consolidated entity in 2005. Under his leadership, the company climbed from 11th to 5th in the market, even amid heightened competition.

Following the financial crisis, De Brouwer led the creation of a new investment management company for KBC in Ireland, which quickly grew to manage around 1000 investment funds and approximately €32 billion in assets. In 2012, he broadened his expertise into financial risk management, focusing on statistics, analytics, data, and numerical methods.

Recent Roles and Publications De Brouwer served as Head of Analytics Development for the Royal Bank of Scotland Group and currently holds the position of SVP at HSBC in Kraków. There, he oversees the Model Review Centre of Excellence and serves as Global Head of Professional Practices for Model Risk Management. He also coordinates collaboration with universities.

He has authored numerous scientific papers and books, with his latest being "The Big R-Book: From Data Science to Big Data and Learning Machines." His work continues to influence both academic and practical approaches to finance, risk, and data science.

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Contents

1 Quantum Computing in Banking

Use cases in banking

- **Optimization**:
  A. portfolio optimization
  B. collateral optimization
  C. stress testing
  D. transaction settlement
  E. asset pricing
  F. ATM replenishment
- Machine Learning
  A. fraud detection
  B. credit scoring
  C. synthetic data and data augmentation
- **Simulations**:
  A. random number generator
  B. Monte Carlo, PDE simulations, etc.
  C. asset valuation
  D. ES and VaR calculations
- **Encryption**:
  A. quantum key encryption
  B. quantum currency
  C. quantum blockchain

Resulting Advantages

- quadratic to exponential speedup
- better risk management
- lower costs
- greener computing
- better forecasting
- more suitable investments
- etc.

Boston Consulting Group estimates a value of $42B to $67B for financial institutions (May 2019). Their 2026 update read: $450 billion to $850 billion in total global economic value by 2040.

Overview: Quantum Algorithms for Finance

Approach	Applications	Algorithms	Challenges	Advantages	Timeline
Stochastic modeling	• Pricing • Risk modeling • Credit Risk	Quantum Monte Carlo	Data loading into qubits	Quadratic speedup	Long term
		Quantum PDE solvers	Input/Output bottlenecks	Unproven speedup	Long term
Optimization	• Portfolio mgmt • Financing • Resource allocation	Convex solvers (SCP)	Hardware precision limits	Unproven speedup	Long term
		Integer solvers (MIP)	High circuit complexity	Theoretical quadratic speedup	Long term
		Heuristic solvers (QAOA/Annealing)	Noise & parameter tuning	Early empirical evidence	Near term
Machine learning	• Forecasting • Anomaly detection • Recommendations	Quantum-enhanced ML	Data loading into qubits	Unproven speedup	Long term
		Quantum-native ML	Training & measurement noise	Unproven speedup	Near term

Table 1: *Quantum algorithms for financial problems. PDE: partial differential equation, SCP: symmetric cone program, MIP: mixed integer program, ML: machine learning.*

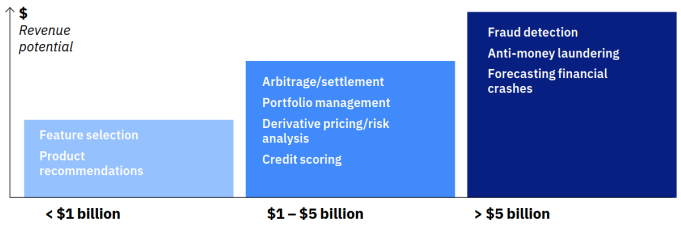
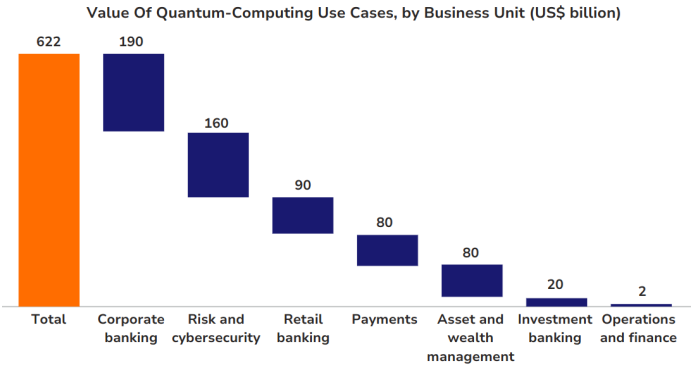


Figure 1: *Source: IBM Report: Exploring quantum computing use cases for financial services. These numbers are the average annual savings for the average bank.*

2 The Value for Bankers



3 Real Examples

Banking application with D-Wave and Multiverse Computing

Examples of Banks' Efforts

HSBC & BT: Quantum Key Distribution for FX Trading (2023)

Application Domain: Post-Quantum Financial Infrastructure Security

Securing live Foreign Exchange (FX) trading transactions with QKD. This safeguards HSBC's transactions against future quantum decryption threats.

- **Mechanism:** Connected HSBC's global HQ in Canary Wharf to a primary data center in Slough via BT and Toshiba's commercial **Quantum Key Distribution (QKD)** network over standard fiber optics.

Figure 2: *A paper about portfolio optimisation with the D-Wave computers. Source: arxiv.org*

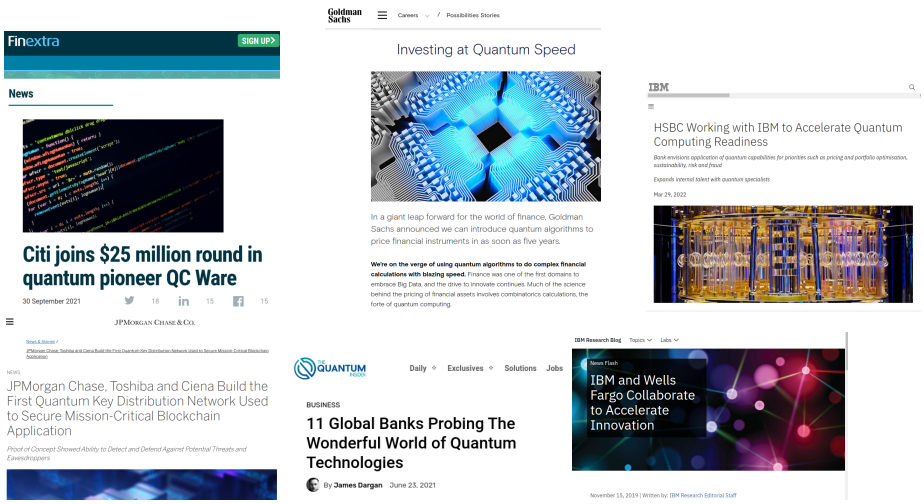


Figure 3: *Sources: finextra.com, goldmansachs.com, ibm.com, and thequantuminsider.com*

- **Operational Scope:** Integrated QKD directly into live FX trading systems processing over $2.5T in daily transaction flows.
- **Key Breakthrough:** First commercial bank to deploy QKD on live financial trading infrastructure, neutralizing "harvest now, decrypt later" cyber attacks.

Reference
HSBC & BT Media Release, *"HSBC becomes first bank to join BT and Toshiba's commercial quantum-secured network"* (July 2023).

HSBC & IBM: Algorithmic Trading Execution (2025)

Application Domain: Corporate Bond Market Liquidity
Predicting trade fill probabilities for corporate bond orders on live market infrastructure.

- **Mechanism:** Utilized IBM System 2 with **Heron processors** running Variational Quantum Eigensolver (VQE) and Quantum Support Vector Machine (QSVM) algorithms.
- **Data Scale:** Benchmarked against over $1,073,926$ Request-for-Quotes (RFQs) in the European corporate bond market.
- **Empirical Outcome:** Achieved an empirical **34% relative improvement** in out-of-sample order-fill prediction accuracy over classical baselines.

Reference
HSBC Media Release & IBM Quantum Research, *"HSBC demonstrates world's first-known quantum-enabled algorithmic trading"* (September 2025).

Mastercard & OQC: Real-Time Fraud Detection (2026)

Application Domain: Payment Network Anomaly Filtering
Minimizing false-positive declines without violating strict sub-millisecond payment settlement SLA constraints.

- **Mechanism:** Implemented a **Hybrid Ensemble Routing Architecture**. Standard low-risk transactions are handled classically, while ultra-high-dimensional feature vectors are dynamically routed to Oxford Quantum Circuits' superconducting processors.
- **Key Breakthrough:** Maintained sub-millisecond network latency while boosting classification precision for edge-case payment fraud.

Academic & Industry Reference
Mastercard & Oxford Quantum Circuits Joint Case Study, *"OQC and Mastercard Demonstrate Quantum-Enhanced Fraud Detection"* (June 2026).

JPMorgan Chase & Quantinuum: Certified Randomness (2025)

Application Domain: Post-Quantum Security & Monte Carlo Entropy

Generating hardware-verifiable non-deterministic entropy for encryption key generation and financial simulation.

- **Mechanism:** Executed phase estimation on a 56-qubit trapped-ion processor (*H-series*), validating entropy output through supercomputing clusters at U.S. National Laboratories.
- **Empirical Outcome:** Proven mathematical non-determinism, replacing classical Pseudo-Random Number Generators (PRNGs) vulnerable to quantum side-channel decryption.

Academic & Industry Reference
JPMorgan Chase, Quantinuum, et al., *"Quantum-verified random numbers"*, published in **Nature** (March 2025).

Goldman Sachs & QC Ware: Derivatives & Option Pricing

Application Domain: Multi-Asset Exotic Option Valuations

Pricing complex derivatives with non-linear payoff structures using Quantum Amplitude Estimation (QAE).

- **Mathematical Speedup Proof:** Classical Monte Carlo algorithms require $\mathcal{O}(1/\epsilon^2)$ iterations to reach precision ϵ, whereas Quantum Amplitude Estimation achieves:

$$\mathcal{O}\left(\frac{1}{\epsilon}\right) \quad \text{vs. Classical} \quad \mathcal{O}\left(\frac{1}{\epsilon^2}\right)$$

- **Impact:** Enables real-time risk sensitivity calculation (Greeks) for large multi-asset derivatives portfolios during volatile trading sessions.

Academic & Industry Reference
Goldman Sachs & QC Ware, *"Option Pricing using Quantum Computers"*, arXiv:1905.02666 / Journal of Quantum Computing.

& Risk Management & Portfolio Optimization

Crédit Agricole CIB & Pasqal
Counterparty Credit Risk (CCR)

- **Tech:** Neutral-atom quantum processors.
- **Goal:** Calculation of Value-at-Risk (VaR) and Risk-Weighted Assets (RWA).

- **Outcome:** Faster evaluation of default probability under systemic market stress.

Ref: Crédit Agricole CIB / Pasqal Press Release (2026).

BBVA & Multiverse Computing
Dynamic Portfolio Rebalancing

- **Tech:** D-Wave Quantum Annealers & Variational Circuits.

- **Dataset:** 8 years of historical price data with real transaction fees and liquidity limits.

- **Outcome:** Reduced runtime from **2 days to seconds** with superior Sharpe ratios.

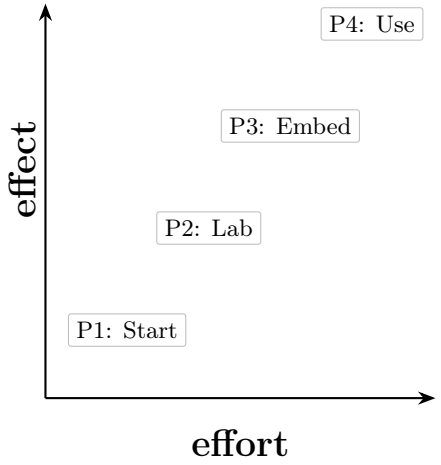
Ref: BBVA Research, arXiv:2007.00017.

Summary: Proven Institutional Case Studies

Institution	Domain	Hardware Partner	Key Benchmark / Outcome
HSBC	Bond Trading	IBM Heron	34% relative gain in fill accuracy
Mastercard	Fraud Detection	OQC Superconducting	Sub-ms hybrid network routing
JPMorgan Chase	Cryptography Entropy	Quantinuum Trapped-Ion	Verifiable hardware random keys
Goldman Sachs	Option Pricing	QC Ware NISQ	Quadratic speedup $\mathcal{O}(1/\epsilon)$
BBVA	Portfolio Optimization	D-Wave Annealer	Runtime reduced from 2 days to secs

4 The Route to Quantum for the Banker

Solutions: Constructing the Bank's Roadmap



Strategic Phases:

- **Phase 1 (Start):** Internal Capability Building & Use-Case Identification
- **Phase 2 (Lab):** Cloud-based PoC Development (QCaaS)
- **Phase 3 (Embed):** Partnerships (startups)
- **Phase 4 (Use):** Hybrid Classical-Quantum Production Systems

5 Conclusion

Strategic Takeaways for Financial Institutions

A. **Post-Quantum Preparedness:** Migration to Quantum Key Distribution (QKD) and post-quantum encryption.

B. **Go Hybrid:** Both hybrid classical-quantum and ensemble approaches.

C. **Quadratic & Exponential Vectors:** Watch high-dimensional feature selection and Monte Carlo simulation.

D. **Develop a Strategy**: Build quantum capabilities ecosystem, forge relations, adopt early.

References & Further Reading

Case Studies & Papers Cited in Presentation

- G. Palmer et al. (2021), "Financial Portfolio Optimization with Quantum Annealers" – arXiv:2106.06735
- IBM Institute for Business Value (2020), "Exploring quantum computing use cases for financial services" – IBM Report
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- Mastercard & Oxford Quantum Circuits (2026), "OQC and Mastercard Demonstrate Quantum-Enhanced Fraud Detection" – Joint Case Study
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- Crédit Agricole CIB & Pasqal (2026), "Counterparty Credit Risk (CCR) Evaluation via Neutral-Atom Quantum Processors"
- BBVA Research (2020), "Dynamic Portfolio Optimization with Quantum Annealers" – arXiv:2007.00017

Industry Reports & Strategic Reading

- McKinsey & Company (2020), "How quantum computing could change financial services" – McKinsey Insights
- IBM Institute for Business Value (2021), "The Quantum Decade" – IBM IBV

Foundational & Academic Textbooks

- E. Rieffel and W. Polak (2011), "Quantum Computing: A Gentle Introduction", MIT Press – MIT Press
- C. Hughes et al. (2021), "Quantum Computing for the Quantum Curious", Springer – PDF Download (Open Access)